Thesis Defense

Investigating How To Support Teachers In Their Teaching And Help Them Improve Their Practices Through Data And Technology

Françeska Xhakaj
CMU-HCII-21-103
July, 2021

Human-Computer Interaction Institute
School of Computer Science
Carnegie Mellon University
Pittsburgh, PA 15213

Thesis Committee:
Amy Ogan, Chair (Human-Computer Interaction Institute, Carnegie Mellon University)
John Zimmerman, (Human-Computer Interaction Institute, Carnegie Mellon University)
Geoff Kaufman, (Human-Computer Interaction Institute, Carnegie Mellon University)
Marsha Lovett, (Eberly Center and Department of Psychology, Carnegie Mellon University)

Submitted in partial fulfillment of the requirements
for the degree of Doctor of Philosophy.

Abstract

Teachers play a crucial role in supporting students' learning. It is crucial to also support teachers in their teaching. Traditional means to support teachers are highly effective but also repetitive, not personalized or not scalable, and infrequent. As classrooms become instrumented with educational technologies, opportunities emerge to provide teachers with feedback through data from these technologies. A small body of work has started to look at supporting teachers with data and feedback outside of class to promote reflection. However this work does not investigate the multiple dimensions of teachers' data needs and does not explore how data affects or can support teachers' goal-setting and behavior change. **In this dissertation**, I investigate how technologies can support teachers' reflection-for-action outside of class, with data from educational technologies. My aim is to help improve teachers' practices and support their long-term behavior change. I initially explore and better understand teachers' data needs and design dashboard prototypes based on those needs. I then investigate how those dashboards affect teachers' practices and how to best support their reflection-for-action through data and technology as a first step towards improved practices and behavior change.

In **Part 1**, I explore teacher data needs in relation to student data. Findings show that teachers manually generate student data and use it to drive instruction. Based on these findings, I designed a dashboard and investigated how it affected teachers. The dashboard influenced what teachers knew about their students, which affected their lesson plan, and in turn guided what they covered in the class session. I demonstrated that data can affect teacher knowledge, decision making, and actions in the classroom, thus leading to behavior change.

In **Part 2**, I explore teacher data needs in relation to their data, design a dashboard that shares with teachers their own data, and investigate how to support their reflection-for-action with motivational feedback. Findings showed that teachers are interested in their data and in how their behaviors affect their students. They reflected on their performance and set goals to improve. Through proxies for behavior change, they showed their willingness, readiness, and intentionality for behavior change, an important first step towards improving their practices. Finally, teachers who received social comparison motivational feedback scored higher in behavior change proxies compared to teachers who received such feedback through verbal persuasion.

In **Part 3**, I explore behavior patterns and relationships in teacher and student data. Findings showed potential for improvement in teacher behaviors and weak to moderate correlations in teacher and student data, hinting at the value of nonverbal immediacy. In co-design studies with teachers, I then investigate how to integrate teacher and student data while supporting reflection-for-action. Findings showed instructors value relationships between teacher and student data, want to see data in a spatial and temporal form, and are interested in activity information combined with student engagement. Support for self-efficacy and value helped them assess performance, set concrete goals and provide actionable suggestions on behaviors to change.

This thesis **contributes** to research at the intersection of the Learning Sciences and Technologies and Human-Computer Interaction. I create a better and deeper understanding of teachers' data needs, their behavior patterns, and of how to support and influence their reflection-for-action. I create dashboard prototypes based on those needs and provide evidence on how these dashboards affect teachers' reflection, goal setting and behavior change. I also provide a theoretical framework and design guidelines for designers of technologies that share data with teachers to support reflection-for-action and long term behavior change. Finally, I present a concrete example of how data can support professionals in their workplace.

Acknowledgments

What a journey!

It has been 6 years since the start of my Ph.D. program, and a total of 10 years, a decade, in higher education! Throughout my Ph.D., there have been many ups and downs, a lot of tears, late nights in the office, but also many happy moments, successes, and achievements. I am very happy and proud to be where I am today and I could not have achieved this without the help and support of so many people.

I would like to start by thanking my advisor **Amy Ogan** for being a huge supporter and for her guiance, not only in my Ph.D. and research, but also in my passion for teaching more in general. Thank you Amy for allowing me to become part of this awesome project where I had the opportunity to support teaching and education yet in another way. Furthermore, I would like to sincerely thank my wonderful committee members: John Zimmerman, Geoff Kaufman, and Marsha Lovett for your thoughtful questions, insightful and detailed feedback, and for your time and patience with my research, as I learned to navigate this process.

I have had the privilege to work in several project teams and collaborate with amazing researchers and mentors. In particular, I would like to thank my collaborators from the CTAT and DataShop teams: Vincent Aleven, Bruce McLaren, Ken Holstein, Jonathan Sewall, Octav Popescu, Cindy Tipper, Joe Bodnar, Ken Koedinger, Gail Kusbit as well as collaborators from the EduSense and ClassInSight team: Chris Harrison, Yuvraj Agarwal, Diana Rototndo, Dohyun Kim, Rofin Andonissamy, Anne Xie, Mudar Memari and many more. Thank you also to the wonderful PIER community, Sharon Carver, David Klahr, Audrey Russo, Brian Junker, Howard Seltman and all PIER colleagues for your continous support throughout my Ph.D.

A huge thank you goes to all my wonderful undergraduate and master students, who I have had the pleasure of mentoring and collaborating with during my Ph.D. and who have contributed to the work presented in this dissertation. These include Jae-Won Kim, Sophia Wilhelmi, Peter Schaldenbrand, Jasper Tom, Nupur Chatterji, Miranda Luong, Na-Young Lee, Yilun Chen, Katie Johnstone, Jamie Dorst, Thomas Serban Von Davier, Erik Ulberg, Josh Kery, Amy Luo, Seoyoung Lee, Katrina Hu, Emma Jiang, Nikhil Behari, Neil Thawani, Bhumika Kapur among many others. I also would like to thank all the K12 teachers and university faculty, and all students who have participated in the various studies throughout the years. My work would not have been possible without you.

A special thanks goes to the awesomest Queenie Kravitz who has been an incredible source of support, positivity and encouragement throughout the years. I can truly say that without you Queenie, I would not have been able to be where I am today. I also want to thank my office mates Fannie Liu, Mary Beth Kery and Kristin Williams and my friends in the HCII Siyan Zhao, Ken Holstein, Felicia Ng, Judith Uchidiuno, Michael Madaio, Xu Wang, Steven Dang, Toby Li, Julian Ramos, Michael Rivera, Jenny Olsen, Kelly Rivers, Erik Harpstead, David Gerritsen, Nikola Banovic, Iris Howley, Nesra Yannier, Yanjin Long, among many others. Finally, I want to thank some of my collaborators at the SCS level including Carol Frieze and Women in SCS and The Teaching and CS Community at CMU for your continous support outside of my Ph.D.

An enormous thank you goes to my family. To my mum Gjenovefa and to my dad Feti, I would not be here today without your many sacrifices and your constant support. Thank you for what you taught me, for believing in me and for making me who I am today. I dedicate this Ph.D. to you, in particular to you mum, this should have been your path. *Prindy mamina dhe babino,* *ju falenderoj nga zemra; do t'ju jem gjithë jetën mirënjohese që më dhatë jetë. J'ua dedikoj juve këtë doktoraturë.* To Enia, my awesome little sister, thank you for always being a rock of support in my Ph.D. and in my life and for always teaching me about astrophysics. And thank you to our new and cutest family member KitKat. To my partner Kyle Xiong thank you for your continuous love and support through the many challenges Ph.D. and life has thrown at us, for always believing in me and for helping me persevere, and for being there for me in the good and in the bad.

Last but not least, I could and would not have been where I am today without the generous support of Mr. Oechsle and Mrs. Oechsle. I am forever indebted to you for my life here in the U.S. and I can never thank you enough for all you have done for me. I wish you were here to celebrate with me, and I hope you are proud of what I have accomplished.

Finally, thank you to everyone not explicitly listed here, for your support during, before, and (hopefully) after my Ph.D.

Contents

List of Figures

Chapter 1

Introduction

> Learning results from what the student does and thinks and only from what the student does and thinks. The teacher can advance learning only by influencing what the student does to learn. *Herbert A. Simon*

Teachers play a crucial role in supporting their students' learning and education in everyday activities in the classroom and outside of it. It is crucial therefore to also support teachers in their day-to-day practices as well as help them work and improve on their teaching, short term and long term. Traditionally, professional development has been used to provide training and feedback to teachers, as a way to support and help them improve on their practices. Such PD has been shown to help improve practices, change behaviors resulting in improved student learning and achievement in class. While very common and highly effective (i.e., [30, 60, 84, 94, 147, 178, 216, 229, 240], etc.), especially at the K12 level, PD tends to be repetitive and not personalized (i.e., seminars or workshops) or not scalable and infrequent (i.e., expert classroom observations) [120, 129]. In addition, at the university level there exists a lack of training and practice opportunities, altogether leading to instructors learning how to teach on their own and feeling isolated [68, 112, 113]. There is a gap, a practical need, and an opportunity to make PD and feedback to instructors more personalized, less repetitive, with opportunities to support reflection and feedback [30, 118, 194]. In particular, prior work emphasizes that in order to be able to produce changes in practice and behavior, PD and training must include opportunities for reflection as well as feedback to instructors [30, 118, 194].

As classrooms become increasingly instrumented with various educational technologies (i.e., [26, 235, 255]) and sensors (i.e., [11, 186]), new opportunities emerge to provide teachers with personalized, scalable and frequent support and feedback. Such technologies could collect and generate data from the classroom, both on teachers and students. This data can then be shared to instructors as feedback on their performance as well as their students' performance and progress in class. Ultimately, this data feedback has the potential to support teacher reflection-for-action outside of class (reflection and goal-setting or planning) [106, 140, 194]. Reflection more in general, and reflection-for-action in particular, are considered an important aspect of learning and personal growth in the workplace and a first step towards improving practices and changing long-term behaviors.

Most of the prior work in this domain has mainly focused on technologies that support teachers' reflection and action in real-time, in the classroom, as they are conducting a class session (i.e., [20, 21, 123]). Also called teaching augmentation tools or orchestration tools, such technologies aims to extend and complement teachers' practices during ongoing class activities through data and feedback. For example, a tool that shared with teachers student learning data helped teachers better and more proportionally split their time and attention among their students, resulting in higher student learning gains [21, 122, 123]. While extremely helpful to instructors to manage their limited time and attention during class time, these real-time tools lead to temporary, short-term behavior changes. A deeper reflection with a more focused goal setting, that can lead to improved practices and long term behavior change, needs more time, head space, bandwidth and less cognitive load on the teachers' side. Prior literature in professional development suggests that behavior changes result from continued efforts over time and are part of a long lasting change in the classroom, which requires small incremental changes over time (i.e., [55, 195, 211]).

A small but growing body of work has started to look at sharing with teachers data and feedback outside of the classroom to promote reflection. This practice would allow for more time and head space for teachers to engage in a deeper reflection, focused goal-setting and planning, with the ultimate goal of improving practices and long term behavior change (i.e., [55]). For example, work from Prieto et al. (i.e., [195]) focuses on designing a technology to support data gathering from the classroom with the aim to support teacher reflection based on everyday evidence. This work explores what aspects of data from existing classroom technologies would be helpful to instructors and how to best gather such data and evidence from the classroom while being unobtrusive and not disruptive to the class session. Similarly, more recent work from Martinez-Maldonado et al. (i.e., [164]) focuses on collecting data from the classroom and understanding how this data can be presented in a meaningful form that would be helpful or make sense to instructors. The work focuses exclusively on collaborative learning environments with the aim to design interfaces that are most helpful to instructors to support their reflection and to help them gain insights into their classrooms. Overall, even though this prior work focuses on designing for supporting teacher reflection, it investigates in a limited context whether teachers even want or need this data and what data they need. For example, this work tends to focus on a small number of instructors, often in an artifical or laboratory like setting (i.e., not in the wild). Further, the work focuses only on student data or only on teacher data. Moreover, even though this work focuses on supporting reflection, there is a gap on supporting and designing for other aspects of reflection-for-action outside of class such as how data and technology can affect goal setting and planning, interest and intentionality in behavior change and further, actual behavior change in the classroom. This would be the first step to support long term behavior change in teacher practices. Work from Gerritsen et al. [98, 99] gets closer to this goal by building a system that provides instructors feedback on measures such as student and instructor talking times. However, this work focuses exclusively on TAs (Teaching assistants) a population very different from teachers, with low to no prior experience in teaching or pedagogical training. TAs potentially are teaching for the first time in their lives and generally have less responsibilities in a course than an actual instructor. Gerritsen frames TAs as learners and focuses on training them in teaching through technology that shares with them data and feedback. Even though this work shows that data affects TAs' awareness and planning, it does not focus on actual behavior change or on investigating ways to affect and better support teacher motivation for reflection-for-action and behavior change, as I do in this dissertation. This work also creates another gap and an opportunity to investigate instructors, a very different population than TAs in terms of their experience, motivations and interest in behavior change, for who teaching is part of their profession and day-to-day activities.

Ultimately, this prior work creates a gap and an opportunity for research to better understand and design for teachers' data needs and to better support and influence teachers' reflection-for-action (reflection and goal-setting) and behavior change outside of class, as a first step towards practice improvement and long term behavior change. My work in this thesis builds and extends on this growing body of work and aims to fill this gap in the literature. **My goal is to investigate how to support teachers in their reflection-for-action outside of class, with data from classroom technologies, and help them improve their everyday teaching practices, as a first step towards long term behavior change.** I approach this work from various perspectives. I initially focus on exploring and understanding teachers' data needs in relation to their students' data, their own data, and a combination of teacher and student data. I then design dashboard prototypes that meet each of these teachers' needs. Finally, I investigate how these data dashboards support and affect teachers' teaching practices in the classroom (reflection and awareness, goal-setting and planning, and behavior change and actions they decide to take in the classroom) and how to best support-reflection for action through such technologies. I work with a variety of data including student learning and teacher and student nonverbal immediacy data. Such data is collected and generated by educational technologies such as Intelligent Tutoring Systems and Instrumented Classrooms. I also focus the data and dashboard designs on supporting constructs, and investigating which constructs, that impact teacher motivation for goal-setting and behavior change in the classroom.

This thesis is organized in the following three parts. Below, I present my aims and contributions for each part of this thesis.

Part 1: Designing a teacher dashboard with student data and exploring how it affects teaching practices

For this part of the thesis, I had three aims. First, I aimed to explore and better understand teacher data needs in relation to their student data in the classroom. Second, I aimed to design a dashboard that meets those needs and shares with teachers their students' data. Lastly, my goal was to evaluate this dashboard in a real classroom environment, to investigate how teachers would use it in their teaching as well as whether and how it would support and affect their teaching practice. To accomplish those goals I conducted the following three studies.

- **Study 1:** I followed a user-centered design process (through Contextual Inquiry and Affinity Diagramming) to investigate what student data is most helpful to teachers and how teachers use data to adjust and individualize instruction. Findings showed that teachers generated data, on their own or with the help of a technology, on students' concept mastery, as well as their misconceptions and errors. Teachers used this data to drive instruction and remediate issues on an individual and class level. The study uncovered how data can support teachers in helping students learn and provides a solid foundation and recommendations for designing a teacher's dashboard.

- **Study 2:** Based on the findings from Study 1, I followed a user-centered design process (through methods such as speed-dating, story boarding and prototyping) to validate and test ideas and designs to address teachers' data needs and support their teaching in the classroom. The final contribution resulted in a high-fidelity dashboard prototype that shares with teachers data about their students' performance and progress in an Intelligent Tutoring System (ITS). The main goal of this dashboard is to support teacher decision-making and reflection as the teacher prepares for the next lecture, outside of class.

- **Study 3:** Lastly, I conducted a classroom study with 5 middle school teachers and 17 classes to investigate how the dashboard affected teachers and students in the classroom. **Findings** show that even though teachers generally know their classes well, a dashboard with analytics can still enhance their knowledge about their students and support their teaching practices. In addition, results showed that the dashboard influenced what teachers knew about their students' learning in the ITS and that the teachers' updated knowledge affected the lesson plan they prepared, which in turn guided what they covered in the classroom. To the best of my knowledge, this was the first study that demonstrated that a dashboard can affect teacher knowledge, decision making, and actions in the classroom, namely, teacher behavior change in the classroom.

Part2: Designing a teacher dashboard with teacher's own data and exploring how to support reflection-for-action

Motivated from the findings and what I learned from Part 1, in this part I aimed to explore and design for teacher data needs in relation to their own data. Much prior work in the literature focuses on student data. However, to help improve teacher practice it is crucial to support teachers through their own data as well. In terms of teachers own data, I focused on nonverbal behavior data collected by an instrumented classroom to support teachers' immediacy. In addition, I wanted to investigate and better understand how to support teachers' reflection-for-action outside of class, as a first step towards behavior change. To accomplish these goals, I conducted the following two studies.

- **Study 1:** I ran an exploratory and design study with 9 instructors. The study aims to understand teachers' values, efficacy, motivations, and interest around teacher immediacy and nonverbal behavior data. In addition, the study explores how these constructs change after the teachers see their own nonverbal data and what goals, if any, they set to change their behaviors in the classroom. Findings show that teachers score quite high but with room for improvement in relation to various measures of value, efficacy, and motivation. Teachers showed interest in location and eye contact data about themselves and their students. They set goals for behaviors they wanted to change and mentioned challenges they face in using such behaviors in the classroom. The study uncovers how immediacy and nonverbal data can help teachers in their practices and provides solid recommendations for designing technologies that support such practices

- **Study 2:** Based on the findings from Study 1, I created ClassInSight, a high fidelity professional development training and dashboard prototype that shares with teachers their own data. I ran a study with 16 instructors aimed at investigating how sharing with teachers their data affects their reflection-for-action and behavior change intentionality. Further, I investigated how motivational feedback aimed at increasing self-efficacy affects teachers' values, efficacies, motivations, goal-setting and their intentionality for behavior change. Lastly, I aimed to test for consistency, generalizability, and statistical significance of the findings, compared to Study 1. Findings showed that ClassInSight affected teachers'goal-setting and intentionality for behavior change. Further, teachers who received motivational feedback through social comparison score higher in proxies for behavior change compared to teachers who receive such feedback through verbal persuasion. Finally, results in this study were consistent with Study 1, and created the opportunity for generalizability and testing for statistical significance. I discuss the implications of these findings for designing technologies that best support and motivate teachers' goal setting and behavior change.

Part3: Towards a teacher dashboard with teacher and student data to support

teachers' refection-for-action and behavior change

The findings from the work in Part 1 and Part 2 opened up multiple interesting paths for investigation in Part 3 of my dissertation work. I decided to focus on the most interesting directions that also seemed to be the most important to investigate first, based on the knew knowledge I gained from Part 1 and Part 2. More specifically, in Part 3, I aimed to explore patterns of behaviors and relationships in teacher and student data as well as investigate how to integrate teacher and student data while supporting reflection for action. To accomplish these goals, I conducted the following investigations.

- **Investigation 1**: I explored and analyzed data collected from 45 courses with an instrumented classroom, and generated through human coding or machine learning models. The aim of this work is to explore patterns of behaviors, in particular with potential for improvement and relationships among teacher and student data. Findings showed very interesting patterns in teacher behaviors such as teachers being immobile and spending the majority of class time in one location, or on average, looking at their students less than half of class time. Further, I found weak to moderate correlations among teacher and student behaviors, which hint towards the value and importance of nonverbal immediacy in the classroom. I discuss the contribution of this work and provide design guidelines for technologies that share with teachers data from the classroom

- **Study 1**: Findings from Part 1 and in particular from Part 2 showed that instructors were interested in both teacher and student data. Based on these findings, I designed for and investigated multiple dimensions on how to integrate teacher and student data and how to support teachers' reflection-for-action. I then conducted co-design studies with 22 instructors which showed that they value relationships between teacher and student data, in particular causal relationships. Further, they want to see these data integrated in a spatial and temporal form, and are interested in activity information, in particular combined with student engagement. In relation to reflection-for-action, support for self-efficacy such as mastery experience and social comparison, together with support for value helped instructors assess performance, set concrete goals and provide actionable suggestions on what behaviors to change in the classroom. These findings provide a solid foundation and recommendations for researchers and designers who create technologies for teachers.

Contributions

This thesis **contributes** to research at the intersection of the Learning Sciences and Technologies and Human-Computer Interaction. I create a better understanding of teachers' data needs, both in relation to their students' data, their own data, and further in relation to combined teacher and student data. I also create a deeper understanding of teachers' and their students' patterns of behavior in the classroom and of how to support and influence their reflection-for-action. Based on this knowledge and teachers' needs, I design and create dashboard prototypes that share with teachers student data, teacher data or both types of data combined. I evaluate these dashboards and provide evidence on how data affects teachers' reflection, planning, goal setting and behavior change in the classroom. I also provide a theoretical framework and design guidelines for designers of technologies that share data with teachers to support reflection-for-action and long term behavior change. Finally, I present a concrete example, instructors in the classroom, of how data can support professional training, learning and practice improvement and behavior change in their workplace.

1.1 Structure of the document

This thesis is organized in three parts, Part 1, Part 2 and Part 3. In Part 1, Chapters 3, 4 and 5 describe the three studies that I ran to accomplish the three aims discussed above. In Part 2, Chapter 6 represents the motivation for conducting the work in Part 2. In addition, Chapters 7 and 8 represent the two studies that I conducted to accomplish the aims for Part 2, as discussed above. In Part 3, Chapter 9 discusses the motivation for conducting the work in Part 3. Chapters 10 and 11 represent the two studies aimed at accomplishing the goals for Part 3. Further, In Chapter 2 I share the related work and literature review and at the end of the document I have included Appendices with materials from the various studies. Finally, Chapter 12 provides a summary of the conclusions and contributions of this work, together with a discussion of future avenues for research and design.

Chapter 2

Background

2.1 Professional Development for Improving Practice and for Behavior Change

2.1.1 Professional Development in General

In 2019, 83 billion U.S. dollars were spent on professional development (PD) and workplace training in the United States [166]. K-12 teacher professional development alone is reported to account for 18 billion U.S. dollars annually [202]. Professional Development (PD) involves ongoing training of a worker in order to improve skills, knowledge, expertise, and competences [58, 72, 104, 109, 175, 188]. PD may involve courses, programs, or activities that occur in professional education or in the workplace [72]. PD is required by many professions such as law enforcement [14], health care [52], pharmacology [205], physiotherapy [188], and coaching [71]. Other fields might not use the term PD while still having a rich literature on their own best practices (e.g. software engineering).

2.1.2 Professional Development for Teaching

Glatthorn (1995) defines teacher professional development as "the professional growth a teacher achieves as a result of gaining increased experience and examining his or her teaching systematically" ([101], p.41). Professional development is considered a way for teachers to learn and transform their knowledge into practice, with the ultimate goal of supporting and helping their students' growth and learning in the classroom [30]. Teacher professional development can include a range of experiences, mainly and primarily formal experiences such as attending professional meetings, workshops, seminars, mentoring, expert and peer classroom observations, teaching consultations by a trained learning professional, microteaching opportunities, etc., as well as informal experiences such as reading educational and professional resources or publications, watching documentaries, etc. [16, 47, 51, 61, 97, 223, 240].

Research on teacher professional development has shown that those activities are important to help improve teacher cognition, knowledge, beliefs as well as teaching practices and behaviors (i.e., [30, 60, 84, 94, 147, 178, 216, 229, 240], etc.) In addition, teacher professional development is considered as one of the main and most important activities for improving student learning and achievement in the classroom (i.e., [91, 156, 194, 239, 240, 241], etc.) Despite this, prior work emphasizes that in order to be able to produce changes in practice and behavior, PD and training must include opportunities for reflection as well as feedback to instructors [30, 118, 194].

There exist major differences in opportunities and requirements for PD in the United States, between the K12 and the university level. To begin with, K12 instructors are required to complete training for teaching before joining the profession. In addition, it is required of them to continue learning in the workplace by continuously taking part in training and professional development. Every teacher in K12 participates in some form of training and learning every year [120]. Many instructors however see this training and PD as repetitive, reinforcing practices and knowledge they already use or know. Often they report these PD experiences do not have a major or any effect at all on their instruction [120, 129]. As a result, there is an opportunity and need in this space, to make PD and training better and more helpful to instructors, by personalizing and adapting them to teachers' needs.

On the other hand, the state of PD at the university level is entirely different. Before becoming a faculty, instructors get little to no training or practice on teaching, with the exception of any teaching or TAing (teaching assistant) they do as graduate students. Even then, they are expected to learn about teaching and how to teach on their own [112, 113], often mirroring models they have seen practiced by their prior instructors [53]. Faculty report they feel isolated in this environment [68]. They also think that there is more need for training, and more frequent training, and that they want to work on and improve their teaching [242]. Similar to the K12 level, there is a need and opportunity to provide more and frequent PD to university instructors.

Lastly, world-class universities, that work hard and put emphasis to teaching quality generally rely on centers within the university to deliver professional development programs and training to support teaching [132]. An example of such a center is the Eberly Center for Teaching Excellence and Educational Innovation at CMU [57]. The mission of the Eberly Center is to distill and translate research on education, teaching and learning into practice and practical help to support and help improve instructors' teaching and students' learning. Such centers are invaluable to helping and supporting teachers and their practices. However, with an increase in demand for teaching help, they might be hard to scale to a larger number of instructors or across multiple universities [132].

To summarize, professional development is an important part of learning in the workplace, and it has been traditionally and largely used by many professions. In particular, for teachers, PD has been shown to help improve practices and change behaviors as well as improve students' learning and achievement in class. Despite that, literature suggests that there is an opportunity to improve PD and make it more personalized, less repetitive, and in particular with a stronger focus on reflection and feedback.

2.2 Reflection for Improving Practices and for Behavior Change

Reflection is a practice that helps turn experience into learning [189] and involves analyzing actions one takes, together with decisions that they make and the consecutive results [140]. In relation to the teaching practice, when reflecting, the teacher would take a step back, ponder and think about the effects of their teaching and the implications of their practices in the classroom. In many professions, reflection is considered an important source of personal growth and improvement of future performance, as well as a critical aspect of the success of the professional at work [59, 181, 189]. In teaching, reflection is considered an integral element of improving educational practice [194] as well as an essential component of a teacher's classroom success [230, 260]. Research has shown that when teachers engage in reflection, their teaching improves [85, 105, 209, 230, 243, 260]. Other work has shown the benefits of reflection on teaching, including improved understanding and practice of pedagogy [105] and increase of performance [76, 209].

In his book, "How We think", Dewey (1933) says that "*Active, persistent, and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it, and the further conclusions to which it tends*, constitutes reflective thought" [76]. Developing on this idea, Schön (1983), in his book "The reflective practitioner", introduces two types of reflection; reflection-in-action and reflection-on-action [210]. Reflection-in-action is defined as the reflection that takes place during an action, namely reflecting and thinking in the midst of action [210]. An example of this would be, as the teacher is conducting a discussion session, they stop for a moment and ask themselves if they have been actively engaging all students in class. Reflection-on-action on the other hand, is defined as reflection on practice that happens after an action has occurred or an event is completed [210]. This type of reflection is more retrospective, and provides the teacher more bandwidth and head space to more deeply reflect on their behaviors. An example of reflection-on-action, would be when preparing for the next lecture, the teacher reflects on how they have been spending their time or attention in class overall. For both those types of reflection, the focus is reflection and sense making on its own, without a focus or emphasis on behavior or practice change. The main difference between those two types of reflections is whether the reflection is happening during class time or afterwards.

To address this lack of focus on changing behaviors and working on improving practices, a new concept, reflection-for-action was introduced in the literature, which was based and developed on Schön's work [106, 140, 194]. Reflection-for-action is a type of reflection that is focused not only on evaluating, making sense, and becoming aware of what happened, but also on thinking and planning about actions to take in the future, on how to guide future behaviors, with the ultimate goal of changing and improving practice (reflection for change [185]). Other literature discussses the same concept of reflection-for-action, namely reevaluating and exploring experiences, with the goal of changing understanding and guiding behaviors in the future, without specifically using the term reflection-for-action [48, 49, 74, 197]. Reflection-for-action can overlap with either reflection-in-action or reflection-on-action depending on whether the reflection-for-action is happening as the action is taking place (i.e., as the teacher is teaching in class) or if it is happening after the event or actions are complete. An example of the latter would be when, as the teacher is preparing for the next class, they reflect on what happened in the previous class and plan what to do during the next lesson [86].

To summarize, reflection is considered as an important aspect of learning and personal growth in the workplace. In particular, reflection-for-action focuses specifically on supporting behavior change and improving practices, both for teachers and for professionals more in general. For teachers specifically, there is an opportunity to employ reflection-for-action outside of class, as the teacher is preparing for the new lecture, as a way to promote a deeper reflection and focused goal-setting, with the ultimate goal of improving practices and changing behaviors in the long term.

2.3 Feedback for Behavior Change

2.3.1 Importance of Feedback

Feedback is considered essential to learning and to behavior change in various contexts and professions (for example, in the medical professions [65, 93, 133]. Feedback influences behaviors, and is critical for learning and motivation [130].

In the domain of learning and education, there are hundreds of research studies and metareviews on the topic of feedback and learning, in particular on feedback for students. Feedback is considered crucial to improving knowledge, skill acquisition, learning, and performance (some of the many examples of this literature include [19, 31, 41, 42, 43, 66, 83, 87, 130, 141, 142, 145, 179, 193], etc.). Feedback is also considered as a significant factor in helping and supporting motivation for learning (i.e., [146, 182], etc.). Moreover, literature suggests that there are many elements that need to be considered when creating feedback, in order to assure that this feedback is good and will help improve learning and behavior change. This includes the timing and frequency of the feedback, the source or agent giving feedback, the content of the feedback (i.e., where the learner is currently and what they need to do to improve) and the clarity and specificity of feedback [19, 103, 218].

Similar to other professions and contexts, for instructors, feedback is considered essential to changing their knowledge and attitudes and to monitoring and improving their performance and practice in the classroom [67, 90, 103, 115]. Literature shows that when teachers are provided with feedback, they change their behaviors and make significant changes in their teaching practices [118, 171, 224]. In particular, faculty at the university level report they need more meaningful instructional feedback [103, 207]. Currently, most of the feedback instructors get comes either from data of student evaluations [103, 137, 153], or from occasional expert or peer teaching observations [103, 215]. Both those methods for providing feedback have limitations, including lack of clarity and specific ways to improve (for student evaluations) or infrequency and challenges with scalability (classroom observations).

To summarize, literature strongly supports feedback as a way to help improve practice and change behaviors, for various professions and domains, including teaching and instructors. However, there seems to be a gap in the type and frequency of feedback instructors currently get. This creates an opportunity to provide instructors with more meaningful, personalized, and more frequent feedback, in particular through data collected in the classroom.

2.3.2 Data as Feedback: Personal Informatics for Lifestyle Behavior Change

Data has been used to support behavior change in various aspects of lifestyle. Specifically, the field of PI (Personal Informatics) investigates and advances sociotechnical systems that help people build an awareness of their own invisible behaviors in support of lifestyle and behavior change [148]. Research on PI has investigated a number of lifestyle behaviors including health and wellness [149], sustainability [96], spending and finances [82], and productivity [62]. Researchers generated a five-stage model to explain how PI works [148]: Preparation, Collection, Integration, Reflection, and Action. Research shows that showing people visualizations of their own actions is not enough to produce behavior change. For PI to work, users must engage in all stages including the last two: reflecting on the pattern of behaviors they want to impact and then taking action to effectively change those behaviors.

This prior work emphasizes both the importance of data as feedback for behavior change as well as the importance of reflection, goal-setting and action taking as a first step towards changing behaviors.

2.3.3 Data as Feedback: Professional Informatics for Workplace Behavior Change

Building on the PI research and work, there is an opportunity for data to be used as feedback for professionals, with the purpose to support and improve their practices, and ultimately lead to behavior change. Some recent work shows one-off examples of this idea of PI for professionals. Researchers noted that therapists rarely receive detailed feedback once they leave school, and neither the therapist nor the patient can tell what's working. They developed a system that monitors and classifies therapists' behaviors and provides them feedback on their actions [121]. Similarly, medical students do not receive enough training on clinical communication skills, which impacts the health outcomes of their patients. Researchers developed a system that allows medical students to practice communicating with patients. It then provides them with feedback to improve their communication skills [150]. Specifically to the teaching domain, other work investigated how PI in combination with an instrumented classroom and a training system on discursive teaching techniques can help teaching assistants (TAs) at universities [99]. The system provides feedback on student and TA talking times and it provides measures showing if student talk and participation increase.

The work on PI discussed above, as well as this recent literature on PI for professionals opens up a new space and creates an opportunity for data to be used as feedback, or as part of feedback, to improve practices and help behavior change.

2.3.4 Data as Feedback for Instructors

Real-time Feedback During Class

A large body of work has focused on providing teachers data and feedback in real-time, during ongoing classroom activities, as the teacher is teaching a class session (i.e., [20, 21, 73, 123, 139, 177]). Often those tools that provide data and feedback to teachers are also called real-time teacher awareness tools or classroom orchestration tools (i.e., [12, 18, 77, 78, 122, 159, 165, 225, 234, 237]). The main focus of such tools has been to support teachers' reflection-in-action by augmenting teachers' awareness and reflection during class or supporting their monitoring of various classroom activities, by presenting them data and analytics on their students' knowledge and performance during class (i.e., [135, 203, 203, 225]). Some work has focused on supporting teachers' reflection-for-action during class, including planning and decision-making to better help them allocate time and attention across students, in the face of limited time and resources (i.e., [18, 21, 73, 78, 124, 159, 183, 187, 225, 237, 245]). Lastly, real-time tools have also been designed to support teachers in their PD and real-time coaching [127, 208, 232].

Prior work has shown that using real-time awareness tools can affect teacher practices as they are conducting a class session or learning activity. For example, a tool that shows teachers data about student learning helped teachers to better and more proportionally split their time and attention among their students, resulting in higher student learning gains [21, 122, 123]. Similarly, other work has shown to enhance teachers' reflection-in-action, by planning whom to help next during class or how much time to spend with each student [20]. While extremely useful to instructors to manage their cognitive load and limited resources during class time, these real-time tools lead to temporary, short-term behavior changes. A deeper reflection, that can lead to improved practices and long term behavior change, needs more time, head space and bandwidth on the teachers' side.

Outside of Class Feedback

A small but growing body of work has started to look at sharing with teachers data and feedback outside of the classroom to promote reflection. This practice would allow for more time and head space for teachers to engage in a deeper reflection, focused goal-setting and planning, with the ultimate goal of improving practices and long term behavior change (i.e., [55]). Prieto et al. (i.e., [195]) focuses on designing a technology to support data gathering from the classroom with the aim to support teacher reflection based on everyday evidence. This work explores what aspects of data from existing classroom technologies would be helpful to instructors and how to best gather such data and evidence from the classroom while being unobtrusive and not disruptive to the class session. Similarly, more recent work from Martinez-Maldonado et al. (i.e., [162, 164]) focuses on collecting data from the classroom and understanding how this data can be presented in a meaningful form that would be helpful or make sense to instructors. The work focuses exclusively on collaborative learning environments with the aim to design interfaces that are most helpful to instructors to support their reflection and to help them gain insights into their classrooms. Finally, work from Gerritsen et al. [98, 99] builds a system that provides instructors feedback on measures such as student and instructor talking times. This work focuses exclusively on TAs (Teaching assistants) a population very different from teachers, with low to no prior experience in teaching or pedagogical training. TAs potentially are teaching for the first time in their lives and generally have less responsibilities in a course than an actual instructors. Gerritsen frames TAs as learners and focuses on training them in teaching through technology that shares with them data and feedback.

While this prior work takes a step forward designing for and supporting teacher reflection with data outside of class, the limitations in the dimensions and context of their exploration (i.e., not considering all the potential dimensions of design, only focusing on a handful of instructors, studying classrooms in specific contexts, not in the wild, focusing only on TAs, a very different population than instructors in terms of experience, motivations and interest in improving practice, etc.) A better and deeper understanding of teachers' data wants and needs is necessary, outside of the restricted context of what data technology can currently provide. Further, with the exception of the work from Gerritsen et al., none of this prior work studies goal-setting. Finally, more research is needed to better investigate how data supports interest in behavior change or actual behavior change in the classroom as well as how to affect or influence teachers' motivation for reflection-for-action and behavior change, as I do in this dissertation.

2.4 Technology in the classroom

2.4.1 Intelligent Tutoring Systems

ITSs are an advanced learning technology that provides detailed, step-by-step guidance to students during complex problem-solving practice, while being adaptive to student differences [26, 235, 255]. A number of meta-reviews show that ITS can enhance student learning in actual classrooms, compared to other forms of learning technologies or classroom instruction [144, 157, 220, 221, 236].

ITSs typically generate and collect a wealth of data about student learning, such as the skills a student has mastered and not mastered, any misconceptions and common errors they have, the time it took the student to complete certain activities, the progress through the activities and curriculum, etc. In addition, ITSs typically generate and maintain a student model [46].

However, relatively little effort has been expended to investigate how this data can best be leveraged to help and support teachers in the classroom [256, 257, 258]. In particular, ITSs are rarely designed to support teachers, who might greatly influence student learning with an ITS. For instance, when many students in a class are learning a particular skill as they are working with the ITS, a dashboard could let the teacher know about this situation, and the teacher could include in their lesson plan and actual lesson, specific steps to address the challenge. More generally, by showing teachers data on their students' progress and performance, it could help make "the invisible visible" for teachers by displaying aggregated, up-to-date information about their students. Based on this information, teachers could provide help to their students beyond what the ITS can provide.

2.4.2 Classroom Sensing Systems

Instrumented or smart classrooms are classrooms that have been enhanced with various sensors (i.e., [11, 186, 195, 217, 226]. These sensors may be embedded in the physical classroom and the furniture in class, allowing for collection and generation of data both from teachers and students. Examples of such sensors include adding buttons or touchscreens to student desks or using systems like "clickers" [10, 80, 89], equipping chairs with pressure sensors to detect various levels of student engagement in class [27, 180] as well as introducing technologies such as QR Codes [70] or ARTags [174] to allow for audience polling. Other work has focused on instrumenting the teachers and students themselves with various wearable technologies and devices. Examples include eye trackers [195], wrist-based sensors [192], electroencephalography headsets [114], microphones [79], accelerometers [195], etc.

A more recent and cutting edge, unobtrusive and non-invasive technology involves instrumenting the classroom with sensors such as microphones and cameras that are remotely controlled. This allows for the collection of audio and video data from class, which then get processed using Machine Learning and various algorithms to detect speech patterns and various behaviors and movements, both on students and teachers, during class [11]. This kind of instrumented classroom allows for automated collection and more frequent generation of various data and analytics, that can then easily be presented back to the teachers.

To summarize, these ongoing advances in instrumented classrooms imply that in the near future, many classrooms might be instrumented allowing for effective and automated data collection.

Part 1: Designing a teacher dashboard with student data and exploring how it affects teaching practices

Chapter 3

How teachers use data to help students learn

This chapter is based in part on the following publications:

- [256] Xhakaj, F., Aleven, V., McLaren, B.M. (2016). How teachers use data to help students learn: Contextual Inquiry for the design of a dashboard. In K. Verbert, M. Sharples, T. Klobučar (Eds.), Proceedings of the 11th European Conference on Technology Enhanced Learning, EC-TEL 2016, (pp. 340-354). Springer International Publishing Switzerland.

Abstract: Little research has investigated what role teachers can play in their students' learning, if empowered with data and how this data can support teachers' teaching and help improve their teaching practices. Many educational technologies, such as ITSs, provide such data to teachers in the form of student performance reports. However, these reports may not be designed to serve teachers' needs well. In this study, I investigated what student data is most helpful to teachers and how teachers use data to adjust and individualize instruction. Specifically, I follow a user-centered design practice; I conducted Contextual Inquiry interviews with teachers and used Interpretation Sessions and Affinity Diagramming to analyze the interviews. I found that, when technology is not there, teachers generate data on students' concept mastery, misconceptions and errors. When educational technologies or other software is available, teachers make use of the data and reports provided by such technologies. In either case, teachers use data to drive instruction and remediate issues on an individual and class level. In this chapter I investigate how data can support teachers in helping students learn and in helping them improve their teaching practices. I provide a solid foundation and recommendations for designing a teacher's dashboard that provides teachers with data on their students' performance and learning.

3.1 Introduction

It is reasonable to assume that the large amount of student interaction data that is routinely collected by educational technologies in the classroom can be helpful to teachers, when presented in a concise and actionable format such as in a dashboard form. It might inform various teaching practices and key decisions that teachers make, such as deciding the focus of discussion for a class lecture or identifying students who need one-on-one attention, with potentially a positive effect on student learning. Dashboards that present student data have been designed for a large variety of educational technologies such as multi-tabletop learning [158], collaborative learning in digital learning environments [170, 233], web-based distance courses [167], online courses [155], Intelligent Tutoring Systems [117], etc. The use of student data for instructional decision-making is not restricted to educational technologies only. For example, mastery learning, a highly effective data-driven instructional method, can be implemented without technology [143]. In 2009, the Institute for Education Sciences (IES, part of the U.S. Department of Education) published a practice guide with recommendations for teachers on how to use data to inform instruction [111]. The IES Practice Guide points out, however, that there is limited scientific evidence that data-driven classroom practices actually improve educational outcomes, indicating a need for more research.

A very small number of studies suggest that a teacher dashboard that presents teachers with student data can lead to improvements in students' learning outcomes. In one such study, the data-driven redesign of a statistics course yielded improved student learning in half the time [155]. A dashboard was one novel component of the redesigned course, but there were other changes as well, so the improvement cannot be attributed solely to the dashboard. In another study, Kelly et al. (2013) found positive effects of teacher reports in a web-based tutoring system for middle school mathematics [138].

My aim in Part 1 of this thesis was to investigate teacher data needs and create tools that would share with teachers data on their students' performance and learning in class and study how data presented in such tools affects teaching practices. Specifically, I aimed to create a dashboard for middle and high school teachers. The dashboard would share with teachers data on their students' performance in an Intelligent Tutoring System (ITS). ITSs are an advanced learning technology that provides detailed guidance to students during complex problem-solving practice, while being adaptive to student differences [26, 235, 255]. A number of meta-reviews indicate that ITS can enhance student learning in actual classrooms, compared to other forms of instruction [144, 157, 220, 221, 236]. Although ITSs typically produce a wealth of data about student learning, relatively little effort has been expended to investigate how this data can best be leveraged to help teachers help their students. Much more research has focused on how this information can be presented to students (e.g., in the form of an open learner model [54]).

A central assumption in my work is that in order to design an effective dashboard, it helps to understand how teachers use data about students' performance and learning in their day-to-day practices and pedagogical decision-making. Therefore, I started off studying teachers' use of data using Contextual Inquiry (CI), a method often used in user-centered design [126]. CI is a technique that allows for data collection in the users' normal work environment to capture in-context detailed information about their practice. Compared to other methods such as participatory design, CI has the advantage that it allows for discovering tacit knowledge from users, which is knowledge that the users are not consciously aware of themselves but use in their day-to-day practice. Although the use of user-centered design methods for dashboard design is quite common, to the best of my knowledge, I am unaware of prior studies that investigate teacher data needs through Contextual Inquiry, as I do in the current work. Some prior studies involved teachers as part of a user-driven design process that included interviews, prototypes and empirical evaluations of dashboard designs [158], surveys conducted to determine the information instructors may need [167], questionnaires used to evaluate and iterate on the features of a learning analytics tool for a web-based learning environment [15], or semi-structured interviews as part of the developing process of a web-based learning analytics tool with a dashboard component [33]. Another study applied participatory design and other design methods to create a dashboard for an educational game app [9]. Other studies do not mention teachers as part of the dashboard design, do not report on the methods used to interpret and select the data, or use theoretical work and previous literature to determine the appropriate design [136, 231, 233].

In this chapter, I describe how I used Contextual Inquiry to better understand (1) what student data teachers need to be effective and (2) how teachers use data to inform and adjust their instruction. The findings and results of this study will inform the design of a teacher's dashboard in an ITS environment that will support and help improve teachers' teaching in the classroom.

3.2 Methodology

3.2.1 Contextual Inquiry on Teacher Practices

I conducted Contextual Inquiry interviews to study teacher practices in using student data to adjust or individualize instruction. Contextual Inquiry is a user-centered design process, part of the Contextual Design method [126]. Contextual Inquiry is widely used to gather field data from users with the aim of understanding who the users are and how they work in their day-to-day basis. During a Contextual Inquiry interview, the researcher meets one-on-one with the participant and observes the participant conduct one of their daily activities in the participant's workplace. In this process, the researcher is considered to take up the role of an "apprentice" and the participant takes on the role of the "master." The researcher does not actively interview the participant with a set of pre-determined questions; rather, she or he observes the participant conduct one of the daily activities or normal tasks. The researcher asks questions occasionally to clarify and understand what and why the participant is doing something. Contextual Inquiry allows gathering of detailed and highly reliable information. It can reveal knowledge and information about the user's work that they themselves are unaware of.

I recruited teachers from various schools that had previously participated in studies with Carnegie Mellon University. I also requested assistance from Carnegie Learning to recruit teachers who currently use the Carnegie Learning (CL) tutor [1], a mathematics Cognitive Tutor – Cognitive Tutors are a type of ITS grounded in cognitive theory [26] – for grades 6–12 (Figure 3-1). I ran Contextual Inquiry interviews with 6 teachers from 3 different schools in the area, namely, 4 middle-school teachers from a suburban, medium-achieving school (2 male and 2 female), 1 female high-school teacher from an urban, low-achieving school, and 1 female middle-school teacher from a suburban, medium-achieving school. Out of the teachers I interviewed, 2 teachers had used the CL tutor before in their classrooms and 1 teacher was using it currently. In addition, 2 other teachers had used in previous years other ITSs as part of various short-term studies from Carnegie Mellon University. Lastly, all teachers used digital grade books or other technology in their classrooms. Thus, the teachers who participated in the study exhibit substantial variability regarding important variables such as whether they work in high versus low-performing districts, whether they have experience with an ITS versus not, as well as the methods they devised themselves for using student data to guide their teaching, and their use of technology in their classrooms.

The focus of the Contextual Inquiry interviews was to observe the teacher in how and what

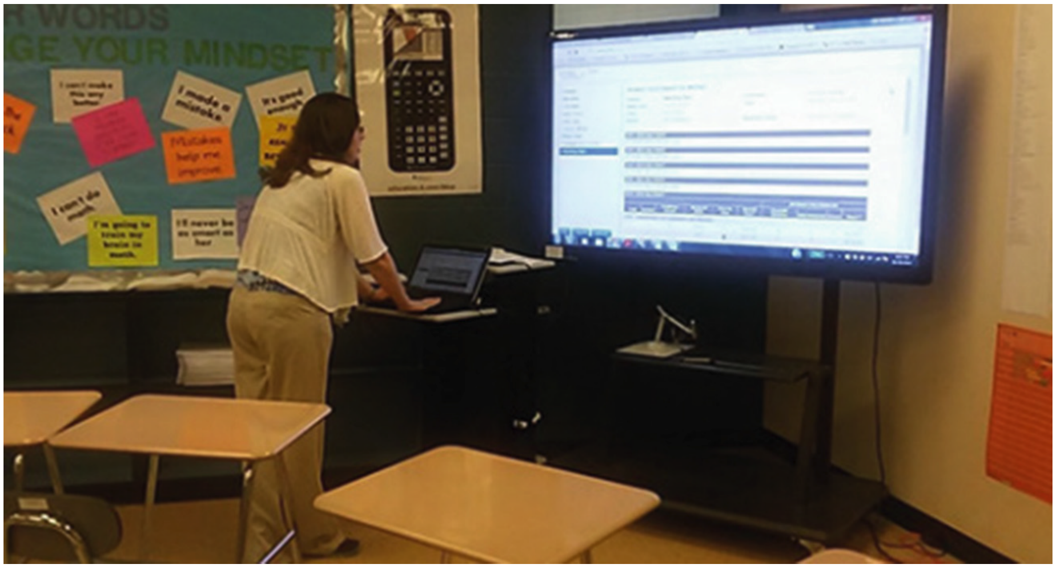


Figure 3-1: Teacher during a Contextual Inquiry interview working on her laptop and smart screen with an ITS report.

data they generated on their students' performance (from materials such as exams, quizzes, assignments, etc.), and how they used this data to drive instruction and prepare for a class. After the Contextual Inquiry interview, I observed the teacher conduct the class they prepared for. During this process I silently observed in the classroom and followed up with an interview with the teacher with questions regarding the classroom observation. Due to constraints in the teachers' schedules, with some of the teachers I conducted the Contextual Inquiry interviews after doing a classroom observation, and then followed with an interview with the teacher with follow-up questions. With two of the teachers who participated in this study, I conducted Contextual Inquiry interviews on one teacher's previous use and another's current use of the reports generated by the CL tutor. These teachers reported that they used the CL tutor 2 days during the week, while the other 3 days they would have lectures in the classroom, outside the tutor environment. Lastly, I observed teachers' use of reports and other technology or software in the classroom. The Contextual Inquiry interviews were video recorded and resulted in a total of approximately 11.5 h of recording.

3.2.2 Analysis with Interpretation Sessions and Affinity Diagramming

The video recordings of the Contextual Inquiry interviews were transcribed to text. I, together with a Master's student, worked through the transcriptions to analyze and synthesize the data from the transcribed interviews. Two standard techniques from Contextual Design were used: Interpretation Sessions and Affinity Diagramming. Interpretation Sessions are team-based tasks aimed to create a shared understanding of the collected data by recording on post-it notes, simple observations and key issues and insights from the interviews of each participant. Affinity Diagramming is a widely-used method that aims to discover patterns that define the whole population by grouping and organizing the post-it notes based on content similarity into a hierarchy that reveals common issues and themes [126].

From 11.5 h of transcribed video interviews, I conducted several Interpretation Sessions, during which I walked through the transcribed video interviews for each participant and created post-

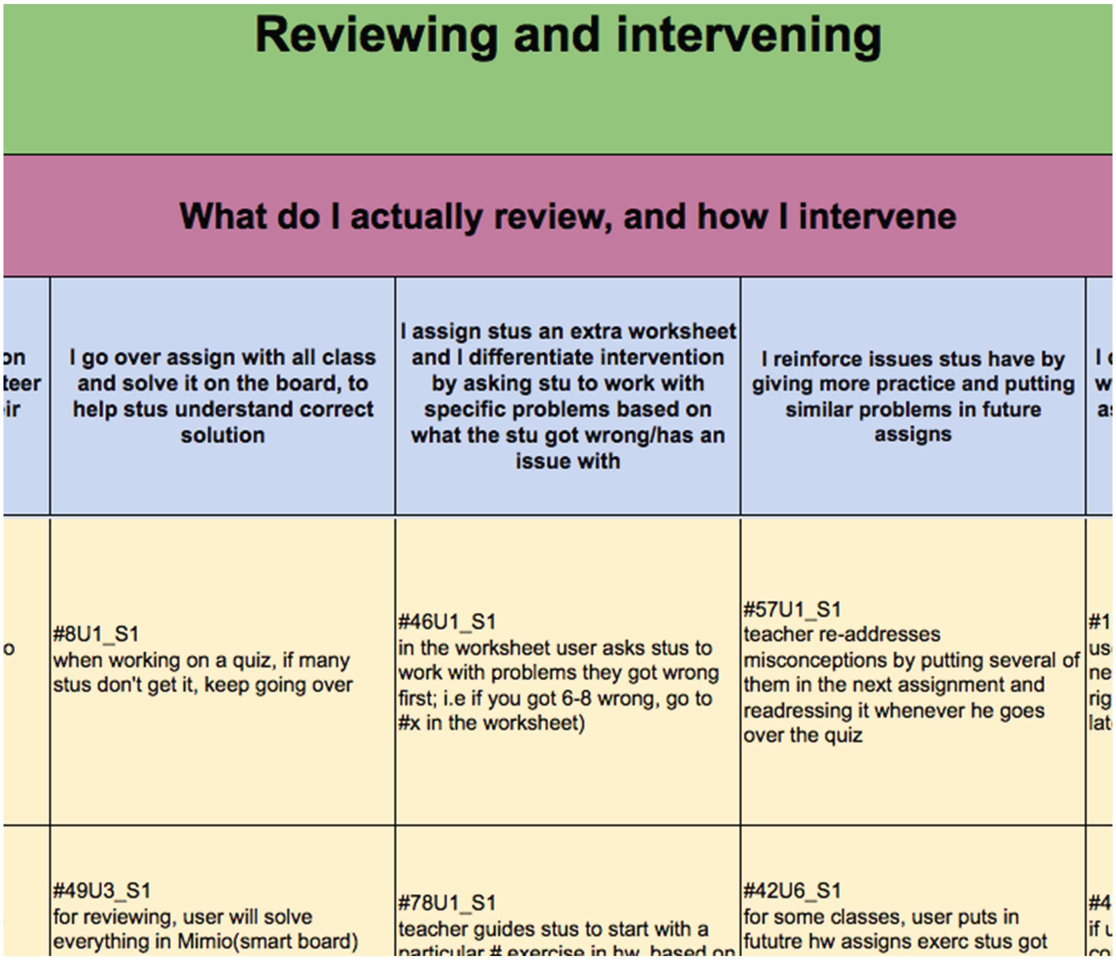


Figure 3-2: Partial view of the final Affinity Diagram.

it notes. I gathered approximately 2000 yellow notes, as illustrated in Figure 3-2 (the two rows from the bottom). I initially followed the traditional Interpretation Session approach and recorded the observations in physical post-it notes (Figure 3-3). Given the large amount of interview data I had collected, I decided to instead store the notes electronically in a Google Spreadsheet. I also approached the Affinity Diagramming in a traditional way first, namely, by using printed copies of the digital notes and organizing them on large sheets of paper (Figure 3-4). However, given the large number of notes, I resorted to creating and keeping the Affinity Diagram in a Google Spreadsheet as well, as shown in Figure 3-2.

I organized the yellow notes into categories based on patterns I identified and similarities in their content. Following the Affinity Diagramming technique, for each category, I recorded the synthesized content of all the yellow notes within the blue categories (third row from the top in Figure 3-2). I then grouped together blue categories based on similarity of content and recorded the information they conveyed within the pink categories (second row from the top in Figure 3-2). Lastly, I grouped pink categories and synthesized their content within the green categories (first row from the top in Figure 3-2). The final Affinity Diagram had 335 blue level categories (with 1–2 up to 12–14 yellow notes per category), 81 pink and 33 green level ones.

Based on the initial focus of the Contextual Inquiry interviews, namely how and what data

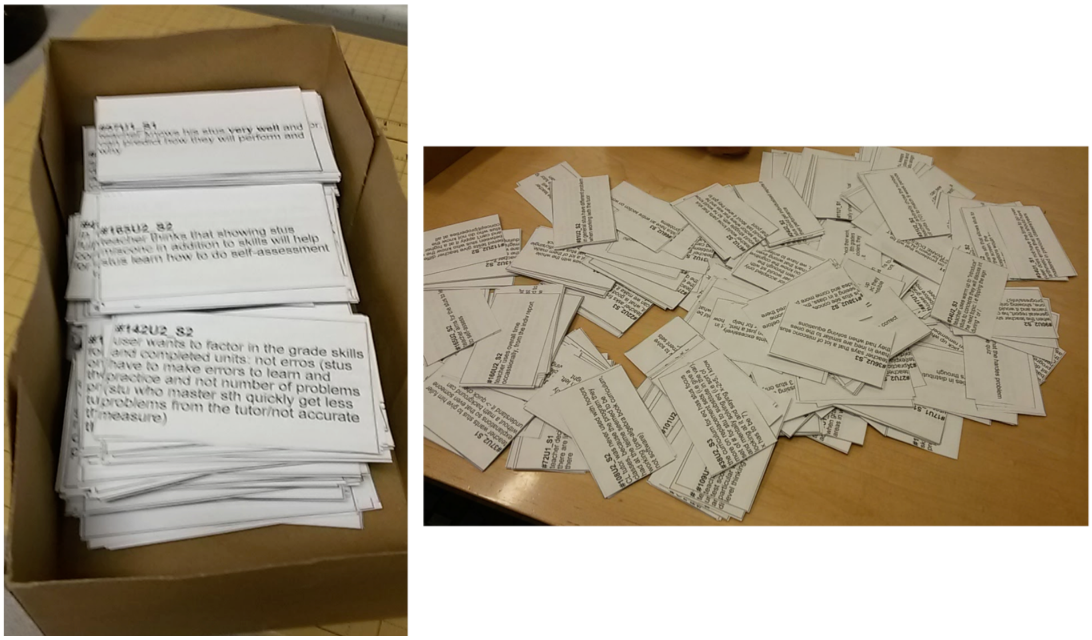


Figure 3-3: Approximately 2000 physical notes generated from the Interpretation Sessions.

teachers generate about their students' performance, and how they use this data to drive instruction and prepare for a class, I focused on the categories of the Affinity Diagram that contained the most important information relevant to this focus. I initially went through the final Affinity Diagram and selected the blue, pink and green categories that contained such information. I then recorded in two lists – what data teachers generate and how they use this data – a summary of the selected categories, in the form of short sentences and keywords. Each of the lists individually was then synthesized based on similarities in content, and the final results are presented in the following section.

3.3 Findings

3.3.1 What Data Do Teachers Use to Help Students?

From the Contextual Inquiry interviews, I found that teachers continuously generate and use data on the progress and performance of their students. They also use data generated by technology such as the CL tutor or other software they use as part of their classroom instruction.

Teachers gather data when grading written student assignments, as well as by having one-on-one interactions with students during or outside of class. In particular, teachers pay attention to whether the overall class or individual students have mastered particular concepts. A concept can be an entire problem that exercises a skill (e.g., finding the greatest common denominator) or one of the steps that leads to the solution of the problem (e.g., graphing the direction of an inequality in the number line as part of graphing the inequality itself on the number line). In addition, teachers try to understand, on a class and individual student level, what causes students the most trouble, i.e., what are the most common misconceptions and errors.

Data provided by technology includes reports and analytics on student progress and performance

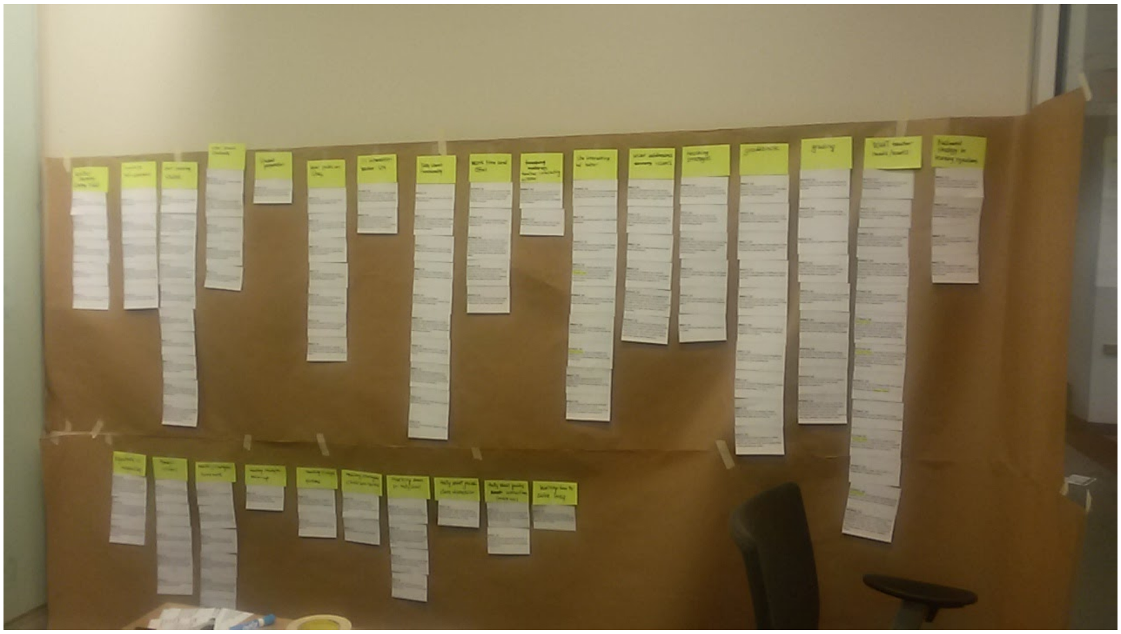


Figure 3-4: The first try at a physical Affinity Diagram.

in the CL tutor or in other software used by the teachers. For example, among the many reports that are offered by this tutor, the teachers I interviewed made most use of the reports that give information on the overall class performance and on the individual student performance in the tutor. Teachers also pay attention to the number of skills students have mastered or not mastered and, less frequently, to time spent working in the tutor.

I also found that teachers use many different ways to record, keep track and organize student data. Some data gets initially recorded on paper and then is transferred to software. For example, some teachers recorded and kept grades in a paper grade book before transferring that information to a digital grade book. Other data on student performance is initially generated through software (such as CL tutor reports or other software reports), and the teacher prints and stores it offline. It is challenging for the teachers to keep track of and integrate both offline and online data.

Some (though not all) of the teachers I interviewed kept track of student errors and misconceptions at a surprising level of detail, as illustrated in Figure 3-5. In the tally sheet on the left of Figure 3-5, a teacher keeps track of the frequency of particular misconceptions (shown in columns) for each problem in an assignment (shown in rows). As the teacher describes, "I will go through each problem and will start writing down where they made their errors. And I will just put tallies. And where I see different things I make sure I circle them so I can focus there whenever I am reviewing that", referring to the misconceptions that most students had and thus should be discussed with that class. In addition, the teacher writes, at the top right of the tally sheet (covered), the name(s) of the student(s) who had the most trouble with a particular concept or concepts. To be consistent across periods, the teacher initially grades all tests or exams for each period and then creates the tally sheet template from the first period, copying it to the tally sheet for other periods. The teacher finishes tallying the sheet for one period before they move on to the next period. If the teacher notices a different or miscategorized misconception in another period, they go back and correct the tallies for that misconception in all the other periods.

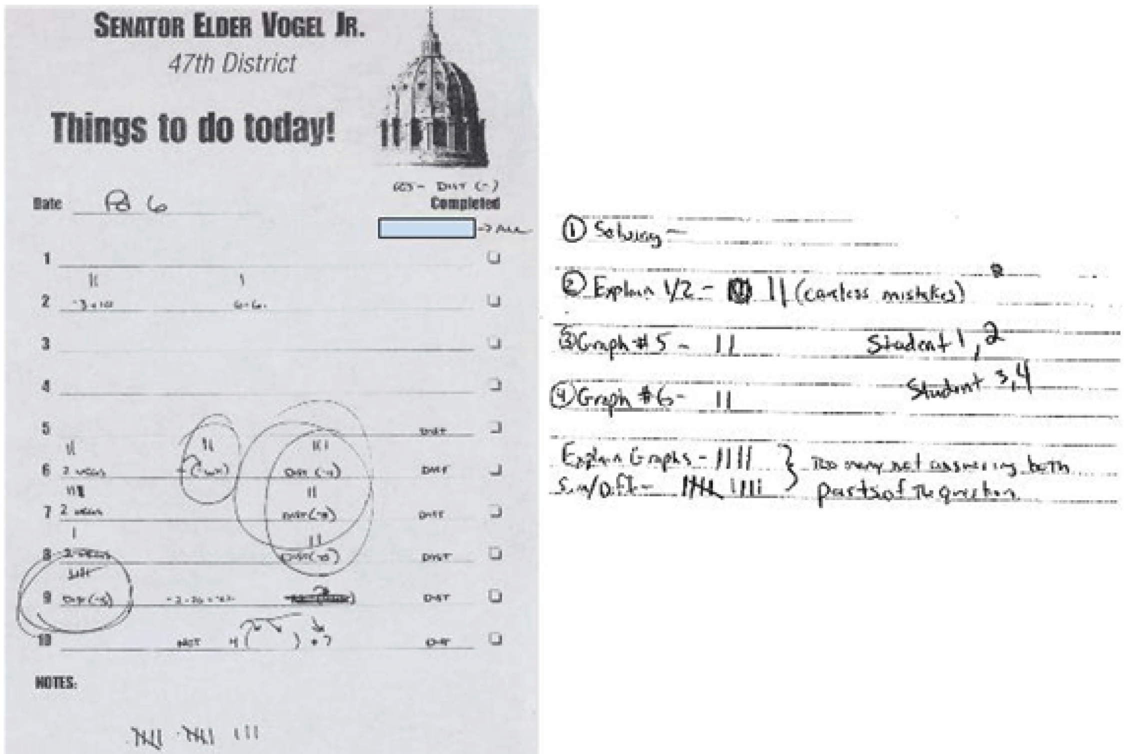


Figure 3-5: Tally sheet from teacher 1 and teacher 2. Student identifiers have been removed.

Another teacher I interviewed uses the tally sheet on the right of Figure 3-5 to tally students who got a problem (or parts of a problem) wrong in an assignment. Each problem in this particular assignment represented a high level concept (for example, exercise 1 was related to solving two inequalities, while exercise 2 asked students to explain the steps to those solutions). For some exercises, the teacher also notes in the tally sheet the reasons the students made the mistakes (for example, careless mistakes or not answering both parts of the question). Lastly, the teacher writes down the names of the students who they want to call on in class (represented by student 1, 2 and student 3, 4 in Figure 3-5).

3.3.2 How Do Teachers Use Data to Adjust and Drive Instruction?

I found that teachers use data to drive and adjust their instruction in many ways. Most of the teachers differentiate how they use data and tune the level of detail to determine whether the best remedy is a classroom intervention or individual, one-on-one sessions with particular students.

Class-Level Decisions

Decide to Move on to the Next Topic and Build on Current Concepts. After generating data on the overall class performance in an assignment or test, the teacher analyzes it to assess the current status of the class and to decide whether to move on to the next topic. If, in the teacher's judgment, the majority of the class has mastered a concept or a set of concepts, the teacher decides to move on with the instruction and build on the current concept(s). As one teacher describes, "*there's times where I'm like 'Ok if they don't know this, I have to start here. But if they do know it, I can start here,' in a different position.*"

Determine that the Class Needs Intervention. The teacher notices when many students have not mastered certain concept(s), or when there are many different errors and issues in an assignment. The teacher decides to intervene and devote more time and attention in class to specific concepts, misconceptions or errors to help students remedy their issues.

Identify the Focus of Intervention. Based on the number of students who have not mastered the concept(s), or have misconceptions and errors, the teacher determines what is important to cover during a class lecture. The teacher can also create worksheets with exercises to allow students to practice the concepts they are missing or having the most trouble with.

Plan What to Discuss and Cover in Each Period. The teacher compares performance on an assignment across periods and adapts instruction (or what to cover in class) based on that period's performance. Sometimes the teacher covers only the topics that a period has the most trouble with; in other cases, the teacher might decide to discuss issues noticed from other periods in every class period.

Display in Class Reports or Analytics from Software. As students were working with the CL tutor, one teacher displayed anonymized class performance reports in front of the classroom, on a smart screen. The teacher aimed to support the students' learning and progress by seeing where they were compared to the other students in the class. In addition, displaying the report in class helped the teacher monitor the students' progress as the teacher walked around the class, while students were working with the tutor. The same teacher also displayed on the smart screen class analytics on students' performance generated from other software.

Individual and Group Level Decisions

Decide Which Individual Students or Group of Students Need Special Attention. The teacher identifies from the generated data individual students who have an issue with one or more concepts, have displayed the same misconception or error repeatedly, or are spending a lot of time but making little progress. The teacher records the individual students' names to work one-on-one with them. If the teacher notices that a group of students are having similar issues, the teacher might decide to work with them as a group.

Determine the Focus of Intervention. If the teacher does not know the reason why a student is having an issue, they spend time with that student trying to understand their problem(s). The teacher determines the focus of a mini-lecture or extra practice to help the student fix the issue and master the concept(s). The teacher will also call on the student during class time to prompt them to participate in discussion or problem solving for the concept(s) they are having trouble with. For groups of students, the teacher can decide to do a mini-lecture, or give practice worksheets, by differentiating intervention as to which student has to work with which exercise in the worksheet, based on individual issues identified.

Show and Give Students Software Reports. The teacher periodically shows, prints and gives students reports on their progress and performance over a given time period, in the CL tutor or other software used in the classroom. The teacher uses the data from these reports to update the students on their progress, what they still need to do, and what their grade is.

3.4 Breakdowns in Current Teacher Practices

The interviews with the teachers, as well as the data analysis emerged patterns of breakdowns in the current teacher practices of generating and using data. Similarly, the interviews showed that the technology that some teachers use in the classroom is not always helpful, and can be inefficient.

Teacher Adapts to Technology, Technology Does not Adapt to Teacher. The CL tutor and other software provide more student data and reports than the teacher needs and can process. The teacher is selective in choosing among the provided reports, choosing only the data that is most useful to them. In addition, none of the technologies I observed provide data about misconceptions or student growth, which are hard to generate by hand. For example, one teacher used the Pennsylvania Value Added Assessment System to see students' growth from year to year. However, the teacher could use such reports only once per year, making it impossible to intervene in classes that the teacher would not be assigned to teach anymore. Another teacher said this about CL reports: "*It would actually be very useful [to see errors and misconceptions] because … a lot of these reports I don't use frequently because it's not necessarily giving me what I need to know.*"

Generating Data is Time Consuming and Effortful. From grading student assignments to interacting with students on a class or individual level during and outside of class, the teacher continuously generates data on students. The teacher also spends time and effort in analyzing and drawing conclusions based on data from different sources, while differentiating the level of detail and instruction for the class or for individual students.

Organizing, Integrating and Remembering Data from Different Sources is Challenging. It takes time and effort to integrate data generated on paper with data from reports of tutors or other software. For example one teacher printed CL tutor reports and other software reports and organized them in a binder (Figure 3-6). This teacher also put post-it notes on the binder and wrote things to remember on the printed reports, or highlighted in color particular students. Even without technology, I noticed that teachers integrate student data from different assignments and interactions with the students and, most of the time, keep track of this information in their heads.

Creating Materials for Intervention is Difficult. The teacher has to spend time and effort to create or find the necessary materials for a mini-lecture or problems and exercises for a practice worksheet. One teacher used various online sites to find and give problems to students to practice for standardized tests. Another teacher looked for individual exercises the student got wrong in the CL tutor, to print and give it to the student to complete on paper.

3.5 Opportunities and Design Implications

From the Contextual Inquiry interviews and findings, I identified opportunities for a technology, such as a dashboard that provides teachers their students' data, to address current breakdowns.

Automate Processes the Teacher Does by Hand. The detailed information on student mastery of concepts, performance and progress that teachers generate themselves can be provided by technology. This would save teachers time, effort and attention that can be used to help students in other ways.

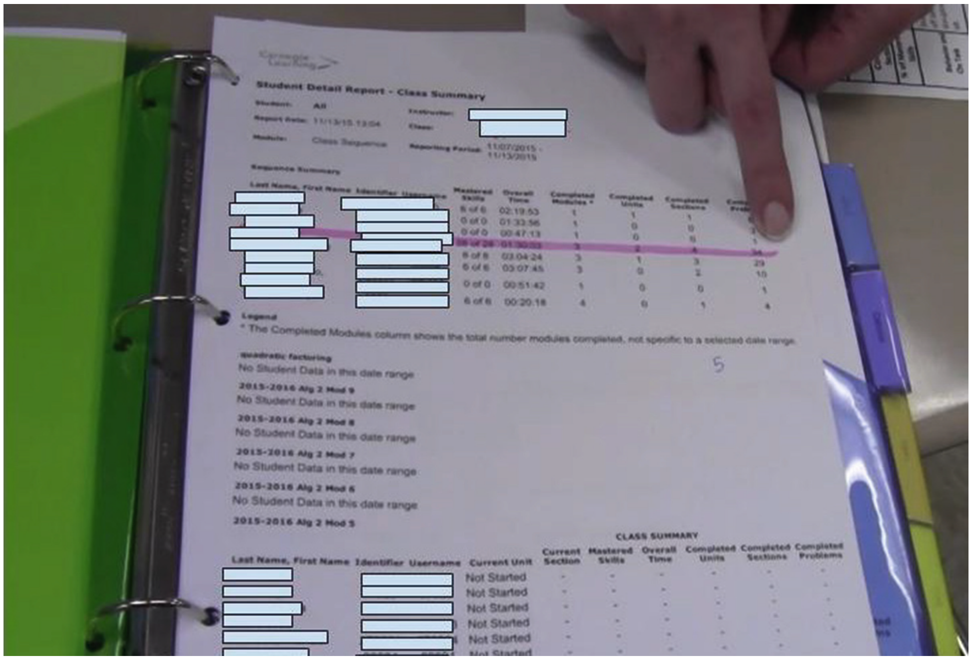


Figure 3-6: Teacher prints and stores reports from CL tutor and other software in a binder offline. Student names and identifiers have been covered.

Adapt to Teacher Data Needs. To be useful to the teacher, a new technology should provide data the teacher most needs in their instruction. This includes data that are difficult to generate by hand and that tutors or other software do not provide currently, but could provide, such as student misconceptions and growth over given periods of time, on the individual and class level.

Help the Teacher Integrate Data from Different Sources. Instead of the teacher having to remember and coordinate data they generate themselves from different assignments and data provided by tutors or other software, technology can help the teacher easily keep track of and manage this data.

Suggest Materials for Intervention. Teachers can receive suggestions from technology on materials and exercises to go over with students (individually or as a class), based on their performance with a topic. In addition, technology can create worksheets and assessments for the teacher by differentiating on the class or individual student performance. Technology should allow the teacher to access the problem or problems the student(s) got wrong and reassign it (or them) to the student(s).

Provide Data on Hint Requests and Student Errors. One teacher who used the CL tutor mentioned that they occasionally used the average hints and errors in the tutor reports to identify students who are goofing off or rushing through the problems, versus those who really need help. Hints and errors are important analytics that can help the teacher understand the performance of their students, and identify the need for intervention, while working with the tutor.

3.5.1 Towards the Design of a Teacher Dashboard with Students' Data

In a classroom that uses educational technologies such as ITSs, where a lot of student data is produced by the technology, a dashboard can provide the teacher with the necessary analytics and functionality to help them help their students learn better. Based on the findings of how teachers use data to drive instruction and help students on the class and individual student level, I have brainstormed and designed preliminary scenarios where a dashboard can be integrated in an ITS environment and help the teacher in this process. In the next Chapter of this thesis, I will cover in detail how these findings guided the design of a teacher dashboard that presents teachers with student data.

Teacher Dashboard for the Class Level. Teachers could use this dashboard when preparing for the next lecture and deciding whether to move on to the next topic. In addition, the data provided by this dashboard would help the teachers identify the need for intervention by giving information on the class performance and progress in the ITS environment. The dashboard would help the teacher determine the focus of intervention, as well as suggest materials, such as example problems or practice worksheets for the class. Another scenario that teachers could use this dashboard for is when they quickly want to review where students' concept mastery stands, and whether a quick intervention or mini-lecture might be helpful. Teachers would use this dashboard when giving students a warm-up exercise at the beginning of class, or a short practice exercise at the end of a lecture. Lastly, the dashboard could provide teachers with real time data on students' performance during the time students are working with the ITS. Teachers would be able to project the dashboard on a wall or screen in class, and would better focus their time and attention on students who need it the most, while other students independently work with the tutor.

Teacher Dashboard for the Individual or Group Level. Teachers would use the information and analytics provided by this dashboard to give one-on-one attention and help to individual students or a group of students with similar issues and problems. The data provided by this dashboard would help the teacher identify the need for intervention, as well as the focus area(s), while providing the teacher with suggested practice problems.

3.6 Discussion and Conclusions

A key assumption in this chapter and my thesis work more in general is that a technology, such as a dashboard, that will present teachers their students' data will be most effective if it is designed with a deep understanding of how data about students' performance and learning can influence teacher decision-making and actions in the classroom.

In this chapter I investigate ways in which teachers generate and use data to drive and adjust their instruction in the classroom. Through Contextual Inquiry interviews with 6 middle and high school teachers, I found that teachers use data to a surprising degree to inform their teaching, both to make decisions at the class level and to plan interactions with individual students. Further, the data they use (and often, generate themselves, by hand) can have a surprising amount of detail, as shown in Figure 3-5. I also found that teachers use data provided by technology, when it is available. On the class level, teachers use this data to decide the next best action to take, for example whether they need to spend more time on a certain topic and when to move to the next topic. In addition, teachers differentiate instruction across class periods focusing on each classes' specific needs and performance. Teachers who use technology in their classrooms make use of reports and analytics provided by the technology, again both on the class and individual student level. However, I also found that teachers have to adapt to the specific technology they use and are selective in deciding which types of reports and data provided by such technology to use. An interesting finding is that teachers differentiate instruction on the individual student level. They spend time, effort and attention to identify what individual students need most help with, what issues they are having and how to help them remediate these issue(s).

These findings provide novel insights into what data teachers generate and how they use it plan instruction and act in the classroom. To the best of my knowledge, this is the first study that investigates, through the use of Contextual Inquiry together with Interpretation Sessions and Affinity Diagramming, how teachers use data in their day-to-day decision-making with or without technology. The findings may be useful for designers of dashboards for various educational technologies. Their importance is not restricted to ITS, since the majority of teachers in the study did not use one with their students.

In the next chapter of my thesis (Chapter 4), I use the results and findings from the current chapter to inform the design of a teacher dashboard with student data collected from an educational technology such as an ITS. Focusing on specific use scenarios, the dashboard will take advantage of the rich analytics generated by the ITS, such as skill mastery, types of misconceptions, progress and time in the assignments, etc. The findings in the current chapter will drive the decisions of what data is most important for the teacher in the given scenario and how it will be presented to the teacher in the dashboard in an easy-to-understand way.

Chapter 4

Developing a teacher dashboard for use with ITSs

This chapter is based in part on the following publications:

- [13] Aleven, V., Xhakaj, F., Holstein, K, & McLaren, B. M. (2016). Developing a teacher dashboard for use with intelligent tutoring systems. In Proceedings of the 4th International Workshop on Teaching Analytics at the 11th European Conference On Technology Enhanced Learning, IWTA 2016.
- [125] Holstein, K., Xhakaj, F., Aleven, V., & McLaren, B. M. (2016). Luna: A dashboard for teachers using intelligent tutoring systems. In Proceedings of the 4th International Workshop on Teaching Analytics at the 11th European Conference On Technology Enhanced Learning, IWTA 2016.
- [258] Xhakaj, F., Aleven, V., McLaren, B.M. (2017). Effects of a Teacher Dashboard for an Intelligent Tutoring System on Teacher Knowledge, Lesson Planning, Lessons and Student Learning. In É Lavoué, H. Drachsler, K. Verbert, J. Broisin, M. Pérez-Sanagustín (Eds.), Proceedings of the 12th European Conference on Technology Enhanced Learning, EC-TEL 2017, (pp. 315-329). Springer International Publishing Switzerland.
- [257] Xhakaj, F., Aleven, V., McLaren, B.M. (2017). Effects of a dashboard for an intelligent tutoring system on teacher knowledge, lesson plans and class sessions. In E. Andre, R. Baker, X. Hu, Ma. M. T. Rodrigo, B. du Boulay (Eds.), Proceedings of the 18th International Conference on Artificial Intelligence in Education, AIED 2017, (pp. 582-585). Springer International.

Abstract: In Chapter 3, I implemented a user-centered design process to study and investigate teacher data needs in the classroom and draw design implications for a dashboard tool that could present data back to the teachers and support their teaching practice. Based on those findings, in this chapter I continue the user-centered design process. Specifically, I use methods such as Speed-Dating, Story boarding, and Prototyping to validate and test ideas and designs to address teachers' data needs and support their teaching in the classroom. The final contribution of this process results in Luna, a dashboard that shares with teachers data about their students' performance and progress in an Intelligent Tutoring System (ITS). The main goal of this dashboard is to support teacher decision-making and reflection as the teacher prepares for

the next lecture, outside of class. The dashboard is meant to be used in in conjunction with and educational technology such as an ITS that collects and generates student data that fuel the teacher dashboard.

4.1 Using Speed-Dating and Story boarding to Design the Teacher Dashboard

4.1.1 Introduction

To continue the user-centered design process, following Contextual Inquiry, Interpretation Sessions and Affinity Diagramming, I employed Story boarding and Speed-Dating as the next step [75, 262]. Speed-Dating is a method that allows for rapid exploration, validation and testing of ideas, in particular future ideas, with users. This method is commonly employed in many research projects as a way to help reduce the risk of designing and creating technologies and tools that users will not adopt [262].

4.1.2 Methods

The primary focus of the Storyboards and Speed-Dating sessions was to validate some of the major findings from the Contextual Inquiry interviews (see Chapter 3). For example, Storyboard #1 (see Appendix A) focused on whether data at the class level or individual level was most helpful to teachers to support their decision making for what to do in the next class sessions. Storyboard #4 on the other hand aimed to validate if student misconception data would be helpful to the teacher to help guide their instruction.

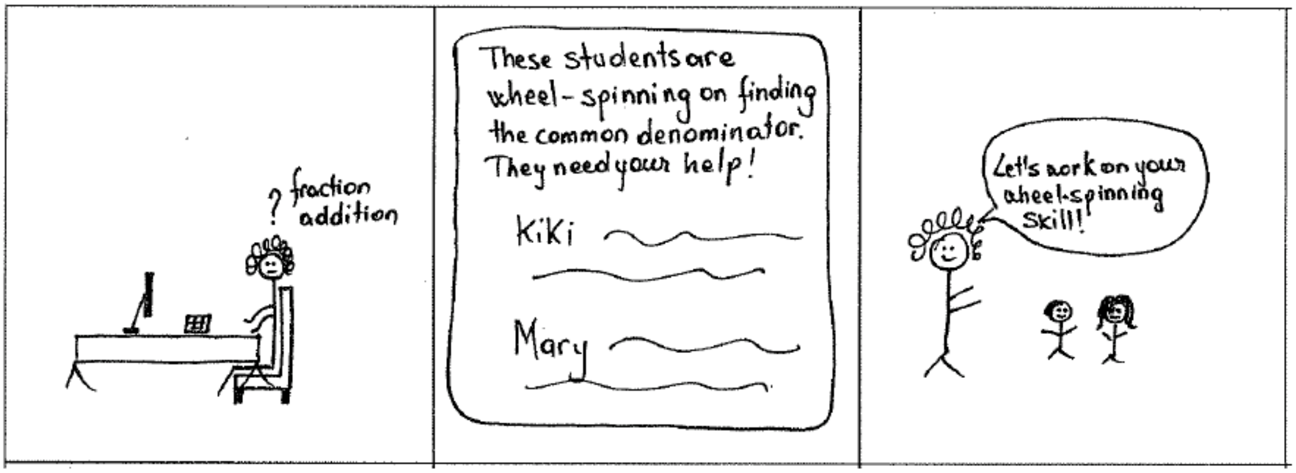
A secondary focus of these Storyboards was to explore teachers' opinions and desires on data and analytics that ITSs can produce but teachers might not necessarily be aware of or familiar with. This includes data such as wheel-spinning (a phenomenon when the students is not learning the skill, despite continuous target practice on that skill [44]) or hint abuse (when students continuously press the hint button until they get to the answer of the exercise [32].). An example Storyboard for this idea is Storyboard #12, also depicted in Figure 4-1, which aimed to explore if wheel-spinning information would be helpful to the teacher's instruction.

The final focus of the Stroyboards was to test some futuristic ideas that challenged the boundary of what is possible with a dashboard technology and what would teachers be comfortable or uncomfortable with. In particular, I wanted to investigate the power dynamics and power separation between the teacher and the dashboard. For example, Storyboard #8 tested the idea of the dashboard automatically assigning students extra practice to who needs it, with little or no input at all from the teachers.

Based on these three focuses, I generated a range of design concepts and created 22 storyboards to share with teachers (similar to Figure 4-1, see Appendix A). Each storyboard had (1) a central question which served as a starting point for a discussion with teachers and around which the conversation was centered, (2) a sketch representing the story, which (3) was supported by a detailed description in text of what was going on in this storyboard.

I conducted Speed-dating sessions individually with 1 female middle-school teacher from a suburban, medium-achieving school and 2 middle-school teachers from a suburban, medium-achieving school (2 male). I showed each Storyboard to the teachers during Speed-Dating sessions that lasted for 1.5 hours and asked the teachers to give their impressions and opinions on each of the storyboards.

Storyboard_12: Does information on student's wheel-spinning in the tutor help guide your instruction?



Mrs. Byrd is looking at the dashboard to see her students' performance and progress in the tutor for the fraction addition topic.	The dashboard tells Mrs. Byrd the Kiki and Mary have been wheel-spinning in the tutor on the finding the common denominator skill. This means that Kiki and Mary have been working for a while with exercises to learn this skill, however they have not mastered it yet. The dashboard suggests that Mrs. Byrd's help is needed immediately	Mrs. Byrd now knows that Kiki and Mary are wheel-spinning on finding the common denominator term. Mrs. Byrd spends one-on-one time with each of them to re-teach them the concept, and also works with them through a couple of practice problems.

Figure 4-1: One of the storyboards that depict from top to bottom: the focus question, the images and the story.

4.1.3 Findings

I initially transcribed and then analyzed the Speed-Dating interviews with the teachers. For the analysis, I summarized the teachers thoughts and opinions per storyboard. Below I summarize at the high level some of the most interesting findings that teachers strongly agreed or disagreed with.

From the Speed-Dating sessions, I found that teachers were very interested in information such as skill or misconception data that showed them where the students were doing well and progressing well and where the teachers' intervention was needed to help the students. In particular, teachers thought trying to understand what misconceptions students had based on the errors they were makings was very challenging and they considered this to be a very important step to taking action and helping the student resolve this misconception. As User 1 mentions in relation to Storyboard #4 (Appendix A):

> User 1: *...if I know, and can figure out what misconceptions are, then yes I will, address it. It'd be nice to have something to actually do that for me [laughs] because, that is very, it at times can be very difficult to, figure out what it [the misconception]*

is.

Teachers mentioned they needed skill and misconception information in particular at the individual student level in order to be able to figure out which students they needed to pay most attention to. Teachers also mentioned that as they prepare for the next lecture, they would keep an eye on the overall class data as a way to help them decide and guide their instruction on whether to move on to another topic or to stay in the current topic.

> User 3: *...I myself would want the individual. In my head I would be looking at it as class overall but I also want to know which kids I need to focus more of my attention on. So that's why I would go with the individual.*

Teachers mentioned they would find useful data that ITSs can generate but teachers currently do not have such as wheel-spinning data and hint abuse information. For example, in response to a follow up question on Storyboard #20, *Would you think it would be helpful for you to know this information so that you can go and talk to the students?*, one teacher said:

> User 3: *That would be nice and knowing ahead of time. If it identifies what Kiki's problem is and you can just run in there real quick and focus on what you exactly need to do and you would go over with Mary, have a different set of questions for her. Just try to figure out where her problems lie ... I would want to have that.*

One surprising finding from the story boarding sessions was the teachers' strong and negative reaction to the power dynamics between them and the dashboard. Teachers liked having power over the dashboard and the decisions it took for their class overall or the individual students. They did not like at all the dashboard being in control of their students or them not having control over the decisions that the dashboard took. In addition, teachers mentioned they they would not accept suggestions from a dashboard without it "gaining their" trust first. For example, in response to my follow up question *Would you trust the software telling you what are the skills that your students are missing the most and what students you need to focus on?* on Storyboard #2, one teacher said:

> User 2: *...I would have to sort of work with it [the dashboard] a little bit, and from working with the students, and seeing them work with the program [ITS], and then what we do in class, you know like that, those both things would go into it. I wouldn't just go with "Oh the computer told me this, yeah I am going to do it ... I would never just willy-nilly trust it.*

4.2 Prototyping

4.2.1 Introduction

Based on the findings of the Contextual Inquiry interviews as well as the findings from the Speed-Dating sessions, I moved to the next stage of the user-centered design process for the teacher dashboard, namely prototyping. Prototyping is the process of creating early models of the technology or tool you are aiming to create, as a test of the concept and process, before investing time, money and energy on implementing the technology or tool at a large scale [56].

4.2.2 Prototyping Iterations

Using the above mentioned findings as a basis, I started sketching low-fidelity prototypes of the teacher dashboard. As can bee seen in Figure 4-2, in the initial low-fi versions I was mainly focusing on including data such as skill and misconception information in the dashboard as teachers both in the Contextual Inquires and Speed-Dating sessions unisonly agreed these were data they used and needed in their teaching and to guide their instruction. A Ph.D. colleague and I worked together to generate several iterations of low-fi prototypes of the dashboard. This work resulted in creating an initial version of a medium-fidelity prototype, Figure 4-3.

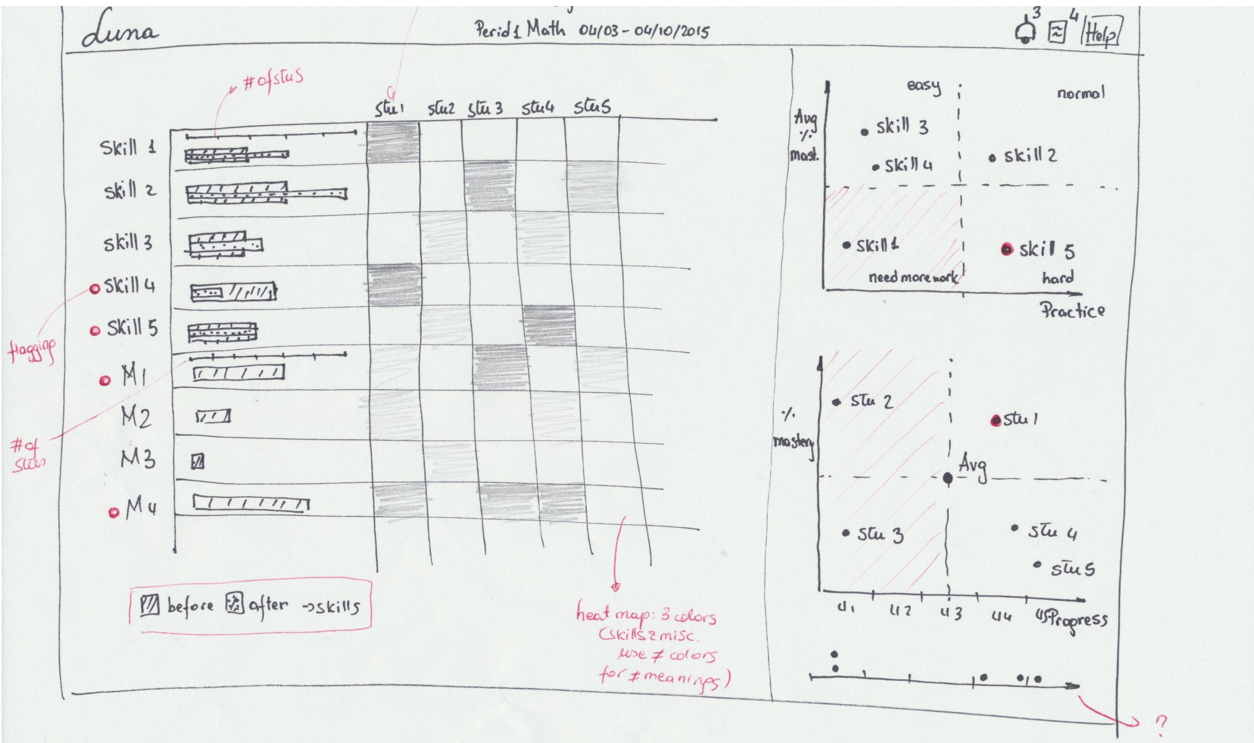


Figure 4-2: Low-fidelity protoype sketches of the dashboard.

Based on the mid-fi prototype, my colleague ran prototyping sessions with three middle-school teachers (two teachers, one educational technology specialist). In those sessions, my colleague showed teachers a paper version of this mid-fi prototype, and ask them to think as if they were preparing for a lecture for the next-day. More details on the prototyping process and some of the major findings are presented in [13, 125].

4.2.3 Final dashboard: Luna

With the help of a design professor from the Human-Computer Interaction Institute at Carnegie Mellon University, my colleague and I iterated on the medium-fidelity dashboard prototype. Some of the main changes we focused on were in relation to making the prototype more user friendly in terms of the amount of information and the cognitive load the mid-fi prototype posed on the teachers. The final result of these iterations was a high-fidelity dashboard prototype which I named Luna, to represent how the dashboard would "reflect" back to teachers data from their students.

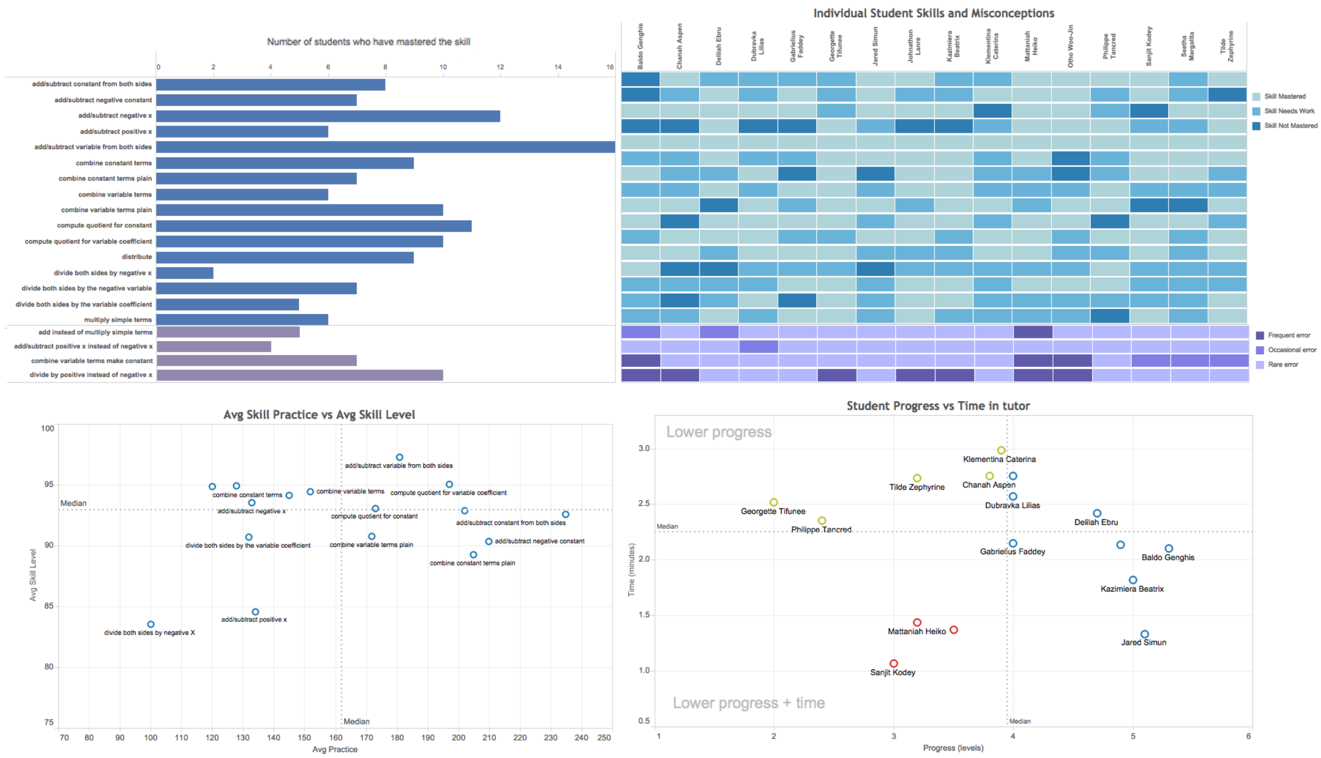


Figure 4-3: The medium-fidelity dashboard prototype used in the prototyping sessions. The dashboard was created based on the findings from Contextual Inquiry and Speed Dating data. From top to bottom, left to right, it shares data (1) on the number of students who have mastered skills or have misconceptions, (2) skill mastery and misconceptions per student, (3) average skill mastery plotted against average amount of practice and (4) student time spent in the ITS plotted against student progress.

I mocked up Luna in Tableau, a data visualization tool (http://www.tableau.com/). The dashboard was populated with real student data from an ITS (Lynnette [154]). This data was processed through a combination of Python Scripts and Excel before it was inputted in Tableau into the dashboard.

Luna displays data about students' learning, both at the class level (Figure 4-5) and individual level (Figure 4-4). The information that is displayed in each of those screens as well as the decision to split the dashboard in two screens were made based on and to address the findings from the Contextual Inquiry, Speed-Dating and Prototyping interviews as described above. Luna is interactive, for example hovering over a skill or error shows a definition and an example exercise of the skill being applied or the error manifesting.

At the class level, Luna shows:

1. the number of students who have mastered each skill in the ITS (as a horizontal bar chart),
2. the number of students who made certain errors (as a horizontal bar chart),
3. a comparison of the level of mastery versus the amount of practice per skill averaged across students (as a scatter plot).

At the individual level, Luna shows per student

1. if they mastered each skill in the ITS and the percent mastery,
2. if they had errors and the number of times they made each error,
3. time versus progress in the ITS (as a scatter plot).

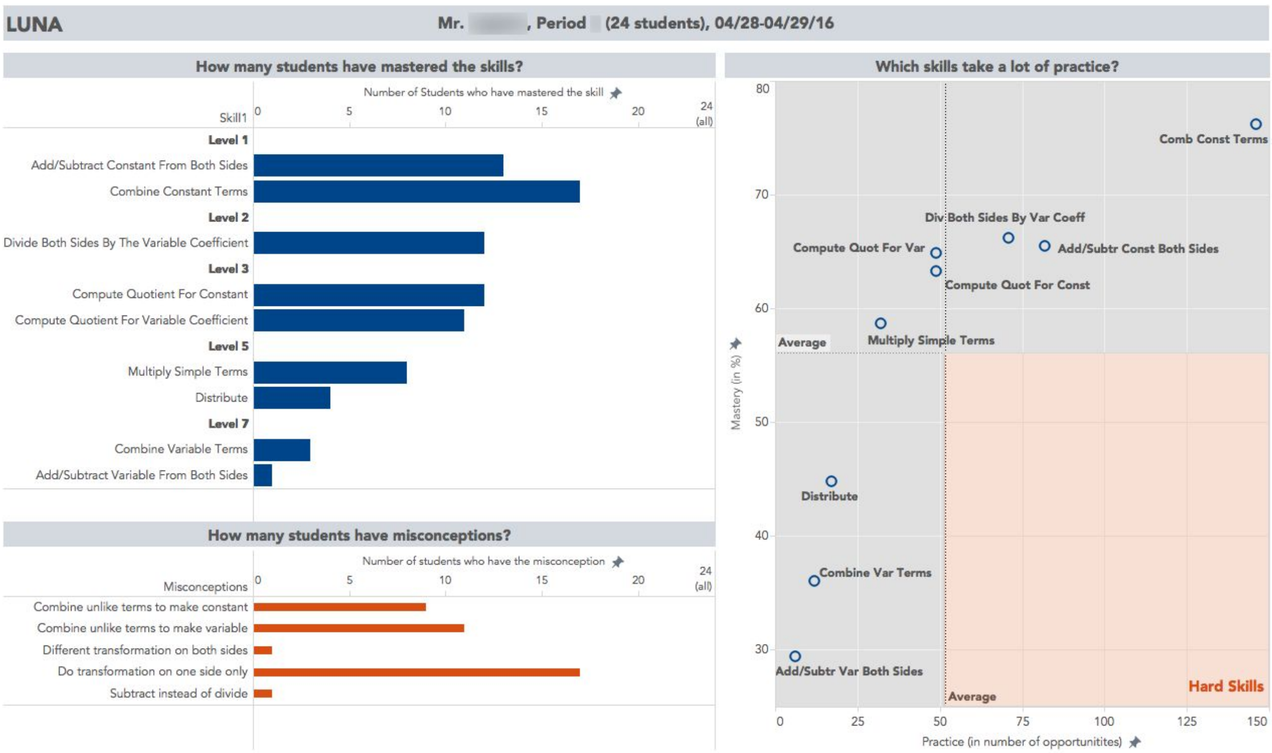


Figure 4-4: Luna: Individual Level Dashboard View.

4.3 Conclusions

In this Chapter, I continued the user-centered design process to investigate teachers' data needs in relation to their students and to design a teacher dashboard that supports teachers' teaching and practices in the classroom by sharing with them data on their students' performance and progress. Following the Contextual Inquiry studies and findings in Chapter 31, in this chapter I used Storyboarding, Speed-Dating and Prototyping to create Luna, a teacher dashboard fueled with student data from an Intelligent Tutoring System (ITS). Luna is a high-fidelity dashboard prototype mocked up in Tableau and it presents teachers data at the classroom level and at the individual student level on their students' skill mastery, errors and misconceptions, and progress in the ITS. In the next chapter of my thesis (Chapter 4), I continue the user-centered design process and investigate how Luna affects teachers and their practices and students and their learning, when employed in a real classroom setting.

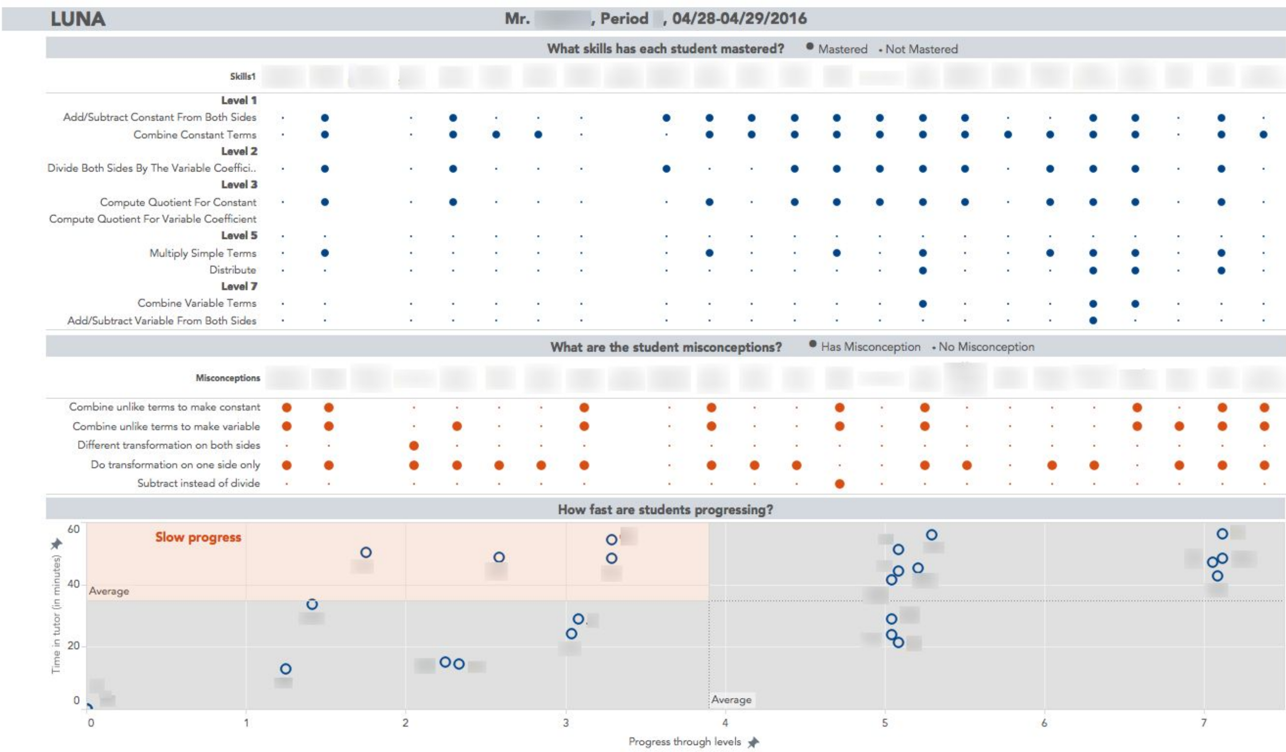


Figure 4-5: Luna: Class Level Dashboard View.

Chapter 5

Effects of a Teacher Dashboard on Teacher Knowledge, Lesson Planning, Lessons and Student Learning

This chapter is based in part on the following publications:

- [258] Xhakaj, F., Aleven, V., McLaren, B.M. (2017). Effects of a Teacher Dashboard for an Intelligent Tutoring System on Teacher Knowledge, Lesson Planning, Lessons and Student Learning. In É Lavoué, H. Drachsler, K. Verbert, J. Broisin, M. Pérez-Sanagustín (Eds.), Proceedings of the 12th European Conference on Technology Enhanced Learning, EC-TEL 2017, (pp. 315-329). Springer International Publishing Switzerland.
- [257] Xhakaj, F., Aleven, V., McLaren, B.M. (2017). Effects of a dashboard for an intelligent tutoring system on teacher knowledge, lesson plans and class sessions. In E. Andre, R. Baker, X. Hu, Ma. M. T. Rodrigo, B. du Boulay (Eds.), Proceedings of the 18th International Conference on Artificial Intelligence in Education, AIED 2017, (pp. 582-585). Springer International.

Abstract: In this chapter, I explore how the high-fidelity teacher dashboard prototype, Luna, which I designed for and created in the previous two chapters of this thesis (see Chapters 3 and 4), affects teachers and students in the classroom, when used with real data from an ITS. Results from a quasi-experimental classroom study with 5 middle school teachers and 17 classes show that even though teachers generally know their classes well, a dashboard with analytics can still enhance their knowledge about their students and support their teaching practices. I found that the teacher dashboard influenced what teachers knew about their students' learning in the ITS and that the teachers' updated knowledge affected the lesson plan they prepared, which in turn guided what they covered in the classroom. To the best of my knowledge, this is the first study that demonstrates that a dashboard for an ITS can affect teacher knowledge, decision-making and actions in the classroom.

5.1 Introduction

Educational technologies, such as ITSs, that generate and collect data on student progress are rarely designed to support teachers and their teaching. Many opportunities are being left on the table for teacher dashboards which might help teachers improve their teaching practices and guide their instruction in the classroom. For instance, when many students in a class are learning a particular skill, a dashboard could let the teacher know about this situation, and the teacher could include, in their lesson plan and actual lesson, specific steps to address the challenge. More generally, a dashboard could help make "the invisible visible" for teachers by displaying aggregated, up-to-date information about their students. Based on this information, teachers could provide help to their students and guide their instruction in a way that is better targeted and personalized to the students' needs.

Despite the large amounts of dashboards designed for various educational technologies, much prior work has focused on evaluating whether such dashboards are useful to teachers and what visualizations or information is most used by them. A small body of work has focused on how these dashboard impact teaching or can support teacher practice. Some studies found that a dashboard can help teachers determine in real-time when to intervene and help students work more collaboratively in a multi-tabletop learning environment [158], or can help them single out problems concerning participation in digital discussion environments and intervene as needed [233]. Other studies have shown that a dashboard's information can help teachers manage web-based distance courses [167], support teachers in moderating discussions in digital learning environments [170] or support their awareness of the classroom state, student progress, and students in need of immediate help in an exploratory learning environment [165]. Finally, although many evaluation studies involving dashboards have been conducted, few studies (with the exception of [138]) have looked at the influence a dashboard might have beyond teachers onto student learning, in spite of a growing realization in the field that effects on student learning should be studied [214, 238].

Much of the prior work on teacher dashboards has focused on real-time dashboards (dashboards that teachers use while students are working during class time). A small but growing body of work has started to look at how to support teachers reflection outside of class (i.e., [**?**]). This would allow for a deeper reflection, where teachers reflect on their practices and plan how to move instruction forward is the first step to improving practice and causing long term behavior change in teaching practices. For example, in a study by Kelly et al. (2013) they found positive effects of teachers reviewing reports from a web-based homework system to decide what parts of the homework to review in class [138]. In another study, Mavrikis et al. (2015) report that information from a dashboard about difficulties students are facing in an exploratory learning environment may help teachers decide what to focus on in the following lesson [165]. Work from Prieto et al. (2017) presents a design framework and a series of guidelines to design technologies that support teachers' reflection based on everyday evidence and feedback, with the aim to improve educational practice. Other work from Gerritsen et al. (2018) introduces the action-reflection-planning framework that can be used with a smart classroom as way to train and provide feedback to TAs [99].

In the current chapter, I build on this growing body of work. Specifically, I look at the scenario in which a teacher uses a dashboard with student data when preparing for a class session; a dashboard might help in focusing the class discussion on the topics most in need of discussion (e.g., problems or specific error types that are currently challenging for the students). I present results from a quasi-experimental classroom study investigating effects of a high-fidelity dashboard prototype, Luna, with analytics from an ITS. After a class session where students use the ITS, teachers use Luna as they plan for and execute the next class session. The study looks at the effects of the dashboard on teacher knowledge, decision-making and actions in the classroom as well as student learning.

5.2 A Causal Chain that Captures Dashboard Influences

I defined a hypothesized causal chain that represents how information in a teacher dashboard may affect teachers and students in the classroom (Figure 5-1). It focuses on scenarios in which a teacher uses the dashboard to prepare for a class session, in blended courses that use some form of educational technology. The teacher dashboard, displays up-to-date information about students' performance, progress, and learning, with some educational technology. To note is the fact that the causal chain may apply to any dashboard, learning analytic tool, teacher awareness tool, or report on student learning in blended courses, where teachers use it to guide their instruction to create a lesson plan and prepare for a class session.

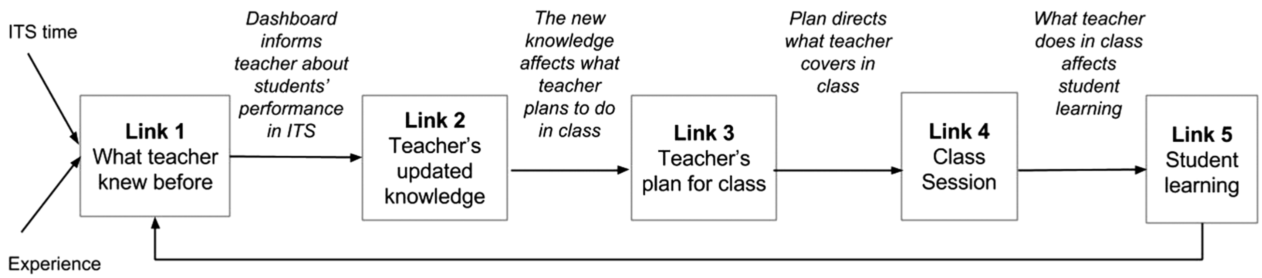


Figure 5-1: A causal chain that represents the effect of a teacher dashboard on teacher practices.

From their experience with a particular class, teachers have knowledge about what their students generally can and cannot do well, at any given point in time (link 1, Figure 5-1). As they work with a dashboard, teachers may learn new information about the performance and knowledge of their students (link 2 in Figure 5-1). When teachers plan for a class session, their updated knowledge may affect the lesson plan (link 3 in Figure 5-1), which then guides what they cover in class (link 4 in Figure 5-1). Ultimately, what teachers do in the class session is what students get exposed to and what affects their learning (link 5 in Figure 5-1). Thus, the dashboard information needs to "travel" through many links; it must be embraced by teachers, incorporated in the lesson plan and used in the class session, for it to reach students and impact their learning. In the study and analysis in this chapter, I investigate the teacher dashboard's influence along each of the links in the chain. This causal chain differs from the LATUX [163] framework, which describes ways to design, develop, evaluate and deploy learning analytics tools for teachers. By contrast, the causal chain captures potential effects of a dashboard from proximal influences on teacher classroom practices and to distal influences on student learning.

5.3 Methodology

In this chapter, I focus on the following research questions:

- (RQ1) How does a dashboard with analytics from an ITS affect teachers' lesson planning and (subsequent) classroom sessions?
- (RQ2) Does the teacher's use of the dashboard help students learn better?

5.3.1 Experimental Design

Five teachers from two suburban schools took part in the study (17 classes, 300 students total). All classes were 7th grade (medium achieving or honors) except for a 6th grade honors class and an 8th grade low-achieving class. Two out of the five teachers had participated in previous iterations of Luna's design. The experiment had two conditions, an experimental condition, in which teachers used Luna while preparing a lesson plan, and a control condition, in which there was no dashboard. Classes were assigned to conditions such that each teacher had classes in both conditions. Conditions were balanced per teacher and school in terms of the level of achievement (high or low achieving class) and the order in which they happened during the school day. There were 9 classes in the control condition and 8 in the experimental condition.

I first provided teachers with 10–20 min of instruction on the analytics and visualizations that Luna displays (see Figure 5-2). For this instruction session, Luna displayed student data collected in previous studies. Students then worked for 60 min with the ITS (Lynnette [154], completing problem sets dealing with basic equation solving. Next, they took a 20-minute pre-test.

In both conditions, teachers were asked to prepare for 20 min for a class session and think out loud during the process; during these sessions, the researcher occasionally asked teachers to explain what they were doing. The sessions were video-recorded. For the experimental condition classes, teachers were asked to prepare for the class session using Luna, which provides information about their students' performance during the session with the ITS. For the control condition classes, teachers were asked to prepare without a dashboard, based on their experience, their knowledge of their students, and on what they noticed when students were working with Lynnette in the lab. (The only difference between the two conditions therefore was whether or not the dashboard was available during the preparatory sessions.)

Teachers then conducted the class sessions they prepared for. (The students did not use the ITS during class time.) During these sessions, each 40 min, 2–4 coders (undergraduate students and staff from our institution) took observational notes using a tool with predefined categories of observations that also allowed for free-form note taking.

After the class session, students took a 20-minute post-test. Both pre- and post-tests contained 9 exercises based on 9 problem sets in the ITS, covered the same equation types, with different numbers, and were assigned in counterbalanced manner. The pre and post-tests allow for an assessment of student learning gains due to the class session teachers conducted based on their preparation with or without the dashboard.

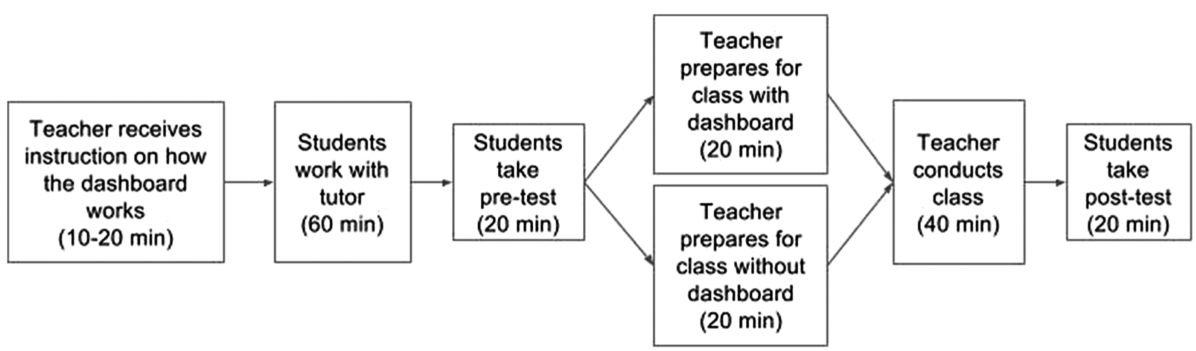


Figure 5-2: Experimental set up for an individual teacher and an individual class.

5.3.2 RQ1: How Does the Dashboard Affect Teachers?

I studied how the dashboard affects teachers in each of the links of the causal chain.

Teacher's updated knowledge. Targeting the first link in the causal chain, I analyzed the video-recordings of the teachers' preparation sessions to assess how Luna affected their knowledge. From these video-recordings, I distilled and paraphrased the main ideas teachers expressed (which I will call statements) as they were thinking out loud during the preparation sessions. A second coder verified the segmentation of the recording into statements by time-tagging each of them. As shown in Figure 5-3, I distinguished four categories of teacher knowledge, characterized by whether they knew it *before* inspecting Luna or became aware of it while inspecting it, and whether the focused-on information pertains to the class overall or to individual students. I created such tables with teachers' statements for each of the 8 experimental condition classes.

Row		Code	Statement
1	Teacher's knowledge or expectations for class	--	KC1- Expect students are good at because they have done this already: Add/Subtract Constant From Both Sides
		--	KC2- Expect students are good at because they have done this already: Combine Like [Constant] Terms
		--	KC3- Expect students are good at because they have done this already: Divide Both Sides By Variable Coefficient
		--	KC4- The Distributive Property, I thought they would struggle with
2	Learned from dashboard for class	(✔)G	LC1- Add/Subtract Constant From Both Sides
		(✔)G	LC2- Combine Like [Constant] Terms
		(✔)G	LC3- Divide Both Sides By Variable Coefficient
		(+)G	LC4- Compute Quotient For Constant (8 did not get to Level 3, 16 who got there mastered it), ok that's good
		(+)N	LC5- 8 students did not get to Level 3
		(+)N	LC6- Combine Like [Variable] Terms (who got there mastered it, it's just that not everybody got there)
		(+)N	LC7- Add/Subtract Variables On Both Sides, the same kids who got to that [Combine Variable Terms] got this
		(✔)B	LC8- Distribute Property, ok that is where they are starting to fall of
		(+)N	LC9- A couple of kids did not grab this [gesturing Level 1 Add/Subtract Constant From Both Sides and Combine Constant Terms]
		(+)N	LC10- A couple of kids did not grab this [gesturing Level 2 Divide By Variable Coefficient]
3	Teacher's knowledge or expectations for individual students	--	KS1- Student 1 would be in one of the higher levels if she was here the first day
		--	KS2- Student 2 wasn't here at all
		--	KS3- Student 3 was here only the second day
		--	KS4- Student 4 and Student 5 would goof around if they work together
		--	KS5- Student 6 would be ok working with Student 7
		--	KS6- Student 4 is pretty strong
4	Learned from dashboard for individual students	(+)N	LS1- I have a high [level 7], medium [level 5], and low group [level 3]
		(!)N	LS2- Student 8 is kind of surprising
		(+)B	LS3- Student 1 is behind
		(+)B	LS4- Student 2 is at (0:0) (wasn't here?)
		(+)B	LS5- Student 3 is at (0:0) (thought was here the second day?)

Figure 5-3: Example of a teacher's updated knowledge at the class and individual level after working with the teacher dashboard.

The statements that represent what teachers learned from the dashboard (rows 2 and 4 in Figure

5-3) were coded based on two coding schemas. The first set of codes aims to classify how Luna's information relates to the teacher's prior knowledge, using the following codes:

1. " ✓ " means that Luna's information confirms what teachers knew about their students (e.g.," *Yeah, [student name] is not surprising...* "),
2. " **!** " means that teachers were surprised by Luna's information, or it was inconsistent with what teachers knew (e.g., *"The only thing that stands out for me is this [pointing at combine like terms make constant and make variable]...*"),
3. " + " means that teachers learned from Luna, but it did not confirm or reject what they already knew, (e.g., "*... looking at it, [the]distributive property they have all pretty much mastered...*").

The second set of codes aims to classify whether the teacher's comment was about students doing well or not well in the ITS, based on data from Luna. It has the following codes:

1. "G" means that the teacher's comment is about information from Luna that showed students did well in Lynnette (e.g., "*I am actually kind of surprised that [student name] made it that far, that's good!*"),
2. "B" means that the teacher's comment is about students not doing well (e.g., "*... I see that that's what students have most trouble in, combine unlike terms to make a variable...* "),
3. "N" means that the teacher's comment is ambiguous (e.g., if the teacher says, "*Only one hasn't mastered the distributive property,*" it is not clear whether he/she views that as positive or negative).

The codes were assigned based only on what teachers explicitly said in the video-recordings of the preparation sessions. I and a trained coder first coded all statements independently. We then met and resolved all disagreements in coding through discussion and mutual consensus. The results reported here are based on this consensus coding.

Lesson Plan. Moving to the next link in the causal chain (link 3 in Figure 5-1), I analyzed how the knowledge gained from the dashboard may have influenced teachers' lesson plans. I focused on the lesson plans for the 8 classes in the experimental condition, which teachers created with help from Luna. To represent the lesson plans, I created tables (Figure 5-4) based on the distilled and paraphrased main ideas teachers mentioned or wrote down during the preparation sessions. These tables show the topics along with the exercises (if any) that teachers planned to cover during the class session, as well as their plans about individual students, when applicable. To study how the information learned from Luna affected the teacher's lesson plan, each of the items in the lesson plan (rows in Table 2) was matched with what teachers learned from Luna (rows 2, 4 in Figure 5-3). For example, if the teacher stated, "*... that is where they are starting to fall off, at the distributive property*" (LC8 in Figure 5-3) and then said "*... we are back into distributive property ... so I can steal some examples from my other ... [the plan for my other class] (writes down some exercises with the distributive property used in the previous class they prepared for),*" I would put the code LC8 under the respective row in the lesson plan table. This coding procedure was applied only to statements for which teachers explicitly stated that the reason they were going to cover it in class because was information from Luna.

Class Session. Moving to the next link in the causal chain (link 4 in Figure 5-1), I counted how many of the statements in the lesson plan that were based on information from Luna, actually made it into the class session. For each class session, I analyzed the joint set of all notes taken

Code			Concepts teacher will cover/review in class (WHAT?)	Exercises teacher will do in class (HOW?)
--			(Revise concepts through equation solving + students working in groups)	
LC9	1		Add/Subtract Constant From Both Sides	x+8=-15
LC10	2		Divide Both Sides By The Variable Coefficient	3x = 24
--	3		Distributive Property/Combining Like Terms	
LC8		a	(Stus started to fall of at the Distributive Property)	5(x+4)=40 3=7(4-2u)-6u
LC6		b	(This has that combine in it)	3(1+4n)-2(5n-3)=25
(From other class)	4		Variables On Both Sides	
		a	Variables On Both Sides	5x+6=2x+15
		b	With Negative Numbers	-7x-2=24-9x
		c	Distributive Property + Variables On Both Sides	4(5n-7)=10n+2
		d	Distributive Property + Variables On Both Sides	2(6d+3)=18-3(16-3d)
LS1, LS2, LS3, LS4, LS5	5		Students work in groups of 3 with worksheet with exercises on Distributive Property + Variables On Both Sides (same worksheet as previous class)	Level 7 1 Student 6 2 Student 9 3 Student 10 4 Student 11 5 Student 12 6 Student 13 7 Student 14 8 Student 4 Level 5 6 Student 15 3 Student 16 2 Student 17 1 Student 18 ~~5 Student 19~~ 7 Student 20 4 Student 21 Level 3 3. ~~Student 8~~ Student 24 1 Student 7 2 Student 22 5 Student 1 6 Student 23 7 Student 5 8 ~~x Student 3~~ x Student 2 (with Student 4 who is pretty strong and they were not here)
--	6		Give worksheet from previous class	

Figure 5-4: Lesson plan, with information attributable to Luna coded in the first column.

during the sessions by all coders. I created tables to compare the lesson plan with the class session (Figure 5-5). Next to each statement of the lesson plan, columns were added to show

- whether teachers covered the planned statement in class,
- a summarized description of what they discussed,
- who was involved in the discussion during the class session.

The categories under the column *Covered* indicate whether teachers covered that statement in class (*Yes/No/Not planned*, with the latter code meaning the teacher did something they did not plan for or did not say they were planning for).

5.3.3 RQ2: Does Teacher's Use of the Dashboard Help Students Learn Better?

I studied whether students in the experimental condition, where teachers used Luna to prepare for the class session, had higher learning gains attributable to the class session, compared to the control condition. For this analysis, I considered student learning gains from pre- to post-test. (These gains can be attributed to the class session led by the teacher, since there were no other learning activities in between the pre-test and post-test.) I had analyzable data for 242 students (students who missed the pre-test, class session or post-test were removed from the analysis). Seven independent graders and I graded the tests. Fleiss's Kappa was 0.98. The grading schema

Code			Concepts teacher will cover/review in class (WHAT?)	Exercises teacher will do in class (HOW?)	Covered?	Concept/Misconceptions	Who?
--			(Revise concepts through equation solving + students working in groups)		Yes	-Focus on what they will do today -Focus on what teacher saw in dashboard: weaknesses and strengths -Focus on Distribute Property and Combine Like Terms where most did not get to -Most reached Level 5 but not all -Focus on working with things they have never done before (Part B)	
LC9	1		Add/Subtract Constant From Both Sides	x+8=-15	No		
LC10	2		Divide Both Sides By The Variable Coefficient	3x = 24	No		
--	3		Distributive Property/Combine Like Terms		Yes		
LC8		a	(Stus started to fall of at the Distributive Property)	5(x+4)=40	Yes	-Focus on Distribution -Focus on two step equations: do add/subtract -Focus on canceling and simplification -Focus on checking answer	Teacher discusses with students, Student 7, 2, 5, 24
				3=7(4-2u)-6u	Yes	-Focus on Distributive Property and Combine Like Terms -Focus on distributing the 7 -Focus on divide and the other steps	Teacher discusses with students, Student 14, 11, 4, 16
					Not planned	-Focus on not distributing to the other side -Focus not distributing to the 6u term	
LC6		b	(This has that combine in it)	3(1+4n)-2(5n-3)=25	Yes	-Focus on splitting stus in groups -Focus on distribution of both parenthesis -Focus on Combine Like Terms, add/subtract, divide -Focus on checking solution	Teacher discusses with students, students work in groups, Student 11
					Not planned	-Focus on distributing the negative -2 with the other negative -3 as it is tricky	

Figure 5-5: Part of a lesson plan compared with what happened during the class session.

gave full credit for correct statements and no credit for incorrect statements.

5.4 Findings

5.4.1 RQ1: How Does the Dashboard Affect Teachers?

Teacher's updated knowledge. Across 5 teachers in 8 experimental condition classes, I recorded on average 12.6 statements per class that were evidence of the dashboard affecting what teachers knew about their students (Updated Knowledge in Figure 5-6). (I will refer to the statements learned from Luna as "learned statements.") There were slightly more such statements at the class level compared to the individual level (7.1 statements per class at the class level versus 5.5 statements per class at the individual level). Teachers seemed surprised more often by information at the individual level (on average 1.4 statements per class) than at the class level (on average 0.38 statements per class). Further, out of the 12.6 statements on average that provide evidence that teachers learn from Luna, 34.7% relate to things that students are not doing well (19.8% at the class and 14.9% at the individual level), while 29.7% relate to things they are doing well (19.8% at the class and 9.9% at the individual level). Thus, Luna's information affected the teacher's knowledge about the class overall and individual students. Furthermore, these learned statements are about students doing well and not doing well with roughly equal frequency.

Lesson plan. Moving to the next link in the causal chain (Lesson Plan in Figure 5-6), 44.6% of the learned statements get incorporated in the lesson plans (5.6 out of 12.6 statements per class learned from Luna). At the class level, teachers include in the lesson plans 33.3% of the learned statements, compared to 59% at the individual level. This finding suggests that Luna prompted change in teachers' lesson plans, both with respect to the class as a whole and to individual students, though more so with respect to the latter. In addition, teachers include an average of 3.1 statements per lesson plan pertaining to students not doing well (24.7% of all learned statements), namely, 1.9 (14.9%) at the class level and 1.3 (9.9%) at the individual level. By contrast, they include only 0.75 statements per class (5.9% of the learned statements) pertaining to students doing well (Figure 5-7)! As a different way of looking at this contrast, teachers include in their lesson plans 20% of the learned statements regarding students doing well, whereas they include 71.4% of the learned statements regarding students not doing well. Thus, the knowledge that teachers gain from Luna is accounted for in various ways in their lesson plans, in particular knowledge about where students are struggling.

	Class Overall			Individual Students		
	Updated Knowledge	Lesson Plan	Class Session	Updated Knowledge	Lesson Plan	Class Session
(✓)	1	0.13	0.13	0.5	0.13	0.13
(+)	5.8	2	1.4	3.6	2.6	1
(!)	0.38	0.25	0.25	1.4	0.5	0.5
G	2.5	0.13	0	1.3	0.63	0.5
B	2.5	1.9	1.6	1.9	1.3	0.63
N	2.1	0.38	0.13	2.4	1.4	0.5
Total	**7.1**	**2.4**	**1.8**	**5.5**	**3.3**	**1.6**

Figure 5-6: Effect of the dashboard measured as average number of statements per class.

I also made informal observations as to how the information teachers learned from Luna made it into their lesson plans. At the class level, in 6/8 classes where teachers prepared the control before the experimental classes, they used as a basis for the experimental classes the plan they prepared for the control ones, but changed and adapted it based on Luna's information. For example, they planned to discuss specific topics students were having trouble with, or added and removed exercises or topics from the plan based on Luna's information. One teacher, who prepared for the experimental before the control class, based the lesson plan for the former entirely on the dashboard, focusing on discussing errors the class was having with example exercises Luna provided for each error. In addition, based on Luna's information, in 1/8 classes the teacher decided not to cover a topic because the class had mastered it, while another teacher planned what topics to cover for the rest of the week, after the class session. At the individual level, in 3/8 classes teachers planned to work one-to-one, during or after class, with students who were not doing well as shown by Luna, while in 2/8 classes one teacher decided they did not need to spend time with individual students, who despite initially not doing well according to Luna, had fixed the problems they had, also according to Luna. In 2/8 classes, teachers adapted a worksheet they planned to give students based on the information in Luna. And lastly, somewhat to our surprise, in 2/8 classes one teacher assigned students to work in groups during the class session, with group composition based on students' progress as shown by Luna. In conclusion, there is a variety of ways in which teachers incorporate in their lesson plans knowledge they gain from Luna both at the class and individual level.

Class session. Moving down the causal chain, teachers implement in the class session 60% of those planned statements (Figure 5-7), which is 26.7% of the ones they learned from Luna (13.9% at the class and 12.9% at the individual level). Furthermore, 17.8% of the learned statements about students not doing well make it to the class session (12.9% at the class and 5% at the student level), as opposed to 4% of the ones about students doing well. Thus, the knowledge teachers gain from Luna that makes it to the lesson plan also gets accounted for and reaches students in the class session.

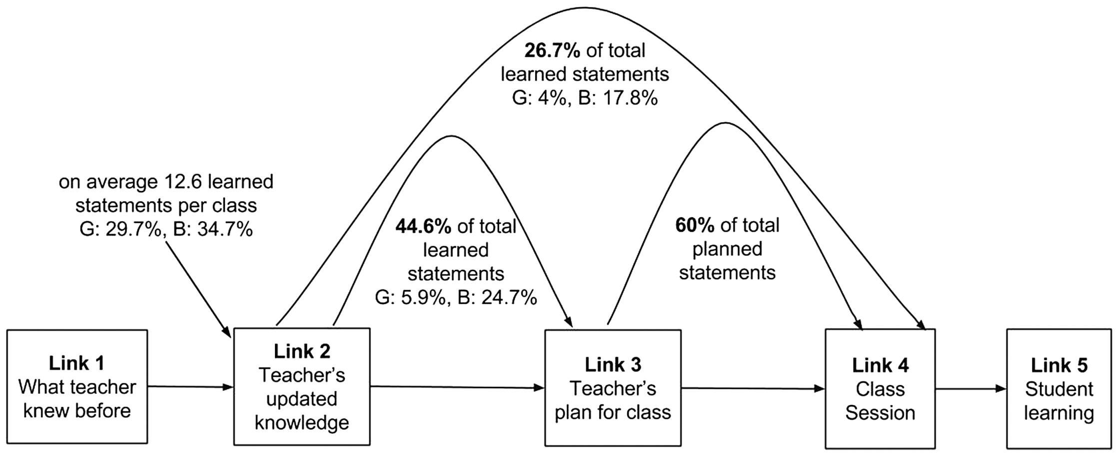


Figure 5-7: How the information from the dashboard traveled down the causal chain. The percentages on the arrows are percentages of the total number of statements teachers learned from Luna. "G" and "B" refer to statements about students doing well and not so well, respectively.

5.4.2 RQ2: Does Teacher's Use of the Dashboard Help Students Learn Better?

To test for knowledge differences between the conditions right before the class session, I ran a Welch Two Sample t-test on the pre-test data to compare the means of the control condition (M = 5.48, SD = 2.89) and experimental conditions (M = 4.53, SD = 3.23). I found that, in spite of the efforts to create balanced conditions, students in the control condition had a significantly higher pre-test mean than those in the experimental condition (t = 2.3908, df = 236.31, p = 0.0176). I used a hierarchical linear model (HLM [196]) with three nested levels to compare the gains from pre- to post-test (which can be attributed to the class session, with condition differences attributable to the dashboard). In the model, students (level 1) were nested within classes (level 2) which were nested within teachers (level 3). I included the condition as a fixed effect, and the difference between post- and pre-test as the dependent variable. There was no significant difference between the conditions in learning gains (t = -1.620, df = 240, p = 0.1065).

5.5 Discussion and Conclusions

In this chapter, I examine and trace the influence of a dashboard on teachers' knowledge of their students, their lesson plans and execution of these plans, and ultimately on student learning; these influences are summarized in a "causal chain" that guides the analysis. To the best of my knowledge, the use of this causal chain, to trace the effects of a teacher dashboard, which presents student data to teachers, on teacher practices and student learning, is a methodological innovation in dashboard research. I note that this causal chain is not specific to ITSs or to the particular dashboard used. Further, to the best of my knowledge, the current study is one of the first that tries to measure not only the effect of the dashboard on teachers, but also on student learning as a result of the teacher's use of a dashboard in a classroom setting [214, 238] (with the exception of [138]).

The study results show that the dashboard affects teachers at all the links in the causal chain. First, teachers update their knowledge with an average 12.6 statements per class (Figure 5-7). In turn, the teachers' updated knowledge helps them to adapt or change their lesson plan and what they decide to cover in class. Teachers incorporate 44.6% of the statements they learned from the dashboard in their lesson plans, which suggests that Luna provided useful information to teachers on their students. Furthermore, teachers implement in the class session 60% of the planned statements, which is 26.7% of the statements they learned from the dashboard (Figure 5-7). This is a substantial portion, even if moving down the causal chain, the number of statements that can be attributed to the dashboard decreases at every link. Perhaps that kind of "dilution" of influence, looking at causal effects further removed from what teachers gleaned directly from the dashboard, is not surprising, although I believe this study is the first to document this phenomenon regarding dashboards.

In addition, I found that teachers attend mostly to information from Luna that shows their students are not doing well in certain aspects of equation solving, as opposed to information about doing well. This perhaps is not surprising in and of itself but it suggests that the dashboard presents information that teachers do not have. Furthermore, although teachers learn almost the same number of statements for both the class overall and individual students who are not doing well, more statements related to the class, rather then individuals, get accounted for in the class session. Lastly, I did not find that Luna influenced student learning. Perhaps that is a result of the "long" causal chain and the dilution that happens moving further into the chain (see Figure 5-7). Generally, I can conclude that the dashboard's information, about skill mastery, occurrence of errors and student progress in an ITS, at the class and individual level, is helpful to teachers as they prepare for a class session, to plan their next lesson which guides their decisions in the classroom.

In sum, the results of the study indicate that a teacher dashboard with their students' analytics can be helpful to teachers. I found that the dashboard's information affects the teacher's knowledge, lesson plans, and what they cover in the class session. In my previous work [256] I found that teachers can have surprisingly detailed knowledge about their students; it was therefore not obvious that the dashboard would tell them much that they did not already know. However, the current study shows that even though teachers generally know their classes well, a dashboard with their students' analytics can still help them know more about their students, and can influence their lesson plans and what actions they take during the lesson.

5.5.1 Limitations as a Jumping Point for Future Work

There are reasons to think that the effect of the teacher dashboard both on teacher practices and students can be strengthened and more influential then what I found in the current study.

To begin with, planning sessions (times when teachers plan with the dashboard) and executing sessions (class sessions) could be longer. For instance, teachers in the current study had only 20 min total (for creating two or three lesson plans), which in retrospect was not enough time for teachers to fully digest Luna's information and plan what to cover in class. Similarly, teachers only held one class session 40-minutes in length, which restricted how much teachers could plan for to cover. These time limitations could explain why teachers only planned for part of the information they learned from Luna and why fewer statements made it from the plan into the class session. Similarly, students took the post-test either right after the class session or the day after. Thus, they had no time to practice what teachers covered in the class session which could explain the no-change in learning gains. Therefore, longer planning sessions and observations of more than one class session could help teachers better plan for and act in the classroom and as a result decrease the dilution effect along the causal chain. In particular, using the dashboard more than once, say over multiple weeks as part of their day-to-day practice could better help teachers' planning for and actions in the classroom, and as a result support their long term behavior and practice change. Inspired by those ideas, Part 3 of my thesis proposes to investigate teachers' dashboard use and behavior change over multiple weeks during the semester.

Secondly, a more focused study on the earlier links of the causal chain could help reduce the effect of the dilution. For example, rather than focusing on the whole chain, from beginning to the end (which is quite long), it might be worth focusing initially on reflection and goal setting, to better support teachers in those stages, before they move to action taking. An increase of goal setting, regardless of the dilution, would cause an increase in actions teachers decide to take in the classroom. Inspired by those ideas, in Part 2 of my thesis I focus mainly and only on helping and supporting teachers reflect and goal set for what they want to change in their teaching practices.

Last but not least, in the current study I investigated teacher data needs only in relation to their students and shared with them only student data on progress and performance in an educational technology. It would be interesting to explore if teachers would like to see their own data, if they would find that helpful or if a combination of their own data together with their students' data would be best to help support their teaching practices and behavior change in the classroom. In Part 2 and Part 3 of this thesis I explore teacher data needs in relation to their own data (Part 2) as well as to their own data combined with students' data (Part 3).

Part2: Designing a teacher dashboard with teacher's own data and exploring how to support reflection-for-action

Chapter 6

Motivation for Part 2

6.1 Introduction

In Part 1 I investigated teachers' data needs in relation to their student data. Findings showed that teachers use student data to drive instructions and very frequently manually generate this data. Further, teachers found student data from an ITS helpful and a dashboard with such data affected teachers' knowledge, lesson planning and actions they took in the classroom. However, in this process I noticed a dilution where only part of the information teachers learned from the dashboard made it to the lesson plans and only part of the planned material made it into the class session. Overall, the results and findings of Part 1 showed that sharing with teachers student data affects their teaching practices and supports them in the process of reflecting, planning and acting in the classroom.

Building on my work and findings from Part 1, in Part 2 I was very interested in investigating a different set of dimensions that would support teachers and their practices in the classroom. In this chapter, I describe my motivation for choosing each of those dimensions and I set the stage for the research and findings I have conducted in Part 2 of the thesis.

6.1.1 Supporting teachers with their own data

In Part 1 I focused on student data, which has been the focus of much prior work. However student data only represents half of the picture. There has been very little work on showing teachers their own data. If we want to help teachers improve their practices it is necessary to focus on their own behaviors as well.

Thus, in Part 2 of my thesis I focus on exploring, investigating and designing for teacher data needs in relation to their own data as well as the effect of this data on their practices. I focus on questions such as how would teachers react to seeing their own data, for example, of their performance and behaviors in class, would they even be interested in seeing their own data or what data would they find most interesting and helpful, how would the data affect teachers goal-setting and interest for behavior change, etc.

As discussed in the Background Chapter (Chapter 2), prior work around Personal Informatics (PI) and Professional Informatics for behavior change provided another strong motivation and inspiration for me to investigate the path of sharing with teachers their own data. Recent work around PI for professionals shows examples in various professions of how data is used to provide feedback to those professionals, as a way to support improving their practices and changing their behaviors. [99, 121, 150]. Taken together, this body of work motivated me to look into this new path of supporting teachers and their teaching with their own data from the classroom.

6.1.2 Working with teachers in higher education

Extending on the discussion in the Background Chapter (Chapter 2), teachers in higher education, often also referred to as instructors or faculty, are a population that rarely receives any data or feedback on their teaching, or any opportunities for Professional Development (PD) in relation to their teaching. This is very much in contrast with K12 teachers who are required to engage in PD training several times each year, with activities that include seminars, workshops, expert or peer classroom observations and consultations [61, 223]. Unlike K12 teachers, instructors at the university level do not have such requirements. Even if the instructors were interested in such PD, in many cases there are rarely any opportunities at their schools or more in general for them to attend. Lastly, instructors often may lack the time, bandwidth or even incentive to take part in such PD. This is the case in particular for instructors at research institutions, where research rather than teaching is the primary focus of their academic careers. Consequently, often teaching is considered to be the professoriate's neglected stepchild [250]. These reasons motivated me that in Part 2 I switch from working with K12 teachers to instead focus my work with instructors at a research university as the primary population.

6.1.3 Immediacy and nonverbal behavior data

An important aspect of teachers' classroom skills, often overlooked in teacher PD training and feedback, are teacher immediacy and nonverbal behaviors. Immediacy is the perceived closeness between people that is achieved through language and communication [247]. Teacher immediacy is conceptualized as those nonverbal behaviors that reduce physical and/or psychological distance between teachers and students and increase their interpersonal closeness, with the ultimate goal of enhancing student learning [22, 23, 102, 201]. Nonverbal behaviors are behaviors that do not involve verbal communication. Nonverbal behaviors that teachers can use in their teaching include location and movement in the classroom, eye gaze, smiles, nods, relaxed body posture, forward leans, gestures and vocal variety [25]. Nonverbal immediacy behaviors are some of the most valuable communication tools instructors have available to them [201]. These nonverbal immediacy skills can help teachers and students have a happier, more productive, classroom experience. There is a large body of research that studies and highlights the strategic and important role of the teacher nonverbal immediacy in teaching-learning processes in the classroom.

To begin with, immediacy is **important to teachers**. It is necessary for teachers to be aware of their and their students' nonverbal behavior to [173] better understand student nonverbal messages, to gain the ability to send students positive signals that reinforce learning and avoid negative signals that hinder learning.

In addition, immediacy is **important to student learning**. Teachers' immediacy is meaningfully correlated with student learning in the course, positively affects students'perceptions of their understanding and learning, as well as it has a modest relationship with students'actual learning performance in the course [22, 253]. Similarly, teacher immediacy and nonverbal behaviors are important as they support students' attitudes towards learning. When teachers display more immediacy, students evaluate more positively the class, instructor, subject matter and course content [22]. Teacher immediacy has a positive relationship with students'attitudes towards learning. More immediate teachers are more motivating to students and their students are more likely to develop positive attitudes toward the class, attend class more and approach rather than avoid the subject [22, 64].

More in general, teacher immediacy is **positively associated with a range of classroom variables**, including: Perceived instructor credibility, fairness and clarity, student compliance, students' perceptions of being mentored, student intent to persist in college, etc. [253].

Motivated and inspired by this prior work, in Part 2 of this dissertation I focus on sharing with teachers their own data in relation to their nonverbal behaviors in the classroom as a way to support and help improve their immediacy and nonverbal behaviors.

6.1.4 Instrumented classrooms for data collection

In Part 1, I used Intelligent Tutoring Systems (ITSs) to collect data on student learning and performance in class. However, ITSs do not provide the infrastructure for collecting data on teachers or their teaching and are not necessarily designed for and with the teacher and their needs in mind.

In order to be able to collect data about teachers themselves and their immediacy and nonverbal behaviors, I needed a technology that would allow for the collection and/or generation of such data. In Part 2 I decided to move to and work with instrumented classrooms (for a more extended discussion please see the Background Chapter (Chapter 2)). Specifically, I worked with EduSense [11], a cutting edge technology that allows instrumenting classrooms with sensors that collect audio and video data automatically and unobtrusively, and makes use of various Machine Learning techniques to generate information on teacher and student behaviors in the classroom. In particular, EduSense allows for the collection and generation of various nonverbal behavior data.

6.1.5 A New Framework for Reflection-For-Action and Behavior Change

From Study 3 in Part 1, I found that when teachers use a dashboard to prepare for class, there is a dilution effect that happens as the teacher walks through the links of the causal chain. Only part of the information that the teacher learned from the dashboard makes it to the lesson plan and similarly, only part of what the teacher planned to cover in class actually makes it into the classroom session. Due to this dilution, in Part 2 I focus on a subset of the causal chain, specifically on strengthening reflection-for-action, namely teachers' reflection and goal-setting practices as a first step to changing their practices and long term behavior. For a more extended discussion of the definition and importance of reflection-for-action, please see the Background Chapter (Chapter 2).

In addition, in Part 1, as the teacher walks through the links of the causal chain, except for the dashboard with the student data, there was not any other support for teachers as they were reflecting and planning their next lessons. I intentionally designed the experiment and dashboard that way as the primary aim of showing teachers the dashboard was to investigate how they would make use of it and how student data would affect their teaching practices. However, in Part 2 I aim to design a technology that will more explicitly and better support the teachers' reflection and goal setting through text-based PD, data presented in various forms, prompts and questions as they work with the data, etc.

To better represent the various stages of reflection-for-action teachers go through as they work with feedback and data from class, I have created a new hypothesized chain of practice. This new chain of practice was based on the causal chain I created in Part 1 as well as other work on professional reflection [140] and frameworks for smart classrooms [99].

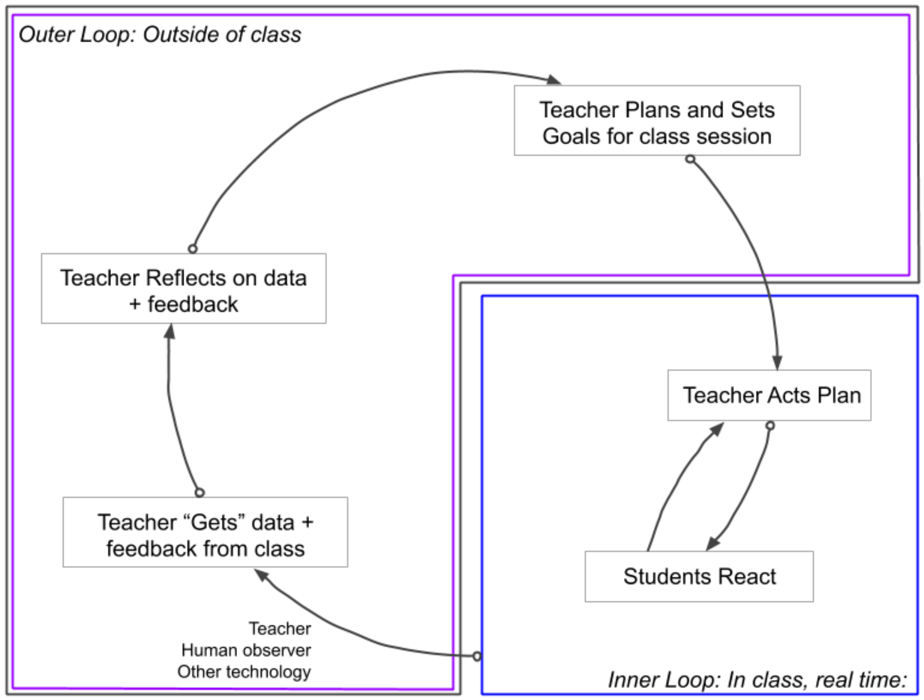


Figure 6-1: A framework for teacher in and out of class practices.

The framework separates the time the teacher is in the classroom (the Inner Loop, represented in the lower right blue square) from the time the teacher is outside of the classroom, thinking, reflecting preparing for the next class session (the Outer loop, represented in purple). It is important to make this separation as the reflections, goals and actions teachers take in real-time, in the Inner Loop, are different from those that teachers takes after class time, in the Outer Loop, as they are preparing for the next classroom session.

During class, teachers and students interact together. The teacher acts their lesson plan and students react to the teacher's actions and behaviors. During this process, the teacher may engage in reflection-in-action or real-time reflection-for-action [210]. This involves for example immediate reflections and decisions that the teachers take during class time, as they are teaching, say to distribute better their attention and time across various students. During the Inner Loop, various technologies such as ITSs or Instrumented Classrooms can collect data on teacher and student behaviors and performance during class time.

In the Outer Loop, teachers may receive data and feedback on their own or their students' classroom behavior and performance. This data and feedback can come from an expert human observer or from some other technology (such as an Intelligent Tutoring System or an Instrumented Classroom). Even without an observer or technology, teachers may keep notes or simply recall what happened in the classroom during the Inner Loop, which can serve as the "data" they get from class. Once they receive this information, maybe in a dashboard or report form, the teachers may engage in reflection-on action [210], a retrospective not real-time reflection

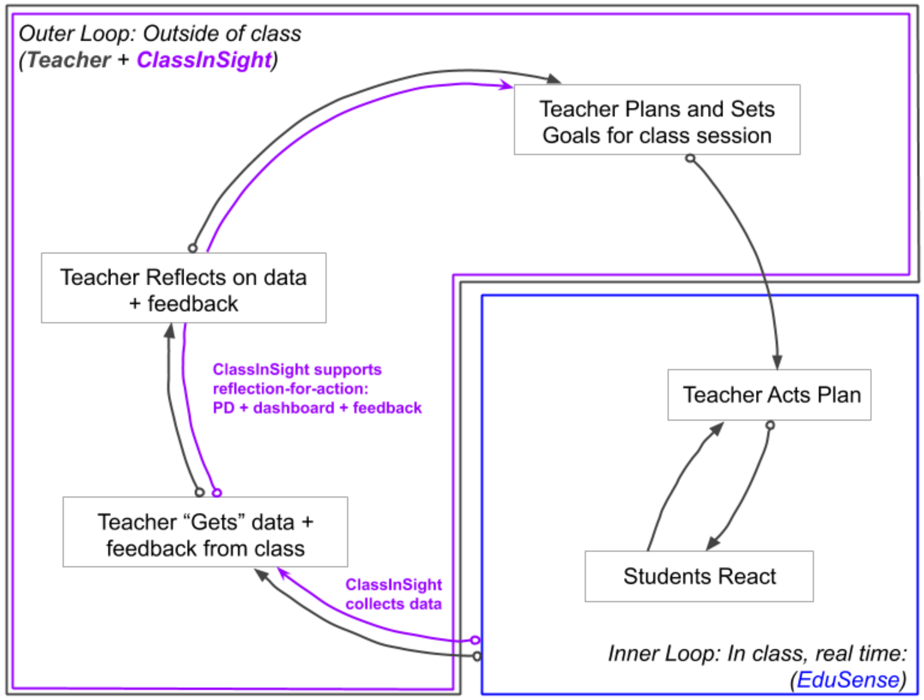


Figure 6-2: Technology supporting teachers' reflection-for-action in Outer Loop.

process. Teachers engage in this type of reflection after an activity has happened, where they have more bandwidth, time and attention to reflect on what happened and why. To take it a step further, in the outer loop, teachers may engage in reflection-for-action which is a process when the teachers are reflecting, planning and setting goals on how to change their behaviors and actions in class. For example, the teacher would reflect about how they are distributing their time in class, as well as think about the next steps of what to do to change their behavior in the next class sessions and how to do that. The teachers then conduct the next class session, where they act the goals they have set for themselves and change their behaviors. And the whole process repeats. This deeper reflection for change is the first step to a longer term behavior change, namely to teachers integrating those behavior changes in to their long term day to day teaching practices.

In order to support teachers in doing reflection-for-action, in the Outer Loop, it is necessary to support teachers: (1) with data and feedback from their classrooms, (2) during the reflection process, as they see this data and feedback, and (3) during their planning and goal setting process for the next class session. The focus of my work in the rest of this thesis is to design and create tools that would provide support for teachers' reflection-for action in the Outer Loop (Figure 6-2. I will refer to this technology as *ClassInSight*.

To begin with, ClassInSight would use the data collected from the Inner Loop (from an Instrumented Classroom technology such as EudSense) to generate meaningful charts and data visualizations to share that with the teacher in the form of dashboard. The technology would be designed with the teacher needs in mind and focus on presenting teachers data that they find meaningful and helpful. To support teachers' reflection-for-action, the technology would accompany the data in the dashboard with additional information in the form of Professional Development, as a way to better support and contextualize reflection. In addition, the technology would share with teachers feedback to support their sense making of the data and contextualizing their performance and would have prompts or ask questions to support their reflection and goal-setting.

6.1.6 Theoretical framework for supporting teachers' reflection-for-action and behavior change

In order to support teachers in their reflection-for-action, and ultimately their interest in behavior change and practice improvement, it is important to first and foremost support teachers' motivation for behavior change. Motivation has been described as the forces acting on or within an organism to initiate and direct behavior as well as an indication of persistence of behavior [191]. Goal-setting is emphasized in the literature as a key motivational process (i.e., [37, 39, 151, 152, 212, 213]). For example, in the teachers' case, their level of motivation directly influences how much teachers will engage in goal-directed behavior and what kinds of goals they will set for themselves to achieve, which as a result will influence action taking, behavior change and further improve teachers' long term practice (Figure 6-3).

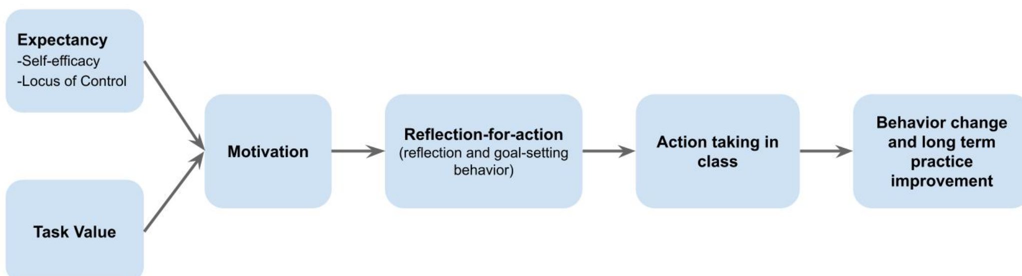


Figure 6-3: Impact of Value and Expectancy Motivation, Goal Setting And Behavior Change. Adapted from [19, 134] and the other literature cited in this section.

There exist many theories and frameworks that have been proposed to explain motivation and how to best support or enhance it (i.e., expectancy-value theories of motivation described in [19, 28, 29, 81, 134, 213, 248, 249]). Self-efficacy (SE), Locus of Control and Task Value are three concepts at the core of many such theories and frameworks that influence the level of motivation (Figure 6-3). These three components interact with one another and influence instructors' motivations to set goals and change their behaviors to improve their practice. Changes in one dimension can change the level of motivation for teachers, and as a result their behaviors and actions.

Self-efficacy (SE) refers to ones beliefs in their own capabilities or that one has the requisite skills to successfully perform a course of action and execute the behavior required to produce the outcomes (i.e., [34, 35, 36, 38, 41, 42], etc.). Prior work has shown many of the benefits of higher SE in teachers (i.e., [254]). For example, in teachers, a higher sense of SE is connected to more effort in organizing, planning, and delivering their lessons, as well as in setting goals that reveal higher instructional aspirations and enthusiasm compared with teachers that have a lower sense of SE [17]. Teachers with high levels of SE also are more likely to be open to trying new ideas, to experiment with innovative instructional methods and tend to exhibit a variety instructional practices and flexibility [100, 108, 222]. Literature has also shown that teachers in high SE are more responsive to their students' needs, are more likely to exhibit greater warmth towards their students and better support the learning and development of their students ([34, 246]). Students tend to learn more from teachers with a high sense of SE and a high SE was shown to have a positive influence on student motivation and achievement [34, 176]. Finally, teachers with a greater sense of SE also are more resilient and persist longer when confronted with challenges, have a greater enthusiasm for teaching, and are generally perceived as more effective teachers [107, 108, 110].

Locus of control refers to a persons beliefs about the control they have over outcomes in their environment. Locus of control can be internal (the belief that the control of outcomes comes within oneself, namely it is a choice) or external (the belief that the control lays being outside oneself, namely it is a chance) [190, 204]. The amount of control that one believes to have (for example in affecting their health outcome or in learning of a new technology) affects their willingness to engage in certain behaviors (i.e., [45, 116, 128]).

And lastly, **Task Value** is related to the belief that the task one is performing or the goal toward which one is working is valuable to oneself [81]. Task value influences the decision on whether to engage and pursue a specific activity or set a goal to change or improve on ones behaviors. There are multiple frameworks that in more detail describe the sources from where value can be derived [19, 248, 249]. Two common sources of value are intrinsic and extrinsic value (for example the value one find s in doing the task versus the value in the outcome or rewards for completing a task).

In Part 2, I focus on investigating how to best support and influence teachers' SE as a way to positively their motivation for goal setting and behavior change. I decided to focus on SE provided the rich and extensive literature on the effects and importance of SE on motivation and behavior change, in general and for teachers specifically, discussed above. Further, I design PD materials aimed to introduce instructors with the value of teacher immediacy and nonverbal behaviors, however in this work, I do not focus on influencing value, or the locus of control of instructors. More details about those choices are described in the studies in Chapter 7 and Chapter 8.

6.2 Content of Part 2

In the following 2 chapters in Part 2 I will share the research and findings on designing a teacher dashboard with teachers' own data and exploring how to support reflection-for-action. In Chapter 7, I describe an exploratory and design study together with findings of sharing with teachers their own data and investigating their data needs and interests. In Chapter 8 I describe a study that builds on these findings and aims to investigate supporting teachers' reflection-for-action through supporting task value and SE. In these studies, I do not focus on measuring behavior change rather I focus on investigating and better supporting reflection-for-action and measuring various proxies for behavior change and teachers' intentionality to change.

Chapter 7

An Exploratory and Design Study of Teachers' Data Needs In Terms of Teacher Immediacy and Nonverbal Behaviors

This chapter is based in part on the following publications:

- [259] Franceska Xhakaj, Na Young Lee, Erik Ulberg, Amy Luo, Seoyoung Lee, Katrina Hu and Amy Ogan. 2021. Investigating Teacher Data Needs In Terms of Teacher Immediacy and Nonverbal Behaviors. In de Vries, E., Hod, Y., and Ahn J. (Eds.). (2021) Proceedings of the 15th International Conference of the Learning Sciences - ICLS 2021. Bochum, Germany: International Society of the Learning Sciences.
- [11] Karan Ahuja, Dohyun Kim, Franceska Xhakaj, Virag Varga, Anne Xie, Stanley Zhang, Jay Eric Townsend, Chris Harrison, Amy Ogan, and Yuvraj Agarwal. 2019. EduSense: Practical Classroom Sensing at Scale. Proc. ACM Interact. Mob. Wearable Ubiquitous Technol. 3, 3, Article 71 (September 2019), 26 pages.

Abstract: Teachers play a crucial role in students' learning. Therefore, it is important to support teachers in their teaching. In particular, it is important to support teacher immediacy and nonverbal behaviors, which are essential to teaching, learning and to creating a positive classroom environment but are often overlooked in teacher training and challenging to capture for giving feedback. As classrooms become instrumented with technologies, opportunities emerge to provide teachers support with data from these technologies. In this chapter, I describe an exploratory and design study with 9 instructors at a R1 institution. The study aims to understand teachers' values, efficacy, motivations and interest around teacher immediacy and nonverbal behavior data. In addition, the study explores how these constructs change after the teachers see their own nonverbal data and what goals, if any, they set to change their behaviors in the classroom. The results of the study show that teachers score quite high but with room for improvement in relation to various measures of value, efficacy and motivation. Teachers showed interest in location and eye contact data about themselves and their students. They set goals for behaviors they wanted to change and mentioned challenges they face in using such behaviors in the classroom. The study uncovers how immediacy and nonverbal data can help teachers in

their practices and provides solid recommendations for designing technologies that support such practices.

7.1 Introduction

Teachers are crucial in supporting students' learning in the classroom. It is very important to support teachers in their practice and help them improve on their teaching. Professional development (PD) is a traditional way to provide training and feedback to teachers. PD is highly effective (i.e., [30, 240] but can often be repetitive, not personalized, not scalable and infrequent (Hill, 2009). In particular, for university instructors, there is a lack of training and opportunities for PD. This leads to instructors learning how to teach on their own and feeling isolated (i.e., [68, 112, 113]).

PD training and feedback often overlooks teacher immediacy and nonverbal behaviors, an important aspect of teachers' classroom skills. Prior work has shown that immediacy has a positive impact on teaching, learning and on creating a positive and inclusive classroom environment (i.e., [22, 64, 173, 253]). Furthermore, it is extremely challenging to collect immediacy and nonverbal data, even with professional observers. Such data is fleeting to get at a small scale (i.e., teacher gaze during a class session), and nearly impossible to get at a larger scale (i.e., students' gaze over the semester). Thus, there is a gap and opportunity to better support teachers and their practices in the classroom.

Recent advances in instrumenting classrooms with various technologies and sensors (i.e., [11]) raise new opportunities to provide teachers with more personalized and scalable feedback. Such technologies could collect and generate data both on teachers and students. In particular, they would make it very easy to collect a variety of nonverbal immediacy data at scale. This information can then be shared as feedback to instructors to help support and improve their practices, as a first step toward changing their long-term behaviors.

In this chapter, I describe an exploratory and design study I ran during the Summer 2019 semester with 9 instructors at an R1 institution. Through the study I aimed to investigate teacher data needs and to understand how such data can support teacher practices and behavior change in the classroom. I focused my investigation on teacher immediacy and nonverbal behaviors and used an instrumented classroom to collect these data ([11]). I used semi-structured interviews paired with boundary object designs ([219]) aimed to engage participants in a discussion about a speculative future. The overall research questions of the study that I discuss in this chapter are the following:

- RQ1: What are teachers' familiarity, values, beliefs, assessment of their performance, their self-efficacy and motivations, etc., around teacher immediacy and nonverbal behaviors? How do such constructs change after teachers see their own nonverbal behavior data?
- RQ2: What data are teachers interested in?
- RQ3: How did seeing their data affect teacher goal setting for changing their behaviors?

The results of the study show that teachers score quite high but with room for improvement in relation to the various measures for values, efficacy and motivations. After seeing their data, teachers' score in relation to those measures increased. Findings also showed that teachers were interested in their and their students' data, and data that showed how students reacted to teacher actions. Teachers were interested in their location, movement, eye contact and gaze data as well as student engagement and attention data. The boundary object designs proved effective to facilitate a discussion about a speculative future. Teachers brainstormed ideas and set goals to change their behaviors. They brought up challenges that prohibit them from improving their immediacy and nonverbal behaviors, including classroom size, the technologies they use, and the physical layout of the classroom. These findings are important to researchers and designers of technologies aimed at supporting teachers and helping improve their practices.

7.2 Methodology

I ran an exploratory design study during the Summer 1 2019 semester at Carnegie Mellon University (CMU). Summer 1 semesters are 6 week long and generally run from May 20th until July 2nd. During this period, a subset of classes that normally run during the Fall/Spring semesters (14-15 weeks) are compressed in 6 weeks, which makes classes 2.5 times faster than usual. During the summer semester, instructors teach from Monday to Friday for 6 weeks straight. As a result, there are fewer classes running and fewer instructors teaching during this time. In addition, due to the faster pace of the courses, instructors have less time to spare for participating in studies and any other activities outside of everyday teaching. Lastly, many high-school juniors and seniors, who more often than not are minor students (per U.S. standard, younger than 18 years old), also take those classes as part of their summer programs. This is important because, as described below, for the purposes of this study the IRB does not allow for studies like the current one to happen in classrooms where minor students are present.

7.2.1 Sensors in the classroom

Classrooms Equipped with Sensors

To collect data on teachers' nonverbal behaviors in the classroom, I used the EduSense a cutting-edge technology that allows instrumenting classrooms with sensors to collect audio and video data automatically and uses Machine Learning techniques to generate information on teacher and student behaviors [11]. There are two sensors installed in each classroom, one at the front of the classroom, facing students, and one at the back of the classroom, facing the instructor at the front (Figure C-2).

Data Collection, Processing, Filtering and Presenting

Data collection happens automatically through a scheduler software that starts and stops the sensors on provided days and times. The collected data (audio and video) is saved in a database and then processed through EduSense. The EduSense system has the ability to generate a variety of measures both on student and teacher behaviors as described in [11].

The data generated by the EduSense system is in a raw and not-directly usbale form for the purposes of showing teachers their own data. For example, the teacher location is represented by (x; y; z) vector coordinates over time and gaze is represented by (x; y) angle coordinates that represent the 3D direction of gaze. These vector and angle coordinate data need to be "translated" into measures that make sense in the physical space of the classroom environment. For this study, the team developed a temporary app that would read a subset of the raw data processed by EduSense and do this "translation" into data that make sense in the physical classroom environment. As an example, the app would take (1) the (x; y; z) location vector coordinate over time as well as (2) the coordinates that divide the front of the classroom where the teacher stands into Right-Center-Left sections. Using this information, the app then would

Figure 7-1: (On the left) Sensor consisting of a camera that collects audio and video data. (On the right) Sensor installed at the back of the classroom, facing the front, to collect audio and video data on the instructor.

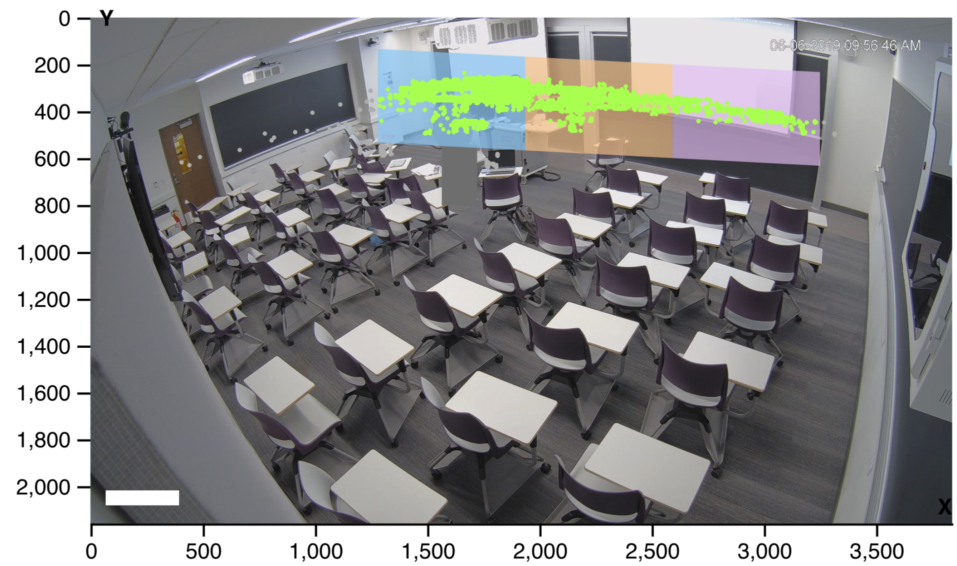


Figure 7-2: Example of the post-processed EduSense data in figure form.

create charts and visualizations that plot where the teacher is standing at the front of the classroom (Figure 7-2) or what percentage of the class time the teacher is spending on the Right-Center-Left sections of the front of the classroom (Figure 7-3). The app was meant for temporary use and only by researchers (not instructors). The temporary app is the first step towards developing the full ClassInSight app.

The next steps in processing and filtering the "translated" data before it is shown to instructors are quite more manual. For example, I would first check the produced charts by hand and notice any outlier class sessions that did not seem consistent with the rest of the data for a particular teacher. For example, in Figure 7-3) class sessions on 6/14 and 6/18 are noticeably different

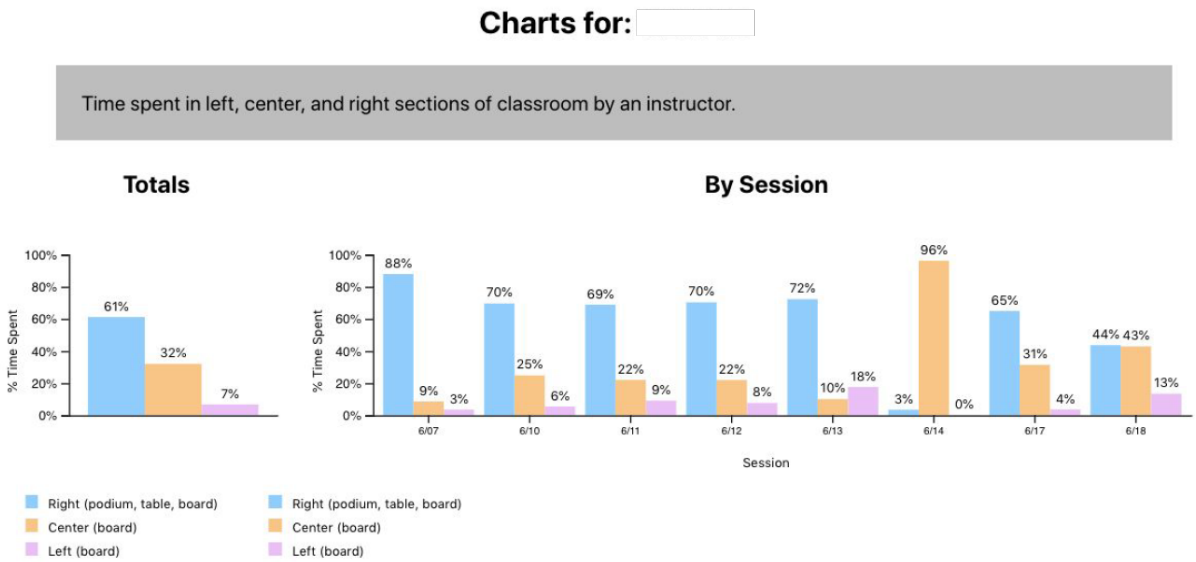


Figure 7-3: Example of the post-processed EduSense data in chart form.

from the other class sessions. After manually checking those two dates, I found that 6/14 was an exam day thus the teacher showed different nonverbals compared to a normal lecture while 6/18 was a session that happened after this study intervention that might suggest a positive change in teacher behavior. Similarly, I would skim through the video recordings and manually filter from the data class sessions where there was an exam (not useful data), a guest lecturer (different instructor) or a different type of activity was happening that day (i.e., student presentations). Such filtering is not possible to be done automatically yet and it has been pinned as future work by the EduSense team. While filtering the data, I would also keep notes of the location of the teacher in relation to the podium/table (behind or in front) and the location of the projected slides. This information was manually entered in the data shown to teachers (i.e., the legend in Figure 7-3). Once I had done all the filtering and validation, I manually copied each chart in the study materials for the respective teachers which then I would print and use during the interviews with the teachers.

7.2.2 Recruiting and Participants

The Process of Recruiting Participants

The first step I took in determining potential participants was to figure out which instructors were teaching during Summer 1 in classrooms equipped with EduSense sensors. I used CMU's Schedule of Classes website (available at https://enr-apps.as.cmu.edu/open/SOC/SOCServlet/search) and filtered courses by semester. I wrote a Python script that would then read the HTML file with the search results of courses being offered during the summer, parse it with a package called BeautifulSoup and automatically filter the classrooms that were equipped with sensors. The final result was a text file with the courses that were being taught in the sensor-equipped classrooms. The only criteria I used to filter instructors and courses to recruit for the study was if these instructors taught in classrooms that were equipped with sensors.

The next step in the recruitment process was to email the instructors with a short description of the study and a request to meet briefly to discuss about the study. Examples of the emails and the study description are included in Appendix B. I started recruiting instructors 1-2 weeks before classes started.

I would personally meet with the instructors, describe the study in more detail to them and answer any questions they had. If the instructors were interested in participating in the study, I would ask them to sign the consent form (see Appendix B). Once I got the instructors' consent, the next step would be to introduce the study to TAs (teaching assistants, if the course had any) and the students in the course and request their consent to run the study (see Appendix B). For students, I would set up a time (2-5 minutes) at the beginning of a class to introduce the study to the students (see Appendix B), and to get their verbal consent to run the study. If all students agreed to the study and there were no minors attending the course, I would start data collection in that class from the next class session until the end of the semester. If the study had even one student who did not agree to the study or if there were minors attending the course, I would not run the study in that course.

I offered instructors a token of payment of $15 per hour for their participation in the study (time they spent outside of class with questionnaires and the interview, as described below). Instructors were not compensated for teaching time. Students were not compensated for their participation in the study.

To note is the fact that fewer instructors teach over the summer semester (there are fewer classes offered during this semester to begin with) which restricts the population I could reach out to for participating in the study. In addition, due to the nature and fast pace of the summer courses, instructors have less time to participate in any studies, provided they are teaching Monday through Friday for 6 weeks. Lastly, many minor students take these summer courses at CMU, which also restricts the instructors and courses I can work with. Per IRB regulations, due to the fact that I do audio and video data collection in the classroom, I am not allowed to do that with minor students present.

Participants Who Took Part in the Study

I emailed 20 instructors who taught at least one class during the Summer 1 2019 semester (2 instructors taught 2 courses and 1 was teaching 3 courses). Out of those 20, 11 instructors showed interest in participating in my study (10 instructors participated with the 1 class and 1 instructor participated with the 2 classes they were teaching).

On the other hand, 4 instructors replied to my email or told me in person they were not interested in the study. Some classes had minor students, thus 1 instructor, despite being interested in the study could not participate while another instructor could participate only with 1 out of the 3 classes they were teaching (the other two classes had minor students). Only in 1 case the instructor was on board with the study but there were students in the class who did not consent to the study. Lastly, for 3 of the instructors I emailed, I never heard back through email and could not find their class running even when I visited in person; this could mean that the class got cancelled or that it got switched to another location without updating the schedule of classes.

Out of 11 instructors who agreed to participate in the study, I decided to drop one course as I got the instructor and student consents too late to have enough time by the end of the summer semester to do any useful data collection. For the instructor who participated with both their classes, I did data collection on both classes but used the data only from one of the classes

Table 7.1: Recruiting and participation in Summer 1 2019

Instructor and class on board with study	11 instructors (all participated with 1 class they were teaching except 1 instructor who participated with 2 classes)
Instructor on board with study but there were minor students taking the class	2 instructors with 2 classes each
Instructor on board with study but there were students in class not on board with study	1 instructor with 1 class
Instructor not on board with the study	4 instructors with 1 class each
Could not get in touch with instructor/class	3 instructors/classes

(randomly picked) as both courses had very similar teacher nonverbal data. The classes that took part in the study were a mix of different subjects and fields (Chemistry, Japanese, Writing, French, Anthropology, Math, Music, Economics, etc.) and different levels (from introductory to higher level courses). Again, I did not filter by any criteria rather than whether the classroom where the class was being taught had EduSense sensors installed.

Out of the 10 instructors remaining in the study, only 9 of them completed the pre-questionnaire. Out of those 9, only 8 took part in the interview and saw their data. Finally, only 7 of the 8 completed the post-questionnaire.

This dilution from how many teachers I reach out to (20) to how many actually complete all stages of the study (7) shows how challenging it is to get enough teachers and students to sign up for in-the-wild classroom studies and how many things need to be taken into consideration and could go wrong during this process. One lesson learned for future studies and potentially helpful to other researchers working in a similar domain is to always carefully consider the number of participants (instructors and classrooms) they need for their studies and then triple that number for the amount of participants they reach out to in order to get a third of them on average take part in all parts of a study.

In addition, given the lengthy process from recruiting to getting final consent of all parties, I was only able to do data collection in the last 2 weeks of the Summer semester. Some of the class sessions I did data collection on were exam sessions or sessions where class was happening outside or in another location, from which I could not extract any useful data on the instructor. In a few other class sessions, despite the class session itself being appropriate for the study, I ran into issues with unconsented third parties being present in the classroom, and due to IRB regulations I could not use those data in my studies (please see the IRB section below for more detail). Thus, ultimately, provided the limited time and these extra challenges with data collection, I ended up collecting anywhere between 3 to 9 class sessions per instructor. On a positive note, instructors tend to be pretty consistent in their data, thus the data is quite similar within a course despite the few class sessions.

7.2.3 Experiment Design

Once I had collected data from a few class sessions, I emailed instructors a pre-questionnaire in SurveyMonkey. I asked them to fill it at their own time and once they did, I requested them to set a 1 hour time to meet with me where I would share with them some Professional Development materials as well as data that I had collected from their class. They could set up the meeting through a link in the website *Youcanbook.me*. I then met with the instructors and ran the semi-structured interview sessions. After the interviews, I followed up with the instructors in another email asking them to fill the post-questionnaire. Originally, I had planned to meet with the instructors in person for them to fill the post-questionnaire, however, it was more convenient for the instructors to do this in their own time. The experiment design as described here is also depicted in Figure 7-4.

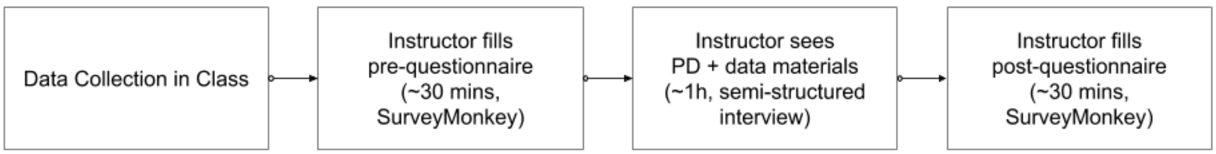


Figure 7-4: Example of the post-processed EduSense data in figure form.

7.2.4 Study Materials

I paired the interviews with boundary object designs on paper, which simulated a future technology and presented teachers with a subset of data collected from their own course as described above. The purpose of the designs was to start a conversation with instructors and engage them in a discussion around immediacy, nonverbal behaviors, and data they could envision wanting or needing. It is challenging to achieve this goal through methods such as Contextual Inquiry or Participatory Design as in the present, instructors get no data on their immediacy and nonverbal behaviors, nor do they get any training or PD on this topic. This makes it challenging for them to envision a technology that could provide such information. The boundary object designs allowed instructors to explore and discuss a future that did not exist for them and created the opportunity for them to engage with ideas of what would be helpful to them in the classroom.

The design of these study materials was based on the research questions discussed in the introduction. I designed the pre and post questionnaires to measure various aspects of teachers' values, beliefs, self-efficacy, motivation, assessments, etc. of their nonverbal behaviors, etc. (as shown in Table 7.1). The Professional Development materials were aimed to introduce the teacher immediacy and nonverbal behavior concepts and the value of such constructs (as discussed in Chapter 6). Further, the data shown to teachers aimed to provide meaningful visualizations to support teacher reflection and and interest in data. The data also provided teachers with various benchmarks and feedback to help them assess their performance and motivate them to change their behaviors. The questions that I asked teachers during the interview were aimed to support reflection and investigate teacher interest in such data and teacher interest in goal-setting and behavior change. Various parts of the post-questionnaire were also aimed to measure teacher goal setting as well as behavior change proxies (such as willingness and readiness to change). Similarly, the additional and final PD materials I shared with the teachers were introduced as a way to provide teachers some suggestions on what goals they could set for changing their immediacy and nonverbal behaviors and how to act out those goals.

Proxemics: The focus of teachers' nonverbal data

The focus of the materials and data presented to teachers were nonverbal behaviors related to proxemics: the location of the teacher in the classroom. More specifically, the data included (1) the percentage of time the instructor spent on the right, center and left sides of the front of the classroom, (2) whether the teacher was in general sitting or standing, and (3) whether they were located behind or in front of the podium or table at the front of the classroom.

The choice of sharing these data with the teachers was based on (1) an extensive literature review of various nonverbal behaviors and their effects on students and the classroom and (2) the capabilities and limitations of the EduSense system to generate certain data. There exists a large body of research that has studied the effects of the instructors' use of immediacy through proxemics while teaching on their students and the classroom environment. Immediate teachers communicate at physically closer distances and they choose direct unimpeded angles when interacting with their students. They spend time among their students rather than behind their desk or a podium [24]. In contrast, a teacher who stands behind their desk or podium and rarely approaches their students or allows them to approach her/him is perceived by students as unfriendly, unreceptive, unapproachable, and nonimmediate and noncaring [201]. Similarly, teachers who sat at, on, beside, or behind their desks were rated by students as low in both affection and inclusion. Teachers who moved in front of their desks or among their students were perceived as warm, friendly, and effective by their students [119]. At the same time, location data was a more convenient data to operationalize and translate into a real classroom environment (from the raw EduSense data, as described above) compared to other data such as gaze that are more challenging to translate into a classroom environment.

Pre-questionnaire and Post-questionnaire: Design and Decisions

Through the pre and post questionnaires I aimed to measure a range of variables as shown in Table 7.1 in order to better be able to understand the values, efficacies and motivations of the instructor population. To begin with, in the pre-questionnaire, I was interested in measuring variables such as teachers' prior knowledge and familiarity with immediacy and nonverbal behaviors and their beliefs, perceived importance and value of those behaviors. In addition, I was interested in measuring variables that could affect teachers' reflection and goal-setting such as their general self-efficacy for teaching and their self-efficacy for immediacy and nonverbal behaviors (as discussed in Chapter 6). Furthermore, I chose two questionnaires to measure teachers' general motivation for teaching and their planned effort, planned persistence and professional development aspirations. I was also interested to measure how teachers perceived and assessed their own nonverbal behaviors in the classroom. Lastly, I collected a range of demographics variables, and information on teachers' experience in teaching and with with professional development.

Many of the items in the post-questionnaire were the same as the items in the pre-questionnaire, as shown in Table 7.1. My aim was to measure any changes in the various variables before and after teachers took part in the intervention as part of the study. In addition, in the post questionnaire I also included a new questionnaire to measure teachers' self-perceived learning and attitudes on the study materials and their motivation for taking part in the study. Lastly, I measured teachers willingness and readiness to change and the specific goals they would set for themselves after the study.

I assigned an anonymous ID to each participant to identify them in the study. I designed and created the questionnaires using SurveyMonkey. Each questionnaire (pre and post) took instructors around 30-40 minutes to complete. In Appendix C I include the full pre and post questionnaires that teachers worked with. Teachers took the questionnaires online despite them being shown in printed form in Appendix C. In Table 7.2 I provide details on the variables I measured in the questionnaires, whether this questionnaire was in pre, post or both, the original source of the questionnaire from literature and the modifications that I did to it to adapt it to the aims of the current study.

Questionnaire	Pre vs Post	Source	Original α	In study α
Self-efficacy (for teaching in general)	Pre: p6-9, Q1; Post: p11-14, Q1	From TSES [227]; Removed Q13 and Q22, kept all others in the same order as original source	0.94	Pre:0.92; Post:0.97
Self-efficacy for immediacy and nonverbal behaviors	Pre: p10-11, Q1; Post: p15-16, Q1	I created based on [40]	–	Pre:0.96; Post:0.99
Nonverbal immediacy self-report	Pre: p12-14, Q1; Post: P17-19, Q1	From [198, 200] removed items 2,5,26 (related to touching behavior) but kept everything else. Change the wording to "while teaching"	0.9	Pre:0.85; Post:0.93
Motivation for teaching	Pre: p15-17, Q1-3; Post: p20-22, Q1-3	I created open-ended questions (items 1 and 2). Item 3 was taken from Table 3 in [250]	Q1: –. Q2: –; Q3: Intrin+Ident:0.79; Introj:0.66; Ext:0.68; Amot:0.748	Pre: Intrin+Ident:0.78; Introj:0.87; Ext:0.29; Amot:0.56 Post: Intrin+Ident:0.81; Introj:0.94; Ext:-2.8; Amot:0.83
Planned effort, planned persistence and professional development aspirations	Pre: p18-19, Q1-2; Post: p23-24, Q1-2	From Table 2 in [244]: kept only the questions in relation to Planned effort, Planned persistence and Professional Development aspirations (with slight modification to the language)	Eff: 0.91; Asp: 0.91	Pre:0.82(Eff:0.93; Asp:0.65); Post:0.94(Eff:0.96; Asp:0.78)
Confidence in teacher immediacy skills	Pre: p4, Q1; Post: p9, Q1	Confidence (Item 1) adapted from Readiness Rulers (RR) (for examples, see [92, 131, 228])	–	–
Value of immediacy and nonverbal behaviors	Pre: p5, Q5; Post: p10, Q3	I created beliefs about immediacy and nonverbal behaviors (Item 5)	–	Pre:0.81; Post:0.69
Around teacher nonverbal behaviors and immediacy	Pre: p4-5, Q2-4; Post: p9, Q2 (removed 3-4 open ended question in post)	I created open ended questions (Items 2-4)	–	–

Prior Knowledge assessment of immediacy and nonverbal behaviors	Pre: p2-3	I created the questions	–	–
Demographics	Pre: p20	I created the questions	–	–
On the course you are teaching this semester	Pre: p21	I created the questions	–	–
Experience in teaching	Pre: p22-24	I created the questions	–	–
Motivation for taking part in study	Post, p 25-26, Q1	From [88]	No alphas reported	Post: Intrin+Ident:0.81; Introj:0.76; Ext:0.86; Amot:1.00
Self-reported learning	Post: p2, Q1-2	From [199], changed from 0-9 to 0-10 scale, changed the wording to match the study activities	–	0.93
Attitudes	Post: P3-8 all questions	From Figure 4 in [63] removed 9-12 and 21-24 for first measure and then for second and third measure only did 1-4 (with slight modifications to the language)	[63] no data, but other papers [102]=0.98, [168]=0.94	0.98
Goals	Post: p28-29	Item 1: commitment and willingness to change and Item 2 readiness to change were adapted from Readiness Rulers (RR) (for examples, see [92, 131, 228]), I created Item 3 specific goals set for change	–	Readiness:0.97; Willingness:0.99

Table 7.2: Pre and Post questionnaire big categories with sources

I designed the questionnaires after doing a thorough literature review on the types of questionnaires researchers had used to measure the variables I was interested in (shown in Table 7.2). I used most of the questionnaires as they were in their original form and research papers they were published in. I modified some of the questionnaires to better fit my study needs. For example, as shown in Table 7.2, for some of the questionnaires I removed questions that made no sense for the current study and for some other questionnaires I modified the wording so that it was teacher and teaching specific. Lastly, some questionnaires I created on my own, as to the best of my knowledge there was no prior work that had created or used such questionnaires.

Structure of the Interviews: Designs and Decisions

After the instructors took the pre-questionnaire on their own time, I meet with them for 1-hour for interview where I shared with them the PD and dashboard materials discussed above. I structured the the interview in a semi-structured format, where I followed a pre-defined protocol of questions while allowing for impromptu and follow up questions based on the discussion.

The full materials that teachers saw during the interviews are shown in Appendix C. The pages with text in Italic, only I (the researcher running the study) saw and read out loud to the participants. This is the protocol with questions that I followed, while also asking on-the-spot questions based on what the teacher said or did. All the other pages in the materials, I prepared in printed form and shared with the instructors during the interview. Below, I list the order of the teachers were introduced to the materials.

1. (*Introduction to Study*): Researcher reads to participant page 1
2. (*Professional Development*): Researcher hands participants pages 2-6 and gives participant time to read and ask questions
3. (*Instructions for seeing their data*): Researcher reads to participant page 7
4. (*Data Part 1: Your performance*): Researcher hands participant pages 8-9 and gives participant time to reflect on data, ask questions
5. Researcher asks participant questions on page 10 to support participant reflection and to investigate what data the participant is interested in seeing
6. (*Data Part 2: Your performance compared to an Effective Teacher Standard*): Researcher hands participant page 11-12 and gives participant time to reflect on data, ask questions
7. Researcher asks participant questions on page 13 to support participant reflection and to investigate what data the participant is interested in seeing
8. (*Data Part 3: ClassInSight Feedback*): Researcher hands participant page 14 or 15 based on the experimental condition the participant is in (verbal persuasion - page 14, Social comparison - page 15) and gives participant time to reflect on data, ask questions
9. Researcher asks participant questions on page 16 to support participant reflection and to investigate what data the participant is interested in seeing
10. Researcher asks participant questions on page 17 to investigate participant's intention for goal setting and desire for behavior change
11. (*How you might work to change your proxemic nonverbal behavior in the classroom*): Researcher hands participant page 18 if they are interested in seeing some suggestions on how they can change their behavior.
12. (*Feedback on Study*): Researcher wraps up interview with questions on how the study could be improved, page 19

Professional Development (PD) Materials

The PD materials are the first materials the instructors were presented with at the start of the interview. The purpose of those materials was to introduce the teachers to the concepts of immediacy and teacher immediacy (the teachers had seen some high level definitions of these topics in the pre-questionnaire). The PD materials also discussed the importance and value of immediacy to teachers, students and classroom environment more in general. Introducing the value of immediacy and nonverbal behaviors was meant as a way to support teachers' motivation for setting goals and engaging in behavior change (as described in Chapter 6). Lastly, the PD materials introduced teachers to different types of nonverbal behaviors focusing specifically on proxemics, the location of the teacher in the classroom and the importance of this nonverbal behavior.

Once the teachers read the PD materials, I answered any questions that they had on the materials. Then, I shared with teachers their own data in three parts.

The data

After seeing the Professional Development materials, teachers were provided data on their performance in the classroom, based on the data collection I did for a few class sessions. Teachers saw the data in 3 parts. I asked teachers to think out loud as they were looking at their data and answered any questions that they had during the process. After seeing each part of the data I asked teachers (1) *How they would assess their performance/how do they think they were doing?* (2) *What other data or information they want to see?* The purpose of those questions was to support teacher's reflection and sense making while making sure they engaged with the data, assessed their performance and expressed their opinions on the provided data or interest in other data.

Data Part 1: Your performance

In this part, I showed teachers "raw data"; their own data visualized in charts without any external assessment or feedback. The reason for this design choice was to see if teachers were aware at all of their nonverbal behaviors and what self-perceptions they had of nonverbal behaviors in the classroom more in general. Lastly, I wanted to explore how teachers would assess their performance when seeing data.

As shown in the study materials in Appendix C, the data presented to teachers in this part consisted of a:

1. Text description of the teachers' data. The text description had some information on the number of sessions I did data collection on, as well as some qualitative information on whether the teacher was generally sitting or standing during class and whether they were staying in front of or behind the podium or table in front of the classroom.

2. A chart showing the teachers' percentage of time staying at the right-center-left sides of the front of the classroom. This chart was an average across all class sessions I did data collection on for that particular teacher.

3. A distribution through a dot chart of the teacher's location at the front of the classroom. The green dots show where the teacher was located at the front while the grey dots show when the teacher was away from the front of the classroom or when the EduSense system would mistakenly classify a student sitting at the front row as the teacher.

4. A view of where the students generally sit in class which was meant as a way to remind the teacher of the physical layout of classroom from the teacher's point of view as well as share with the teacher an example of where their students generally sit.

Data Part 2: Your performance compared to an Effective Teacher Standard

In this part of the data, I showed teachers once again their own data similar to Part 1, however this time their data was shown against an Effective Teacher Standard. The purpose of this part of the study was to provide teachers some feedback to help them assess their own performance and contextualize how they are doing. The materials the teachers were presented with (also in Appendix C) were as follows:

1. A text description of what the literature suggests an effective teacher does and does not do in the classroom, in terms of their nonverbal behaviors.
2. The bar chart from Part 1 showing the percentage of time the teacher spent at the right-center-left sides of the front of the classroom compared against "an effective teacher standard" line at the value of 33.3%. This effective teacher standard was based on the premise that teachers should strive to spend an equal amount of time in front of the students in each part of the class (right-center-left), which would lead to an average of 33.3% (100%/3) of the time per part (right-center-left).

Data Part 3: ClassInSight feedback

In the third and last part of the study, in addition to sharing with teachers their own data, I provided to them motivational feedback from the ClassInSight app. Motivational feedback is a type of feedback that aims to motivate the participant to do better rather than simply to inform them about how good or accurate their performance is [213]. My aim was to investigate how teachers would react to this motivational feedback, and would this feedback be motivating to them to set goals to change their behavior in the classroom and to help increase their self-efficacy and motivation as measured in the post-questionnaire.

Teachers received one of the two types of the motivational feedback in Part 3 representing the two experimental conditions: the verbal persuasion condition and the social comparison condition. I randomly split teachers in these two conditions. Except for this part where teachers were divided in conditions, every other part of the study and experiment was exactly the same for all teachers and they saw the same materials, types of data and information. I picked the conditions based on Bandura's work on self-efficacy [34, 35, 38] which shoes that both verbal persuasion and social comparison have the power to support and improve self-efficacy at varying degrees. My aim was to support teachers SE as a way to support their motivation for goal-setting and behavior change (as described in more detail in Chapter 6).

Verbal persuasion [34, 35] is generally used to support people to believe that they have the skills and capabilities to achieve what they seek. Verbal persuasion can help people reach a successful performance however it is generally considered as limited in its power to increase self-efficacy or create permanent long term increases in self-efficacy. This because outcomes are described and not experienced by the participants and can depend on the credibility of the persuader [261]. In my study, I provided teachers Verbal persuasive feedback in the form of a short paragraph of text that mentioned they have been doing a very good job and most certainly have the ability and skills to improve (for the full feedback, see Appendix C.3, page 14).

Social comparison [34, 35, 38] on the other hand is a form of vicarious experience and refers to people assessing their abilities and capabilities in relation to how others have performed on the same task or topic; namely people self-compare with others to assess their performance. How people judge their abilities and capabilities is influenced by who they compare themselves with. For example, seeing oneself surpassed by others undermines self-efficacy however seeing oneself surpass others strengthens personal efficacy. In my study I implemented social comparison by presenting teachers their data compared against another instructor who was doing worse than them in terms of proxemics (the percentage of time spent at the front of the classroom on the right-center-left sides). The data was accompanied by a paragraph saying that their performance was very high compared to other instructors who had worked with ClassInSight in the past (for the full feedback, see Appendix C.3 page 15).

Goals

At the end of the interview, I asked teachers if, based on the materials and the data that they saw, they would like to change something in the nonverbal behaviors they use in their class and if so, if they could list 2-3 ways they would like to change and why. The purpose of this question was to measure the willingness and readiness of teachers to change their behaviors in the classroom and the goals, if any, that they would set to themselves. I also wanted to have a discussion with teachers around what they saw as feasible or not in changing their behaviors, things they were excited to change and things they were unwilling or foresaw would be difficult to change.

In addition, I asked teachers if they wanted to see some suggestions on how they could change their nonverbal behaviors in the classroom. My aim was to first measure once again teacher willingness to consider behavior change as a proxy and first step before actual behavior change. Secondly, I wanted to provide teachers extra PD materials with suggestions and ideas of what they could change in their nonverbal behaviors in the classroom that were more actionable.

How you might work to change your proxemic nonverbal behavior in the classroom

If the teacher replied yes to the question above, I would share with them a one-page PD material with more actionable suggestions on how they could change their nonverbal behaviors in class, focusing on location related behaviors while including some other behaviors more in general. Suggestions included how to spend a more equal amount of time in each part of the class, how to stand more in front of a podium or desk and how to maintain student attention and engagement. I introduced this part of the PD to support teacher goal setting and provide them some more suggestions of what they could change in the classroom if they were interested to, and how to go about that.

7.2.5 Data analysis

Analyzing the questionnaire data

My team and I conducted the analysis of the questionnaires and generated the charts and results as described in the Findings section. We used Microsoft Excel and R to conduct the analysis and generate the charts.

Cronbach's Alpha for the questionnaires

In Table 7.2 I have calculated Cronbach's Alpha [69] for all the items in both the pre and post questionnaire. In the column next to the calculated Alpha, I have included the original Alpha found in the literature under the Source column. Note, there were multiple items in the pre and post questionnaire that were single questions (i.e., confidence) or only two questions (i.e. external regulation), for which Cronbach's Alpha could not be calculated. This can be insufficient to fit the assumptions for calculating the alpha as the literature recommends 3 items at least [169]. In addition, in many cases, the source of the questionnaire did not use or share a Crobach's Alpha thus the value is missing in the "Original Alpha" column. Lastly, the reader should keep in mind that, as described in the same table, the questionnaires were often modified and changed slightly or drastically to match the study goals.

Despite the low number of participants in the study (9 for pre and 7 for post), the alphas are generally quite high (above 0.8) and match the original alpha when available, with a few exceptions. Even for the items that I created on my own, the alphas are quite high. In the cases when the alphas are on the lower end, it can be justified with the fact that there were a very small number of participants which would affect the value of the alphas. To summarize, provided that the questionnaires have been used and vetted in literature and provided the small sample size in this study, the calculated Cronbach's Alphas are adequate for the following analysis.

Analyzing the interview data

Research assistants in our team transcribed the interviews independently. We then used Atlas.ti to conduct a deductive thematic analysis on the transcriptions [2, 3, 6, 7, 8, 184]. As the first step of the deductive thematic analysis, I defined a set of broad themes based on the study aims and research questions and the existing knowledge my team and I had from running the studies and re-watching and discussing the interviews. The broad themes included teachers' interest around data, teachers' assessment of their performance, teachers' ability to monitor nonverbals in class, teachers' interest around setting goals and changing behaviors as well as teachers' comments around student likeability or feedback. I created a Microsoft Word document with a description of each of those themes and examples from the interviews of what counted and did not count for each theme. My team (4 students) and I ran a thematic analysis and independently tagged with the major themes the same interview . We then came together and discussed discrepancies and uncertainties in the tagging. We repeated this process once again, at which point we had reached a common understanding of the major themes. We then split the interviews among ourselves, and once a week came together to discuss interesting findings or points of uncertainty. Once the interviews were fully tagged with the major themes, we came together to discuss potential patterns within each major theme which created sub themes. We reviewed and organized these sub themes in a second word document and based on it and the discussion described here I wrote the following findings section.

7.3 Findings and Discussion

In this section I will focus on investigating and analyzing instructors' (1) pre and post questionnaires and (2) their interviews. In order to have a more coherent presentation and discussion of findings, I have organized the findings based on the source of the data (pre, post questionnaires and interviews) rather than the research questions of the chapter. In the Conclusions section I bring back the research questions and summarize the findings and contributions of this chapter.

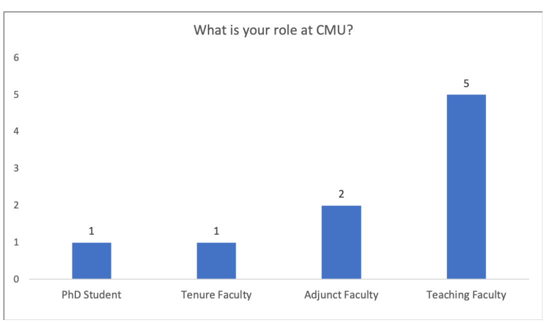
To look up the questions in any questionnaire, in Table 7.1 I have included the page numbers for each questionnaire which can also be found in Appendix C.2. The following analysis is based on the data collected from 9 teachers filling the pre-questionnaire and 7 teachers filling the post. In total, 8 teachers took part in the interview sessions.

7.3.1 Analysis and Discussion of the Pre Questionnaires

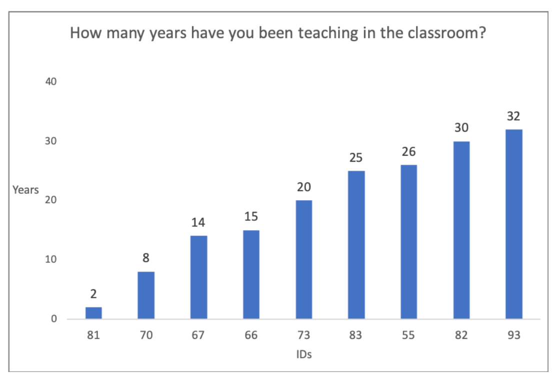
General Information

From the 9 instructors who took the pre-questionnaire 7 were male and 2 were female. The majority of the male participation could be an effect of the more general geneder distribution in the CMU faculty population. In relation to their role at CMU, 5 instructors were Teaching Faculty, 2 were Adjunct Faculty, 1 was Tenure Track Faculty and 1 was a Ph.D. student (Figure 7-5(a)). Their teaching experience varied from less than 10 years (2 teachers) to more than 10 years (7 teachers) (Figure 7-5(b)). In relation to their experience with teaching, only 2 out of 9 teachers had been certified as professional teachers while 1 instructor responded they did not understand what a certified professional teacher meant. Most teachers had experience teaching at the college level, while 4 also had experience with various levels of K12 teaching.

In relation to their experience with professional development, the majority of teachers, 7 out of 9, mentioned they had worked with the Eberly Center for Teaching Excellence and Educational Innovation at CMU by consulting with them, taking seminars or teaching in their instrumented classrooms. The number of seminars they had attended varied widely (from 1 being the minimum to as many as their time allowed). Outside of PD from Eberly, only 3 out of 9 teachers had not had any other training on their teaching or any other type of professional development. The experience the rest of the instructors had with PD involved doing research in education (1), had acquired a double major/primary major in education (3), had taken workshops outside of school (1), had taken part in education conferences (1), or were certified teachers as described above (2). To begin with, the population in this particular study is heavily skewed towards instructors whose primary job and focus is teaching (i.e., teaching faculty). This is also an effect of running the study during the Summer semester, where the majority of instructors are teaching faculty, as for other instructors such as tenure faculty, Summer is generally a time to focus on research, and not teaching. As a result, the above mentioned findings in terms of the rich experience instructors in this study have with Eberly or PD outside of CMU make sense in the context of the population, dedicated and invested in teaching.



(a) Participant roles at CMU.



(b) Number of years instructors have taught in the classroom, regardless of the level taught.

Figure 7-5: Participant demographics.

Familiarity with immediacy and nonverbal behaviors

When asked to self report on their familiarity with the concept of immediacy, most teachers (6 out of 9) said they were not familiar with immediacy or teacher immediacy (Figure 7-6), 2 others reported they were "Sort of" familiar and only 1 responded "Yes" to being familiar with this concept. In addition, when asked to provide a definition for immediacy or teacher immediacy, only 2 out of 9 teachers were able to give a definition for immediacy that came close to the immediacy concept while the rest of the instructors either gave a definition that was totally off from the actual concept (4 teachers), replied they had no idea what immediacy was (2 teachers) or did not respond to the question at all (1). Examples of wrong definitions include *ID 73: "I would guess presenting material in such a way that results are immediately relevant? Or responding to students questions/confusion immediately."* On the other hand, when asked about their familiarity with nonverbal behaviors, most teachers expressed some level of familiarity with the term and they all could provide a definition as well as some examples of nonverbal behaviors. Provided that immediacy is a concept that mostly comes across in literature, it is understandable why most teachers had no idea what it was. This also shows that despite the large teaching and PD experience the participants in this study have, they had not heard or got any training on immediacy before. At the same time, nonverbal behaviors are more likely to come up in everyday conversations, outside of teaching, mainly in terms of "body language" which is a more commonly used term.

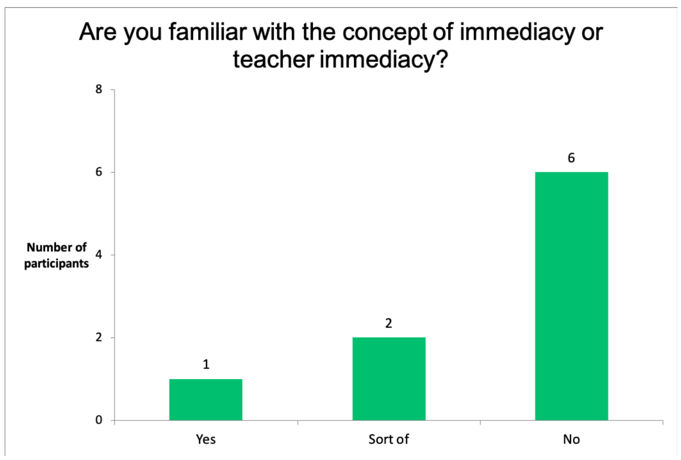


Figure 7-6: Answers to the question of whether they were familiar with the concept of immediacy.

After asking the above questions to teachers, from this point on in the pre-questionnaire, teachers were provided with definitions for immediacy and nonverbal behaviors at the beginning of each questionnaire (please refer to the questionnaires in Appendix C.2). These definitions were meant to help contextualize and define those constructs for the instructors as well as help and support them to better answer the questions related to those terms.

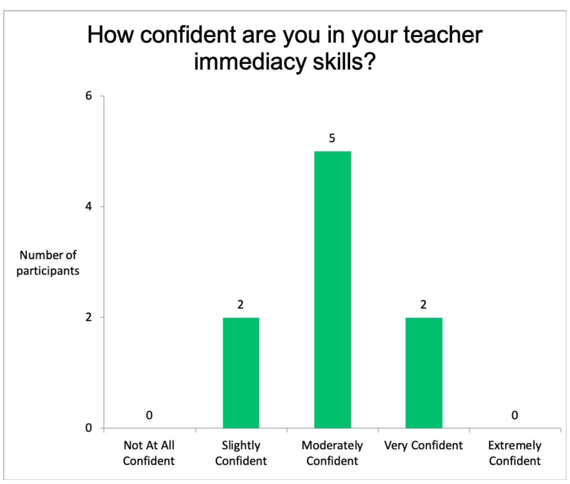
Confidence in immediacy and nonverbal behaviors

When asked to quantify their confidence in their immediacy skills, most teachers responded they were confident in their teacher immediacy skills as shown in Figure 7-7(a). In total, 2 out of 9 teachers responded they were "Very Confident" and 5 out of 9 teachers responded they were "Moderately Confident" in their immediacy skills. Only 2 teachers responded they were "Slightly Confident". Overall, the weighted average of teachers' answers was 3 out of 5 (namely, "Moderately Confident"). Despite not being familiar with immediacy as a concept, many of the teachers in this study, provided their many years in teaching experience, have made use of methods to help develop immediacy or report with their students in the classroom. It is positive that these results show teachers are quite confident in their skills, however it seems there is room for improvement to move the teachers' answers towards "Very" and "Extremely" confident in the scale.

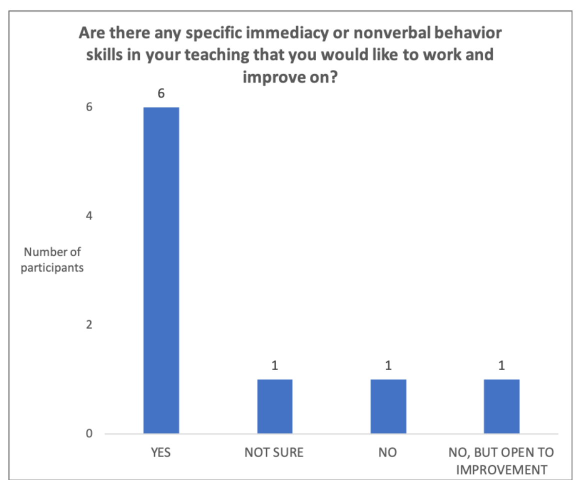
Behavior Change Intentionality

Along the same lines, teachers were asked if they had any specific immediacy or nonverbal behaviors skills that they wanted to work and improve in their teaching. Their responses are summarized in Figure 7-7(b). The majority of the teachers, 6 out of 9, responded "Yes" in that they wanted to work on behaviors such as more gaze and eye contact with the students as well as more movement in the classroom (among students when they are doing group work and away from behind the media and console technology they used). One teacher responded they were "Not Sure" if there were any specifics immediacy or nonverbal behavior skills they wanted to work on while another one responded "No" to the question. Lastly, one teacher said they did not have a specific behavior in mind for change, however they were open to improvement. It is very interesting to note that the 6 teachers who responded "Yes" to this question, included all the 5 teaching faculty, as well as the 1 Ph.D. student in this study. The teacher who responded "Not Sure" was a tenure faculty and the teachers who responded "No" and "Not really but open to improvement" were the two adjunct faculty. One explanation for these results could be that for teaching faculty, constantly working on and improving their teaching is of primary importance to their job while for tenure faculty or adjunct faculty teaching might not be of primary importance and they may have other priorities that take most of their time and energy.

Lastly, when asked to provide examples of nonverbal behaviors that they use in their teaching, one teacher mentioned they may use them but they were not so conscious of them while the other 8 teachers provided various examples including facial expressions and gesturing, movement around the class such as sitting or standing closer to students, as well as using eye contact and gaze.



(a) Teacher confidence in their immediacy skills.

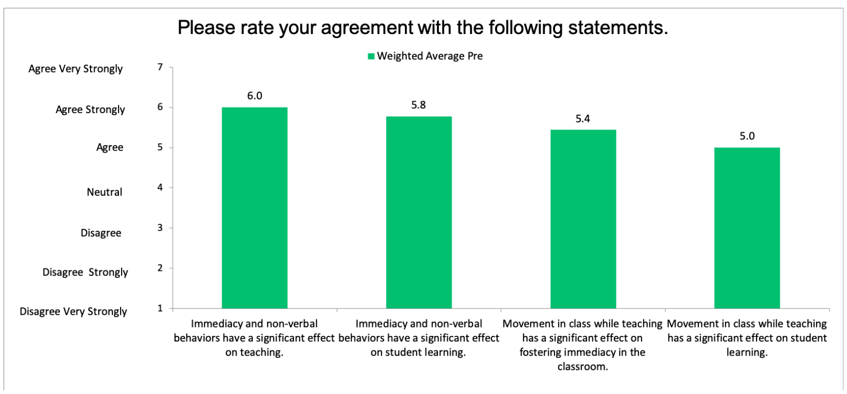


(b) Responses to whether teachers have any immediacy or nonverbal behavior skills they want to work on or improve.

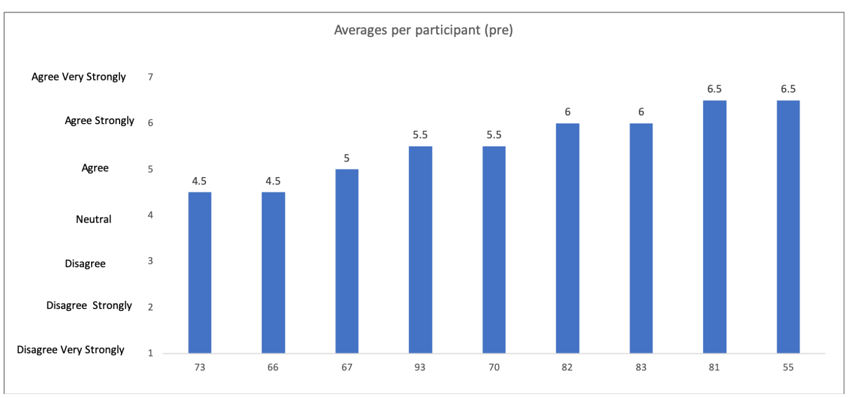
Figure 7-7: Teacher confidence and interest in changing.

Values and Beliefs around Immediacy and Nonverbal Behaviors

In Figure 7-8(a) I share in a weighted average form teachers' beliefs and values around immediacy and nonverbal behaviors. Overall, teachers score between "Agree" and "Agree Strongly" with each of the statements. In particular, teachers "Agree Strongly" with the statement that immediacy and nonverbal behaviors have a significant effect on teaching. Surprisingly, they score a little lower with the statement that these constructs have a significant effect on student learning. This is interesting as an effect of immediacy and nonverbal behaviors on teaching would translate to an effect in student learning, but maybe this indirectness seems too far fetched to teachers. When asked about a specific nonverbal behavior, movement in class while teaching, teachers score generally slightly lower. They believe movement has an effect on fostering immediacy but the effect of movement on student learning scores lower. The reason for this drop from "Strongly Agree" on immediacy and nonverbals in general to only "Agree" on movement specifically might be because teachers might not value movement as much as they might value other nonverbal behaviors such as gaze and eye contact, or there might be other factors that make movement challenging in the classroom. I discuss this point more in detail in the teacher interview analysis section. In Figure 7-8(b), I plot per teacher, their average values and beliefs around immediacy and nonverbal behaviors. The majority of teachers, 7 out of 9, score between the "Agree" and "Agree Very Strongly" categories in the scale. The total unweighted average across all participants is 5.6, leaning toward "Agree Strongly" of the value of such constructs for teachers, their teaching and their students' learning. All in all, these results show that teachers value immediacy and nonverbals in the classroom more to support teaching and slightly less to have an effect on student learning.



(a) Weighted average of teachers' beliefs and values of immediacy and nonverbal behaviors.



(b) Average values and beliefs per participant.

Figure 7-8: Teachers' values and beliefs around immediacy and nonverbal behaviors.

General and task-specific Self-efficacy

In relation to Self-efficacy, the pre-questionnaire measured teachers' general self-efficacy for teaching (SE) as well as their self-efficacy for immediacy and nonverbal behaviors specifically (SE-NVB). I used a general as well as immediacy specific self-efficacy questionnaire because according to Bandura [36], judgements of self-efficacy are very task specific which means that measures of self-efficacy should also be tailored to the task and domain of interest. In Figures 7-9(a) and 7-9(b) I plot the distribution of teachers' answers to each of the two self-efficacy questionnaires. The x-axis represents the average score per teacher over all the questions in the questionnaire, while the y-axis represents the number of teachers who got that score. At a high level, despite the small sample size, both charts (Figures 7-9(a) and 7-9(b)) hint at a uniform distribution for SE and SE-NVB. In addition, SE and SE-NVB have very similar distributions, which is positive in particular as the SE-NVB questionnaire was created by me based on [40]. To look in more detail at the instructors' scores in terms of self-efficacy, I split the 1-9 scale of the questionnaires, from "Not at all" to "A great deal", into three buckets: low [1, 3.66], mid [3.67, 6.33] and high [6.34, 9]. I calculated that the participants "fell "into the mid and high buckets, respectively 2 teachers in the mid-SE/SE-NVB and 7 teachers in high-SE/SE-NVB (Figures 7-9(c) and 7-9(d)). The average score of SE across all instructors was 6.86 out of 9, while the average score of SE NVB was slightly higher, namely 7.14 out of 9. This means that the instructors in this sample had quite high self-efficacy, both general and specific to immediacy and nonverbal behaviors. Again, this maybe an effect of the majority of the instructors in this sample being teaching faculty.

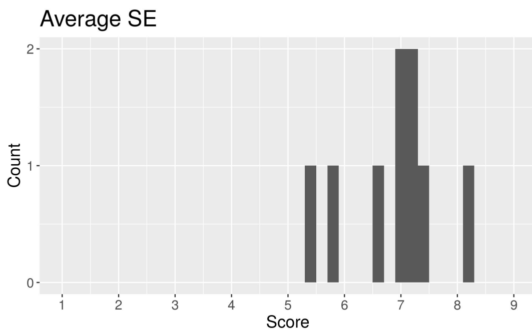
Self-reported nonverbal behaviors

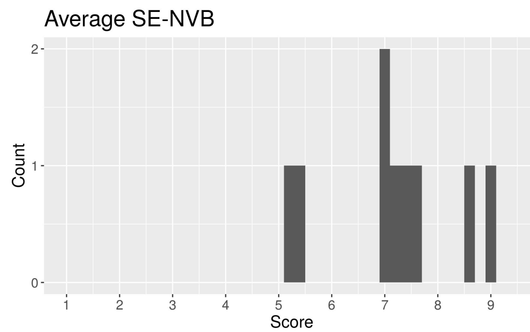
The questionnaire that asked teachers to self assess their nonverbal behaviors ranges in score from 35 (minimum score) to 127 (maximum score). These values were calculated after the reverse scoring is taken into account and after removing some questions that did not contribute to the study, as described in Table 7.1. The average score for the pre-questionnaire was 103.3 and the standard deviation was 9.5 (Figure 7-10(b)). This shows that teachers in this study perceive they use nonverbal behaviors quite often in class, with the lowest value being 90 and the highest one being 117 in the range 35-127. Despite the high scores, there is still room for improvement to increase how instructors self-perceive their nonverbal behaviors. Similarly, individual participants responded quite highly generally (as shown in Figure 7-10(b)) and the distribution of their answers is showing a tendency towards normal distribution, despite the small number of participants (Figure 7-10(a)).

Motivation

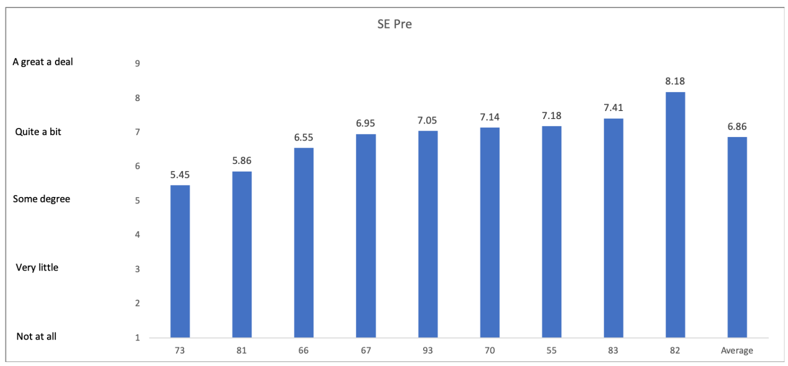
When asked what decreases their motivation in trying to do their best in the classes they are teaching this semester, 5 out of 9 teachers responded that students who do not pay attention in class, who are not engaged and who are unresponsive during class decrease their motivation. Similarly, when asked what things motivated them in trying to do their best, one teacher responded that they found student engagement motivating while 3 teachers mentioned students' interest in the topic they were teaching as well as their learning in general was motivating. These answers support the case for the importance of immediacy and nonverbal behaviors in creating a more friendly, immediate and as a result comfortable classroom environment that helps students have more interest in the course and as a result be more attentive and engaged in class.

When asked "*Why are you teaching this course?*", in general all instructors said they were interested in teaching, enjoyed teaching and had expertise in teaching that particular subject. In addition, one instructor said they were teaching this course because it was a requirement for them while another instructor said that someone had to teach the course. Lastly, 3 instructors

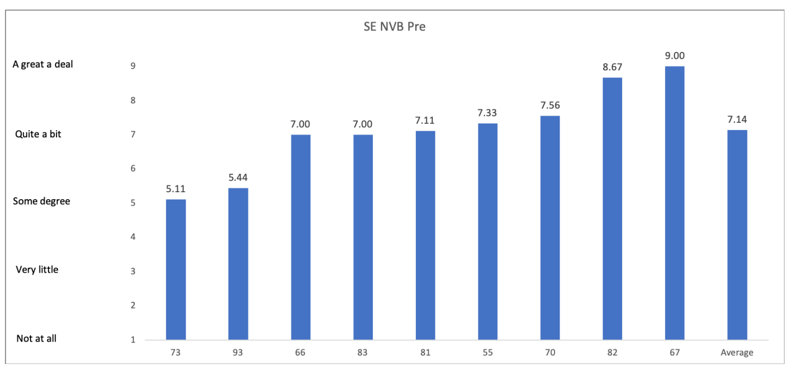




(a) Teachers' general SE for teaching. (b) SE for immediacy and nonverbal behaviors.



(c) Average SE score per participant and overall average.

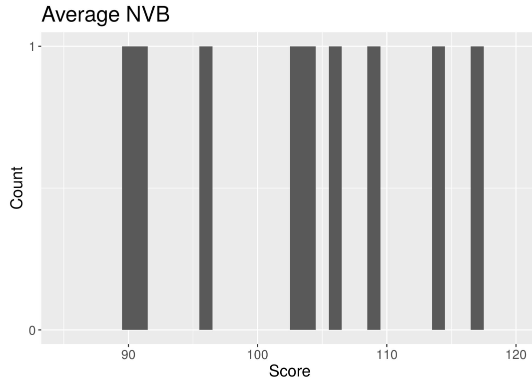


(d) Average SE NVB score per participant and overall average.

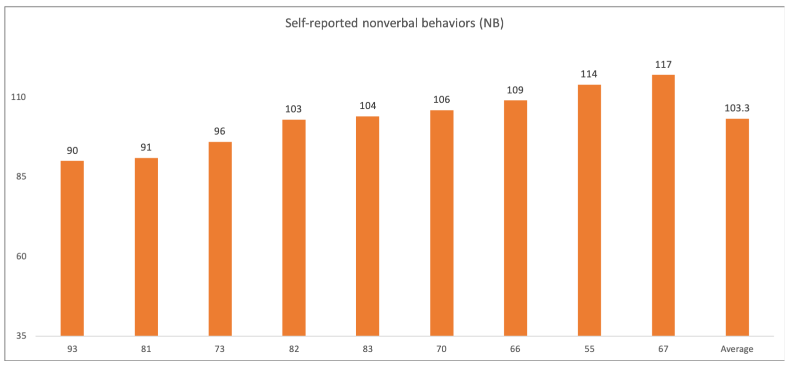
Figure 7-9: Teachers SE and SE for NVB.

said that teaching the course provided them with extra income over the summer.

Teachers were also asked to rate their agreement with statements that represented various reasons of why they teach. This questionnaire was was adapted from [250] and measures teachers' motivation in relation to teaching focusing on five levels of motivation: intrinsic, identified, introjected, external regulation and amotivation [206, 250] as shown in Figure 7-11. In their analysis, [250] merge the intrinsic and identified motivations due to the difficulty in differentiating between these levels of internalization. They also analyze separately the introjected and external regulations and they do not study amotivation due to the low reliability and difficulty of interpreting this construct. Following this model, in my analysis I study intrinsic and identified



(a) Score distribution in the nonverbal immediacy questionnaire.



(b) Average score per participant in the nonverbal immediacy questionnaire.

Figure 7-10: Teacher self-reported NVB.

motivations together, and I study separately external regulation, introjected and amotivation. In Table 8.12 I list the questions of the questionnaire that measure the respective motivational constructs.

As shown in Figure 7-13(a), teachers on average score higher on intrinsic motivation (4.4 out of 5, between "Agree" and "Totally Agree" on the scale), and lower on the other constructs (average 3.4 for external and 3.3 for introjected, both between "Undecided" and "Agree"), with amotivation being the lowest (average 1.2 between "Totally Disagree" and "Disagree"). Looking in more detail at Figure 7-13(b), 8 out of 9 teachers scored between "Agree" and "Totally Agree" in relation to intrinsic motivation and 1 teacher scored between "Undecided" and "Agree". The 8 teachers with high intrinsic motivation included all the 5 teaching faculty, the 2 adjunct faculty as well as the Ph.D. student, while the 1 teacher who scored lower was the tenure faculty. These results could indicate that for teaching faculty, whose focus and job are to primarily teach, are more intrinsically motivated while for tenure faculty for whom teaching is not their primary focus, might be less intrinsically motivated when it comes to teaching.

In the same Figure 7-13(b), in relation to their external regulation, 5 out of 9 teachers scored between "Agree" and "Totally Agree" while the rest scored between "Totally Disagree" and Undecided'. As also seen in Figure 7-12, the teachers seems to be split when it comes to external regulation: half of them are externally motivated while the other half score quite low

Table 7.3: Motivation constructs and the questions in the questionnaire

Intrinsic + Identified	• Because for me, the task of teaching is of personal importance • Because I find the task of teaching interesting • Because I derive much pleasure from teaching • Because the task of teaching provides the chance to realize an aspect of my academic profession that is of personal meaning to me • Because I see my teaching as a significant contribution to my students' overall academic success • Because during teaching I'm in a pleasant mental state of "flow"
Introjected	• Because a good performance in teaching contributes largely to my self-esteem as a professor • Because my aspiration is to be successful at teaching, otherwise I would feel like a loser • Primarily because I get positive feedback from students • Because I feel very uncomfortable if I neglect my teaching
External Regulation	• Because my employment contract demands me to teach • Because I get paid for it
Amotivation	• I don't know, sometimes I don't see the actual purpose of teaching • I don't know why, because the work conditions provided for academic teaching are unbearable • Teaching doesn't mean a lot to me, because I can't really see what academic teaching can accomplish in my students • (Following [250], removed to increase reliability) Because I would feel bad if I Would neglect my task of teaching

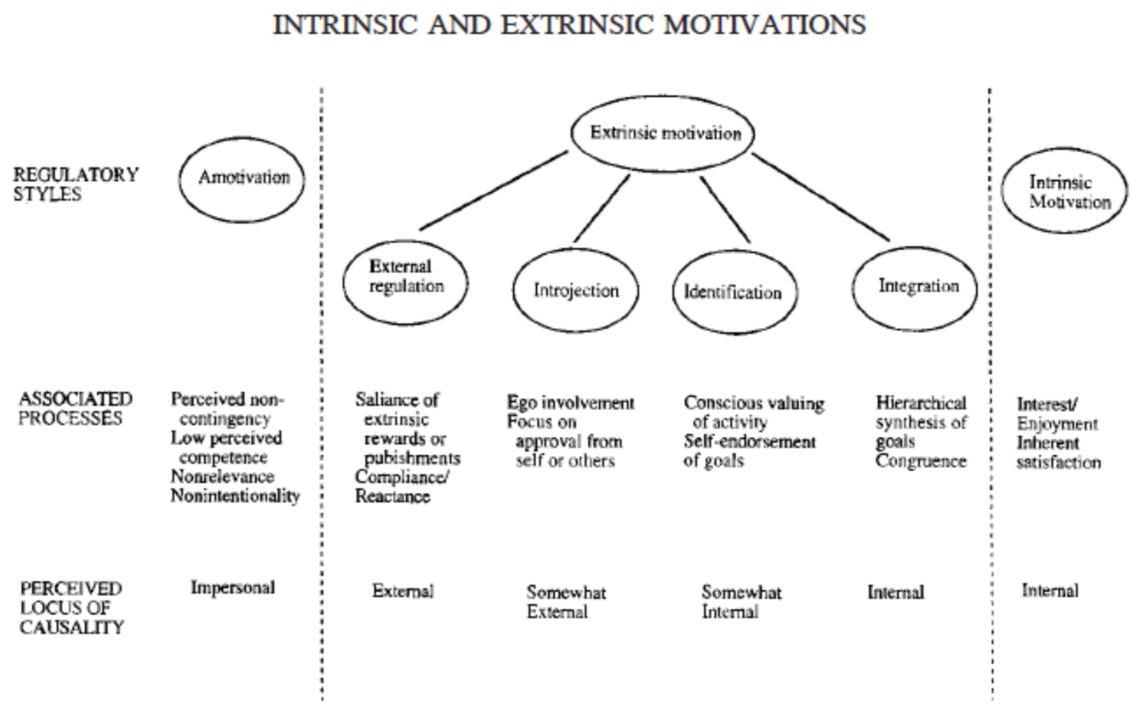
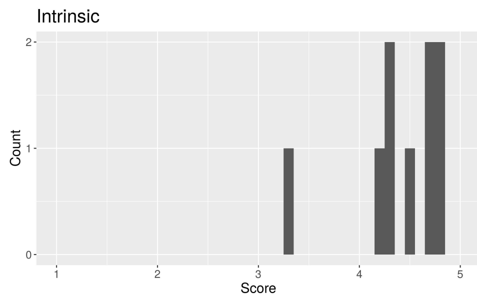


Figure 7-11: A taxonomy of human motivation, taken from [206].

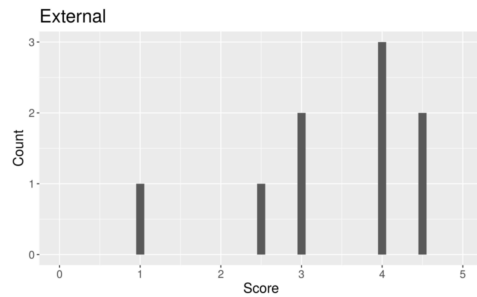
on this construct. Similarly, for introjected motivation, that [206] counts as somewhat external, also depicted in Figure 7-11, only 2 out of 9 teachers scored between "Agree" and "Totally Agree", 6 scored between "Undecided" and "Agree" and 1 scored between "Totally Disagree" and "Undecided". Again, it seems that for the two extrinsic motivational constructs, external regulation and introjected motivation, teachers are split in the "high" half and "low" half groups.

As a result, almost half of the teachers (4 out of 9) in this study scored high in terms of intrinsic as well as external motivation, with a similar score between the two constructs. In the other cases, the teachers (3) were generally more intrinsically motivated by a large margin, while in only one case the teacher was primarily externally motivated. Not surprisingly, this teacher was the tenure faculty in this study. It is interesting to note that while most faculty (8 out of 9) are intrinsically motivated, only half of them are also extrinsically motivated while the other half are not. This again might be function of the population in this study, where the majority are teaching faculty who are passionate and motivated in relation to teaching, which translates into intrinsic motivation.

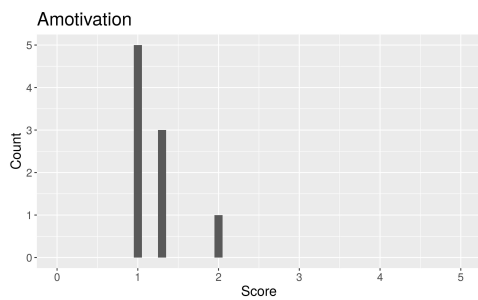
In terms of the planned effort, planned persistence and professional development aspirations, teachers on average scored quite high, specifically at 6.17 out of 7, closer to "Extremely" on the scale (Figure 7-14(c)). Looking at the individual participants (Figure 7-14(b)), 6 out of 9 teachers scored a 6 or higher in terms of their planned effort, planned persistence and professional development aspirations and the other 3 teachers scored between 5 and 6. Again, this makes a lot of sense provided the majority of instructors in this sample were teaching faculty who, compared to other faculty and tenure faculty in particular, might be more motivated to put



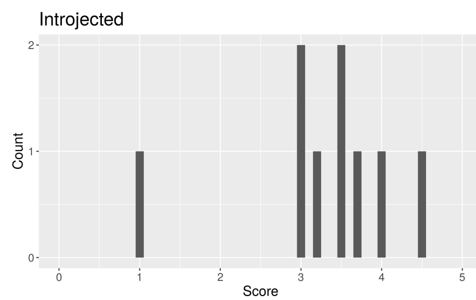
(a) Intrinsic Motivation Distribution.



(b) External Motivation Distribution.



(c) Amotivation Motivation Distribution.



(d) Introjected Motivation Distribution.

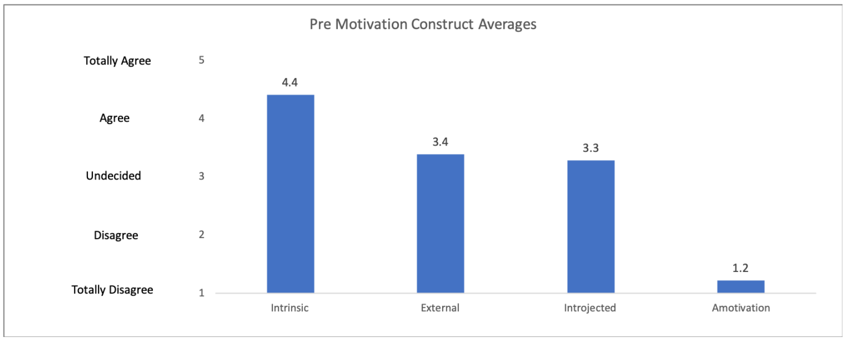
Figure 7-12: Score distribution for the 4 motivational constructs.

effort and persist in their teaching, as well as to have high PD aspirations.

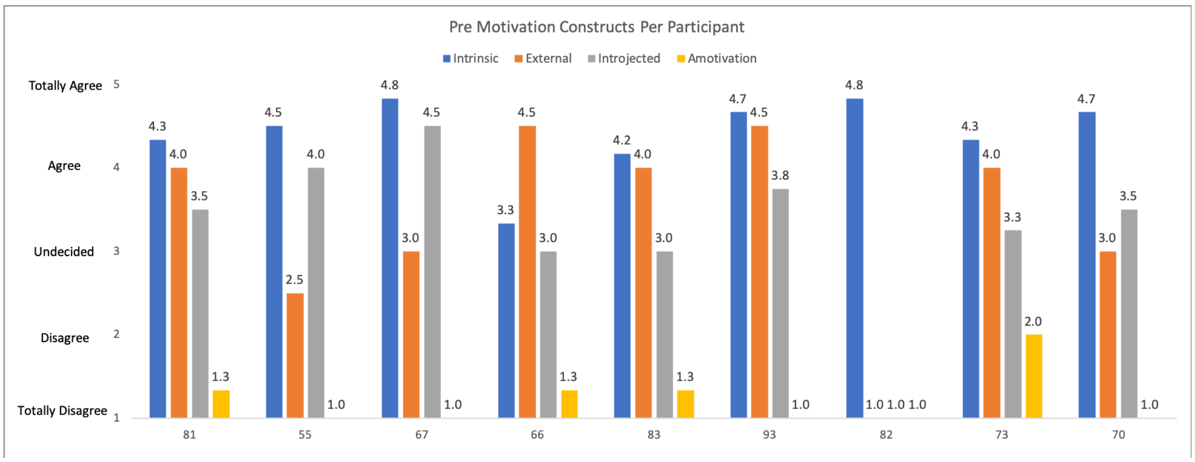
In addition, on average teachers' effort and persistence score in the questionnaire (average 6.24) was slightly higher than their PD aspirations score (average 6.07) (Figure 7-14(c)). Taking a more detailed look into their PD aspirations, in Figure 7-14(d) I notice that there are two items where instructors scored lower compared to the other items. Specifically, on the items aimed to measure teachers' aspirations to undertake and participate in further professional development courses, teachers score lower. A reason for this might be the time it takes to take part in further professional development. Another reason could be that instructors in this study were quite experience with PD, within and outside of CMU, which can lead them to think further professional development is not necessary. Lastly, in Figure 7-14(d), it seems that instructors score the highest in continuing to acquire curriculum knowledge followed by continuing learning how to improve their teaching skills. These high scores in terms of their motivations to improve show that instructors in this study are willing to work on their teaching.

7.3.2 Analysis and Discussion of Post and Pre vs Post Questionnaires

In this section, I will analyze the post-questionnaires as well as investigate and discuss any changes in teachers' scores from pre to post. Note that 7 out of the 9 participants who took the pre-questionnaire also took the post-questionnaire (one participant did not take part in the interview and as a result they did not fill the post-questionnaire either, while the other participant completed all stages of the study up but the post-questionnaire, potentially because they left for summer break before they were able to complete this last stage). As a result, the analysis in this section is based on the 7 participants who completed all the stages of the study. In the Table 7.4 I show per participant, the stages they completed and they did not complete,



(a) Average per motivational construct.



(b) Score distribution for the 4 motivational constructs per participant.

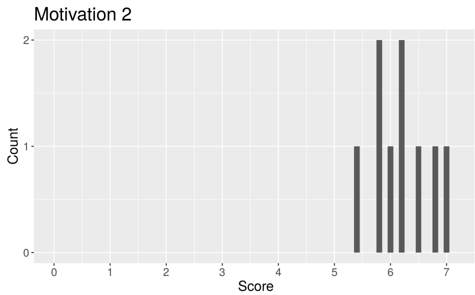
Figure 7-13: Score distributions of teacher motivation in the pre-questionnaire

as well as the condition they were randomly assigned to. In the post-questionnaire, there were 4 participants from the verbal persuasion condition and 3 participants from the social comparison condition.

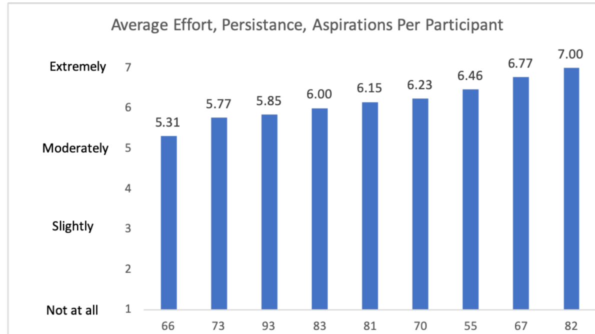
Teachers' learning from the PD materials and data presented in the dashboard

Before starting the analysis of this part, I would like to mention that the post-questionnaire question measuring self-reported learning from the dashboard module, due to a typo, was missing score "6" on a scale from 0-10 (thus the scale jumped from "5" to "7"). Despite that, the following analysis is done with the full scale.

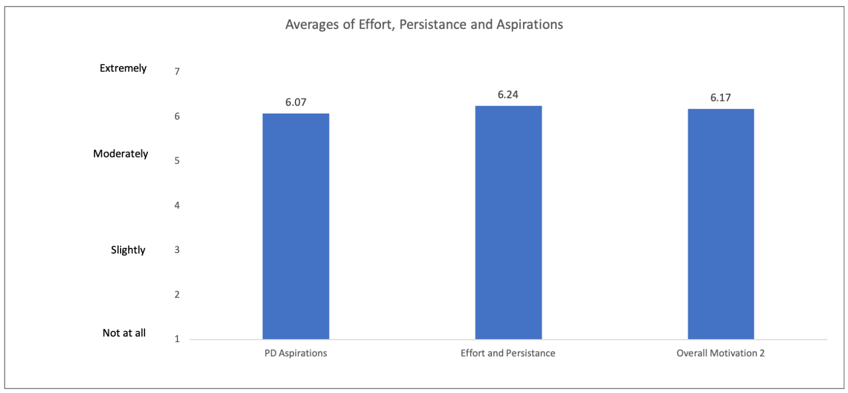
Overall, teachers self-perceived they learned from taking part in this study where they were able to see PD materials in relation to immediacy and nonverbal behaviors as well as see their own proxemics nonverbal behavior data in the classroom. As shown in Figure 7-15(b), overall teachers said they learned on average 6.6 (on a scale 0-10), with the average learning from PD (6.4) being slightly lower than the learning from seeing the dashboard and their own data (6.9). This difference suggests that teachers find both PD and data helpful to increase their knowledge and learning, but they self-perceive they learn more from seeing their own data and the dashboard module. In the same Figure, I share how each individual participant scored in their self-reported learning from PD and data as well as their average self-reported learning. Half of the instructors, 4 out of 7, scored on average quite high (with a value of 7 or above



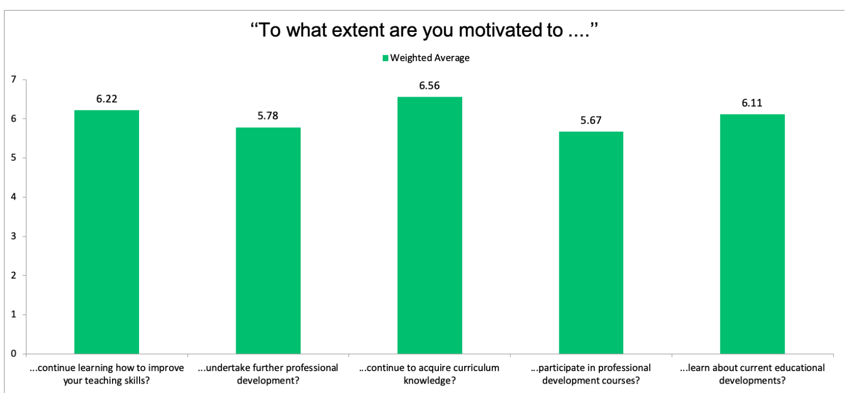
(a) Distribution of teacher planned effort, persistence and professional development aspirations.



(b) Distribution per participant.



(c) Average of teacher planned effort, persistence and professional development aspirations.



(d) Weighted average of teachers' answers to the professional development aspirations questionnaire.

Figure 7-14: Information on teachers' planned effort, persistence and professional development aspirations.

in the 0-10 learning scale). Of the other three instructors, 2 of them scored on average below the "Learned Somewhat" scale and 1 of them scored on average a little above the "Learned Somewhat" scale. In relation to the condition, the verbal persuasion condition compared to the social comparison condition scored slightly higher on learning from the PD module, learning

Table 7.4: Participant completion of experiment stages as well as condition in the study.

Participant ID	**Condition**	**Pre-Q?**	**Interview?**	**Post-Q?**
55	Verbal Persuasion	Yes	Yes	Yes
66	Verbal Persuasion	Yes	Yes	Yes
73	Social comparison	Yes	Yes	Yes
67	Verbal Persuasion	Yes	Yes	Yes
93	Verbal Persuasion	Yes	Yes	Yes
82	Social Comparison	Yes	Yes	Yes
70	Social Comparison	Yes	Yes	Yes
81	Verbal Persuasion	Yes	No	No
83	Social Comparison	Yes	Yes	No

from the data and dashboard as well as the average learning.

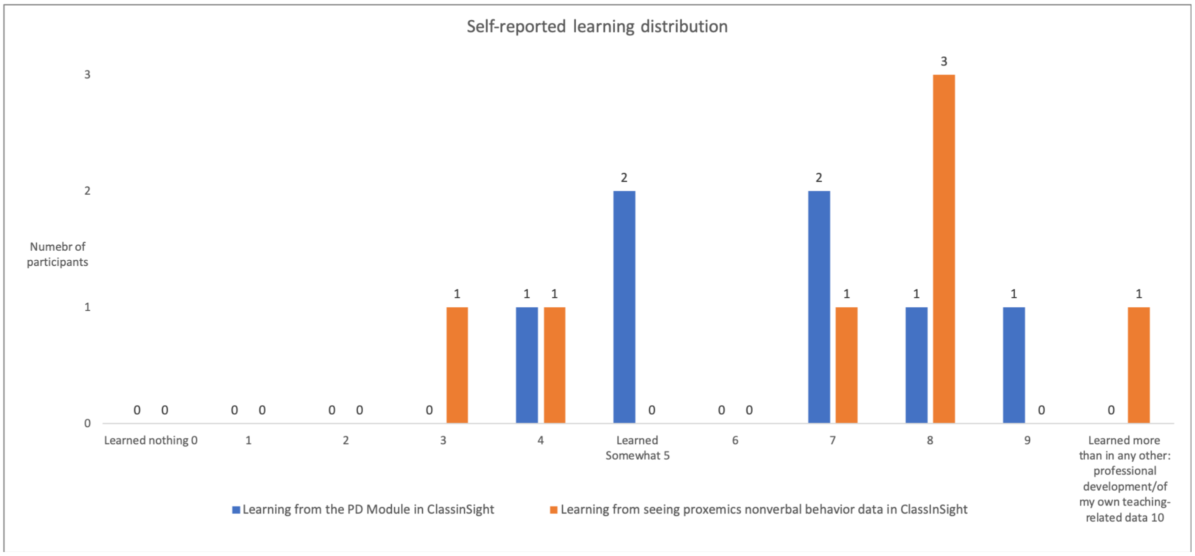
Taking a look at the distribution of teachers' answers (Figure 7-15(a)), 4 out of 7 teachers replied with a score of 5 or above to learning from the PD module, while 5 out of 7 instructors replied with a score of 5 or above to learning from the data and dashboard module. In fact, one instructor self reported that they "*Learned more than in any other of my own teaching related data*". To note is the fact that the instructors who took part in this study, as described previously in the pre-questionnaire analysis, had a rich experience with professional development and training within and outside of CMU. Them scoring this high despite that, shows that both the PD materials and their own data and dashboard showed them information that they could learn from, even more compared to their prior trainings.

Along the same line of reasoning, the teachers who scored slightly lower on their self-perceived learning of PD, maybe had other PD or training in their lifetime, not related to immediacy and nonverbal behaviors, that was very useful to them. That does not mean they did not learn from the PD in this study, rather their learning compared to their prior experience was one way or another. Similarly, maybe they received other data, even from the Eberly center, that they learned more than the subset of their nonverbal behavior data shown in this study. Again, that does not mean they did not learn from their own data, but that their self-perceived learning was respective to their prior experience on this matter. In summary, based on the results in this section, it seems that teachers self-report high levels of learning both from the PD module as well as the data and dashboard they saw in ClassInSight, despite them having had rich experience with PD and other trainings in their lives.

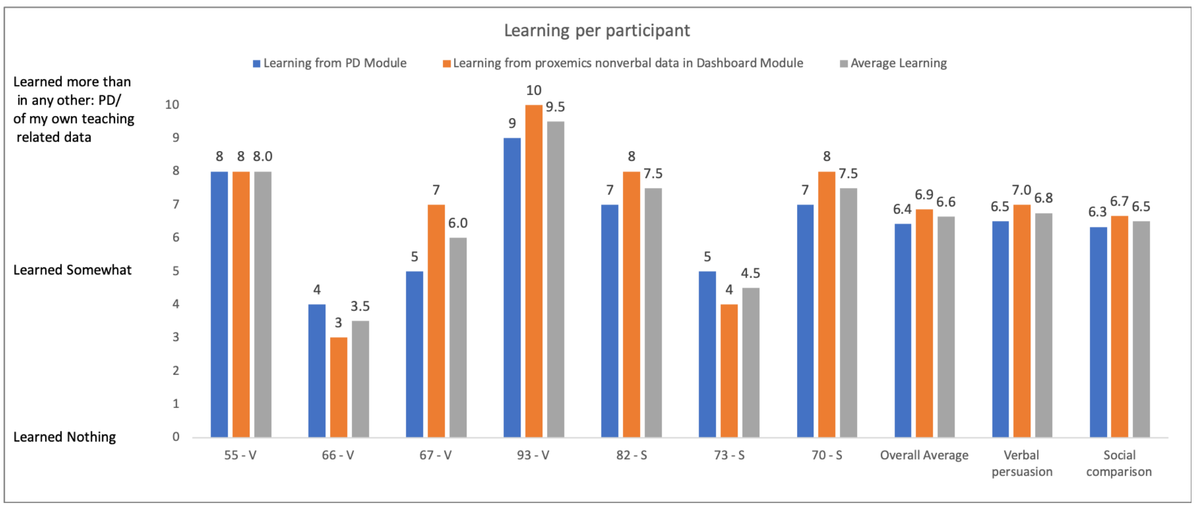
Teachers' attitudes from the PD materials and data presented in the dashboard

In this section I will analyze teachers' attitudes in various dimensions. Note that the attitude questionnaire had several subscales ranging from negative to positive and vice versa. For the analysis, I reversed them so that all subscales worked from negative to positive including Good/Bad, Valuable/Worthless, Fair/Unfair, Positive/Negative, etc.

In Figure 7-16(a) I calculate the average attitudes for each of the questions in the attitude questionnaire. I also present an overall average across all the attitude questions. Overall, teachers scored quite high in relation to their attitudes (average of 6.03 out of 7.00). This means that instructors in this study have positive attitudes towards the PD module and data they saw in this study. In addition, teachers scored the highest in their likelihood to enroll



(a) Distribution of participants' answers to the self-reported learning prompt.



(b) Self-reported learning per participant.

Figure 7-15: Participants' responses to self-reported learning questions in the post-questionnaire.

in another PD of related content (average 6.25). This is positive because first it shows that teachers see the PD provided in this study as important and valuable. Secondly, it shows how important training and PD on immediacy and nonverbal behaviors is for teachers. Similarly, the likelihood to engage in the behaviors recommended in the PD is quite high (average 6.18, the second highest average), showing that the PD module in the study incentivized teachers to attempt and engage in the recommended behaviors. Teachers also score a 6 out of 7 on average in relation to their attitudes about their proxemics data, an overall positive view of the data that they were presented with. Lastly, they also have a quite positive attitude in terms of the feedback they got from ClassInSight (6.17 out of 7) showing the importance and necessity of feedback following data provided to them.

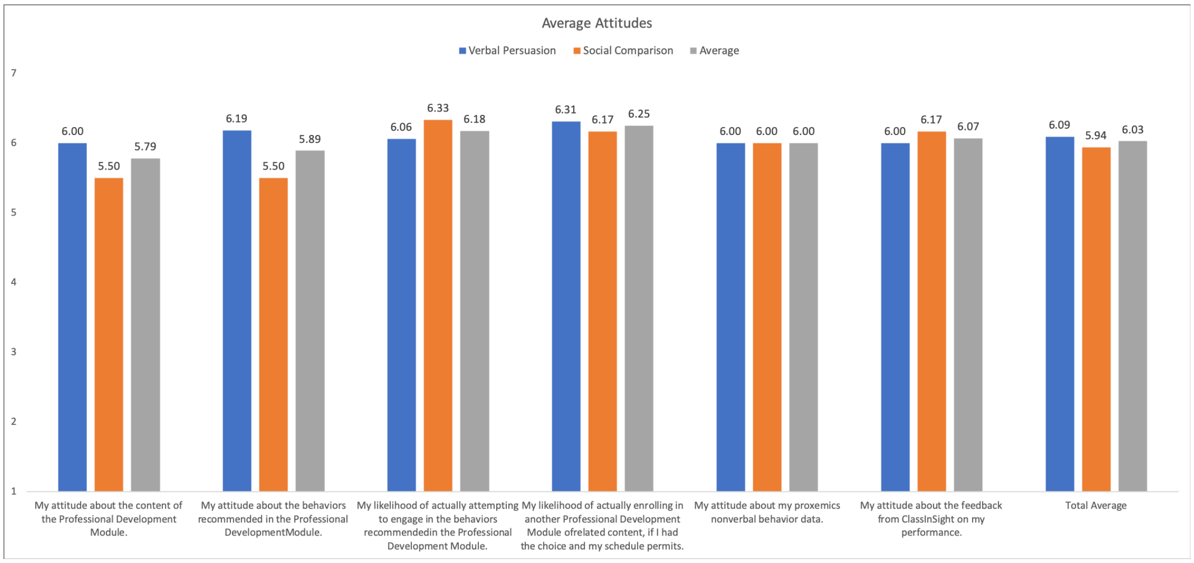
In relation to the two conditions in the study, overall, on average the verbal persuasion condition scores slightly higher than than the social comparison condition (averages 6.09 and 5.94 respectively). However, when looking at their attitudes about the ClassInSight feedback (which was the only part, Part 3, in the study where the conditions were introduced) the social comparison condition has a higher (6.17) average compared to the verbal persuasion group (6.00). This could mean that seeing their data perform better when compared against other instructors (the social comparison group) provides a more positive attitude for instructors than seeing only a paragraph of motivating text as feedback (verbal persuasion group). Similarly, the social comparison group scores slightly higher in their attitude for engaging in the recommended behaviors, which again could hint in the direction that seeing their data perform better when compared against other instructors results in a higher and more positive attitude on the participants. The two groups score similarly in terms of their attitudes about the nonverbal behaviors, and in all the other attitude measures, the verbal persuasion group scores quite higher.

Taking a look at individual instructors, (Figure 7-16(b)), the attitudes of per participant are generally consistent for each of the questions in the questionnaire. There are a few exceptions that are interesting to discuss. Participants 66 and 73, even though they score lower an all the other attitude questions, they score higher in their likelihood to enroll in another PD module of related content was higher. On the same note, 4 out of 7 teachers reported a maximum of 7 on their likelihood to enroll in another PD of similar content. Again, those results show that teachers value such PD opportunities, in particular with immediacy and nonverbal behavior related content, and they have a high likelihood to enroll in such PD in the future. Similarly, there were 4 teachers out of 7 who reported a maximum of 7 in their likelihood to attempt and engage in the behaviors recommended in the PD module. This again is very interesting and positive and it shows the willingness of these participants to change their behaviors and engage in new behaviors. Lastly, it is interesting to see that participant 55, while they score a high on all measures, in relation to attempting such behavior they score a lower value of 6.3. As described in the interview analysis section below, their likelihood of attempting such behaviors might be restricted by other factors such as the physical barriers in the room. This may apply to other participants as well who scored lower on this likelihood.

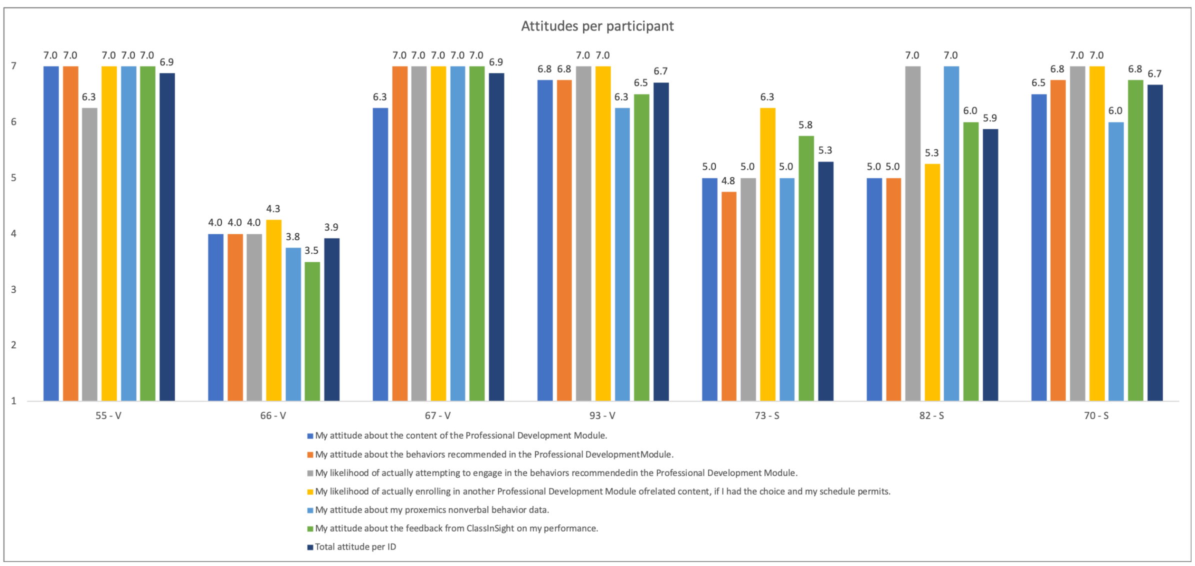
Confidence in immediacy and nonverbal behaviors

In the post questionnaire, 6 out of 7 teachers assess their confidence in their immediacy and nonverbal behaviors uniformly distributed between "Moderately Confident" (2 teachers), "Very Confident" (2 teachers) and "Extremely Confident" (2 teachers), while only 1 teacher assesses it as "Slightly confident" (Figure 7-17(a)). The weighted average of teachers' self-reported confidence in the post-questionnaire was 3.71 which is quite high. Comparing it to the pre-questionnaire in Figure 7-17(a), teachers' confidence has increased from pre to post (with the weighted averages from 3 to 3.71 respectively) and the distribution of the instructors' answers has shifted towards the "Very" and "Extremely" confident spectrum of the scale. Comparing the changes in this question from pre to post per participant (Figure 7-17(b)), there are 2 teachers who did not change their score pre to post, while 4 teachers increased, with one of them increasing from "Moderately" to "Extremely". Lastly, 1 teacher decreased from "Very" to "Moderately".

In relation to the condition (Figure 7-17(b))), the verbal persuasion group had a slightly higher average (3.3) in the pre-questionnaire compared to the social comparison group (3.0). However, in the post-questionnaire, both groups score similarly (3.8 and 3.7 respectively). Note, this average per condition in pre and post was based only on the 7 participants who took both the pre and post questionnaires. These results show that the social comparison group had the highest increase in confidence in pre-to-post compared to the verbal persuasion group, even



(a) Average attitude per question and overall.



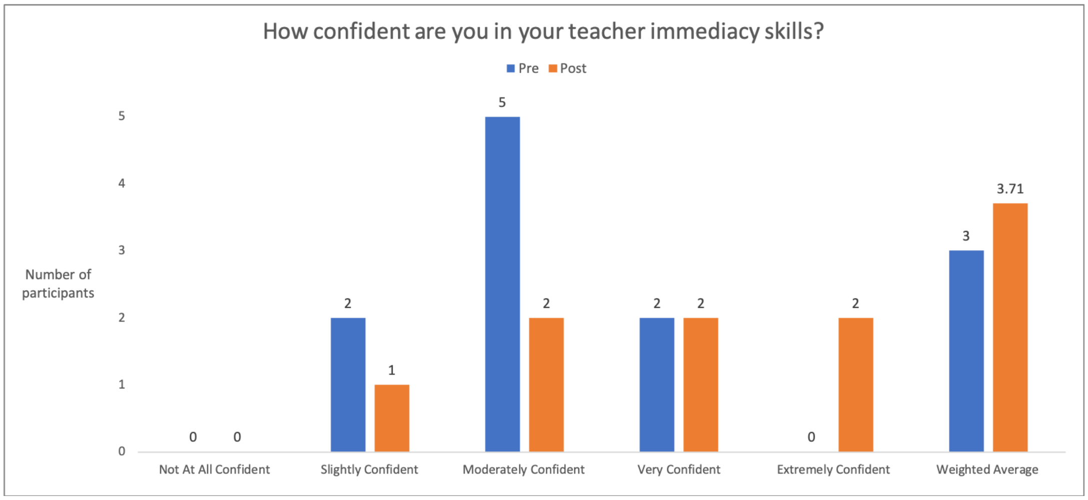
(b) Attitudes per participant with averages.

Figure 7-16: Participants' self-reported attitude

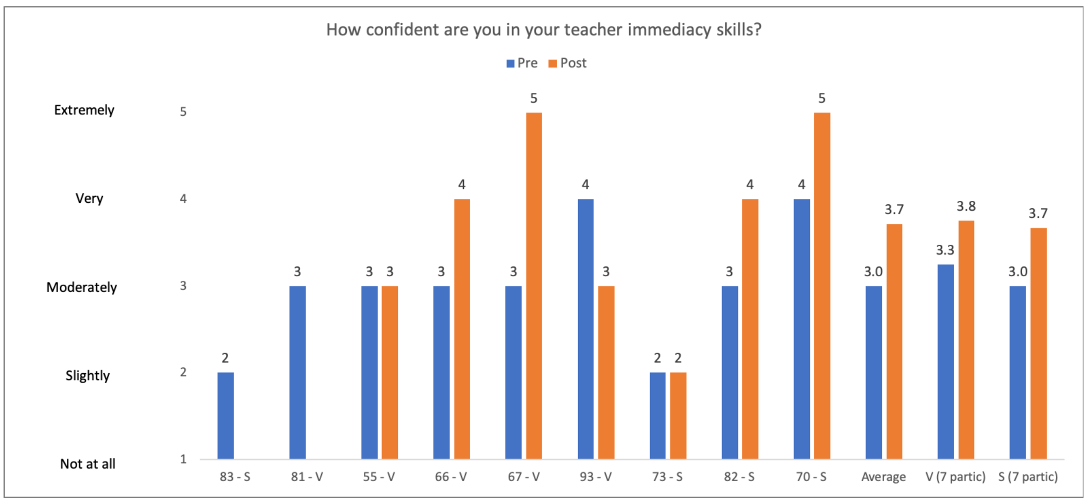
though both groups increased. The higher increase in the social comparison group could indicate that seeing their data perform better compared to other instructors at CMU increased teachers' confidence in their own immediacy skills. In conclusion, these results show that overall, teachers increased their confidence from the pre to post questionnaire.

Behavior Change Intentionality

In the post-questionnaire, the majority of teachers (5 out of 7) said that they had specific immediacy and nonverbal behaviors they wanted to work and improve on, while 2 teachers responded "No" to this question (Figure 7-18). The latter teachers are the participants who responded "No" and "Not sure" in the pre-questionnaire, thus one of them did not change their



(a) Pre-post confidence distribution and weighted average.



(b) Pre-post confidence per participant and averages.

Figure 7-17: Teachers' self-reported confidence.

opinion while the other one changed it from "Not Sure" to "No". However, all the other teachers who responded "Yes" in the pre-questionnaire, responded "Yes" in the post-questionnaire as well. In addition, the one teacher who responded "No, but open to improvement" in the pre-questionnaire, changed their stance and responded "Yes" here.

In relation to the behaviors that they were interested in working and improving on, teachers mention both proxemic related behaviors (on which they received data) as well as other non-verbal behaviors on which they did not receive data but they read and learned about in the PD materials. Behaviors included more movement in class, including moving closer to students and in particular moving away from behind the podium, more eye contact and facing their students, as well as having an open body language and more gesturing.

Values and Beliefs around Immediacy and Nonverbal Behaviors

In relation to the value and their beliefs around immediacy and nonverbal behaviors, teachers

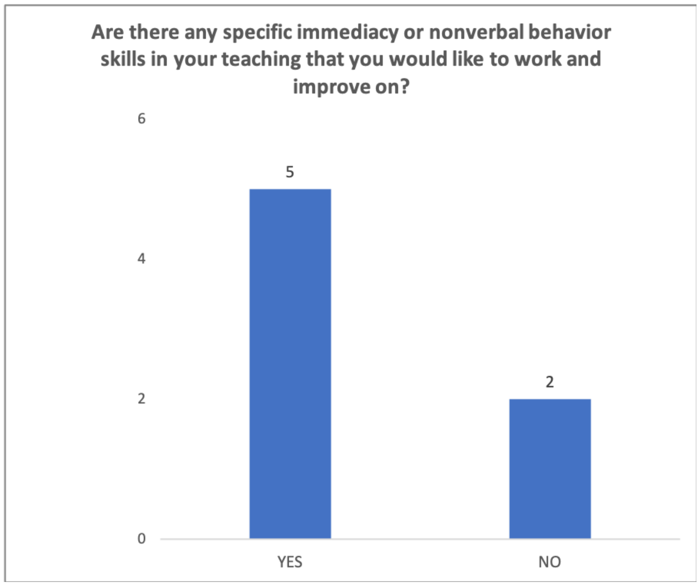


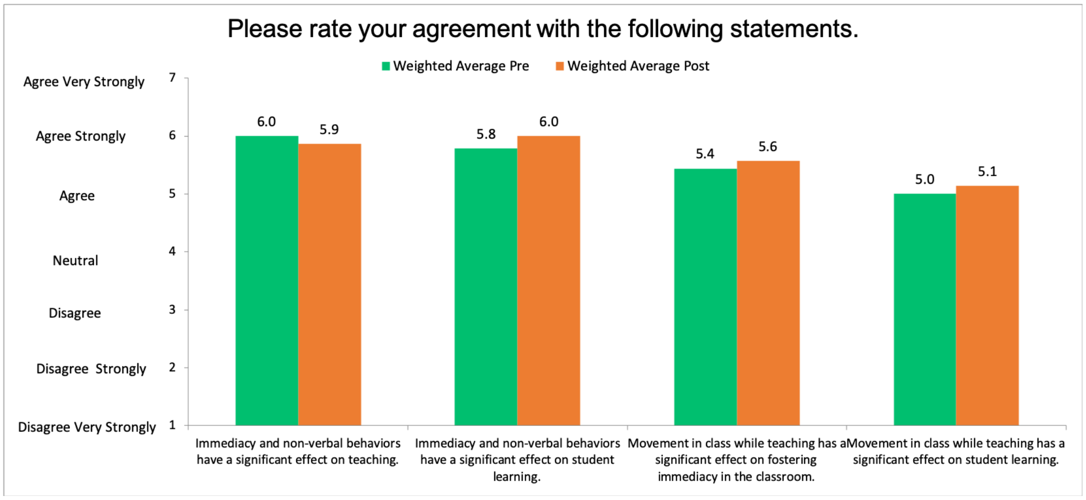
Figure 7-18: Teachers' interest to change their immediacy and nonverbal behaviors expressed in the post-questionnaire.

still score quite high in the post-questionnaire (Figure 7-19(a)). The highest score in post is in relation to teachers' beliefs on immediacy and nonverbal behaviors having a significant effect on student learning (weighted average of 6.0). This is positive and it shows that teachers see the importance and value of such behaviors on students and their learning. Similarly, teachers score high on the effect they see such behaviors have on teaching (weighted average 6.9). Compared to pre, there is a slight decrease in the value teachers see immediacy and nonverbal have on teaching, however for all three other questions, there is a slight increase. This might be an effect of the smaller number of participants in the post-questionnaire (7) compared to 9 participants in pre. Overall, it seems that the pre and post results on teachers' values and beliefs remained relatively the same from pre to post.

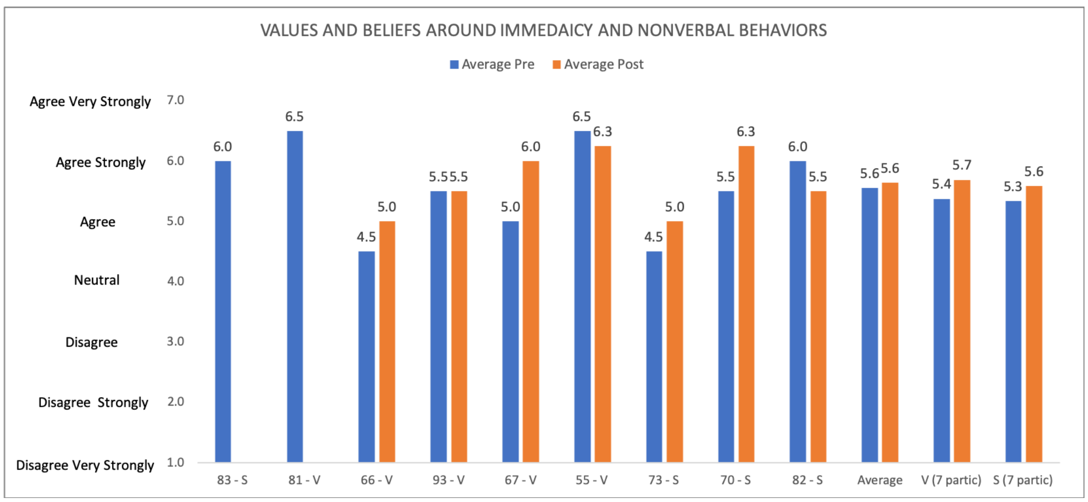
Taking a look at each of the individual participants (Figure 7-19(b)), overall multiple instructors score quite high; between the scales "Agree" to "Agree Very Strongly". On average from pre-to-post, 1 participant did not change their score, 4 participants increased and 2 decreased in their values and beliefs around immediacy and nonverbal behaviors. On average, there was a very slight increase in values and beliefs from pre to post (average pre for 9 participant 5.6, adjusted average pre for 7 participants 5.4, average post for 7 participants 5.6). In relation to the condition, the verbal persuasion and social comparison conditions seem to have scored similarly both in the pre and post-questionnaires. As a result, both conditions had the same increase from pre to post. These results hint to a positive trend of increase of teachers' values and beliefs from pre-to-post.

General and task-specific Self-efficacy

In relation to SE, there was an overall increase in the average score from pre (6.86 over 9 participants and adjusted average 6.93 over 7 participants) to post (7.45) as shown in Figure 7-20(a). These results hint in the direction that seeing PD as well as data on their nonverbal behaviors helped instructors increase their general SE for teaching. Looking at the conditions, the verbal and social comparison conditions start at a similar value in the pre-questionnaire



(a) Pre-post values and beliefs around immediacy and nonverbal behaviors.

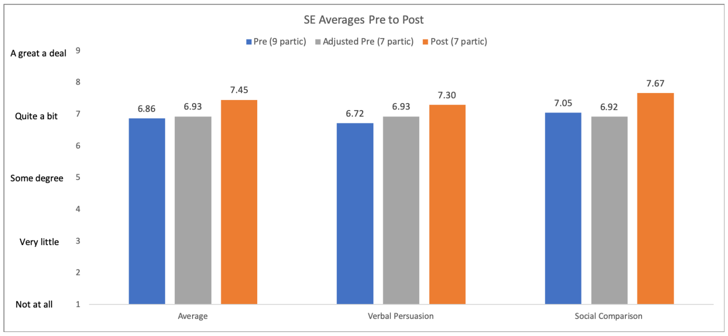


(b) Pre-post values and beliefs per participant, on average as well as per condition.

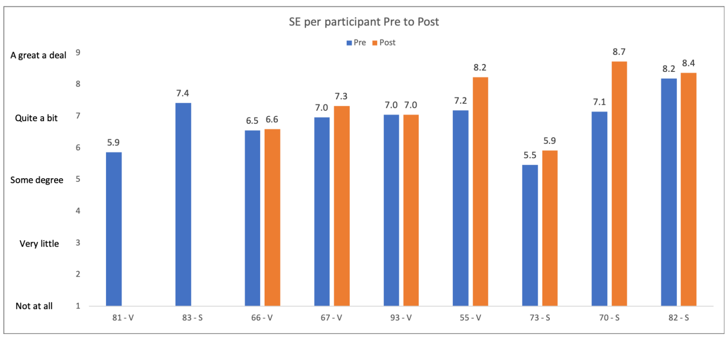
Figure 7-19: Values and beliefs around immediacy and nonverbal behaviors.

(adjusted averages of 6.93 and 6.92 respectively) and they both increase in the post-questionnaire (7.30 and 7.67 respectively) as shown in Figure 7-20(a). It seems that the social comparison group had the highest post-questionnaire score overall as well as the highest increase from pre to post. The results hint in the direction that the social comparison intervention had the highest effect on increasing instructors' SE in relation to their teaching from pre to post. This is consistent with prior literature on SE (i.e., [35]).

Looking at each participant (Figure 7-20(b)), 6 out of 7 instructors increased their SE efficacy score from pre to post while 1 participant scored the same. Splitting the 1-9 scale, from "Not at all" to "A great deal" into three buckets low [1, 3.66], mid [3.67, 6.33] and high [6.34, 9] as in the pre-questionnaire analysis, the participants in the post-questionnaire would fall into the mid and high buckets in relation to their post score, respectively 1 teacher in the mid-SE and the other 6 teachers in the high-SE (Figure 7-20(b)). That means that the instructors in this sample had quite high self-efficacy both in pre and in post, and in majority, they had some increase from pre to post.



(a) Average pre to post for SE.



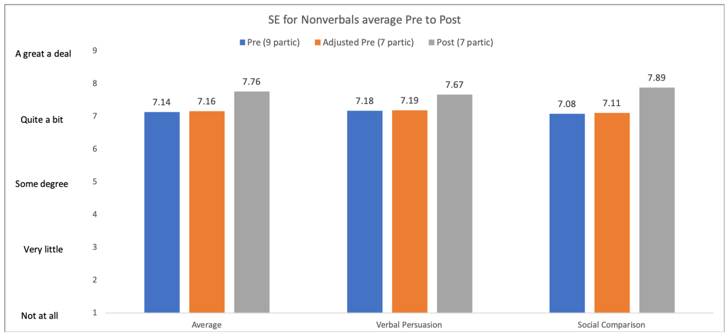
(b) Pre to post changes per participant.

Figure 7-20: Pre to Post general teaching SE metrics.

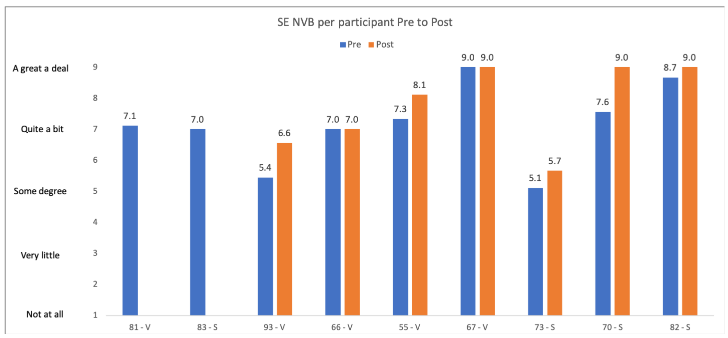
In relation to SE for NVB, there was an overall increase in the average score from pre (7.14 over 9 participants and adjusted average 7.16 over 7 participants) to post (7.76) as shown in Figure 7-21(b). These results show that seeing PD as well as data on their nonverbal behaviors helped instructors increase their SE specific to nonverbal behaviors. Looking at the conditions individually, the social comparison condition scored slightly lower on the adjusted average in the pre-questionnaire (7.11) compared to the verbal persuasion condition (7.19). However, on average both conditions increased in the post questionnaire to 7.67 (for verbal) and 7.89 (for social). The social comparison condition had a much higher increase from pre to post, compared to the verbal persuasion condition. The results hint in the direction that the social comparison intervention had the highest effect on increasing instructors' SE NVB from pre to post, also supported by prior literature as described above.

Looking at each participant individually, 5 out of 7 teachers increased from pre to post and 2 participants stayed the same (with one of them being at ceiling effect 9 out of 9 in both pre and post). Again, splitting the 1-9 SE NVB scale, from "Not at all" to "A great deal" into three buckets low [1, 3.66], mid [3.67, 6.33] and high [6.34, 9], the participants would fall into the mid and high buckets in relation to their post score, respectively 1 teacher in the mid-SENVB and 6 teachers in the high-SENVB (Figure 7-20(b)). That means that the instructors in this study had quite high self-efficacy for nonverbal in the post-questionnaire and the majority had an increase in score from pre to post.

To note is that there was a slightly higher increase from pre (adjusted over 7 participants) to post on average in relation to SE for NVB compared to general teaching SE. This result is normal and understandable provided that self-efficacy as a construct is very task specific [36]. In addition, for both SE and SE for NVB instructors scored quite high but there was no a ceiling effect overall, thus creating room for improvement.



(a) Average pre to post for SE for nonverbal behaviors.



(b) Pre to post changes per participant.

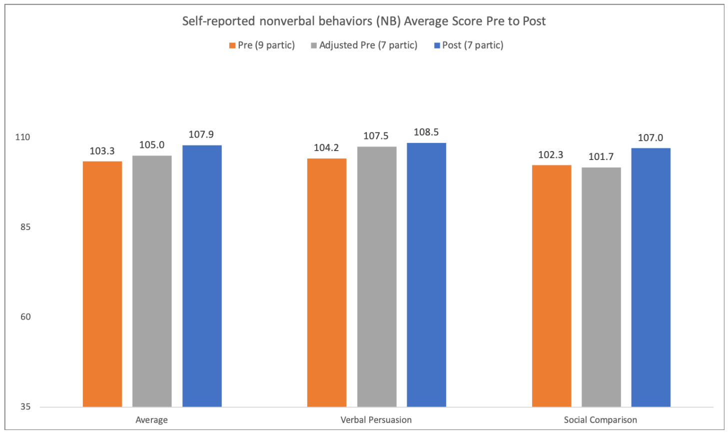
Figure 7-21: Pre to Post SE for nonverbal behaviors metrics.

Self-reported nonverbal behaviors

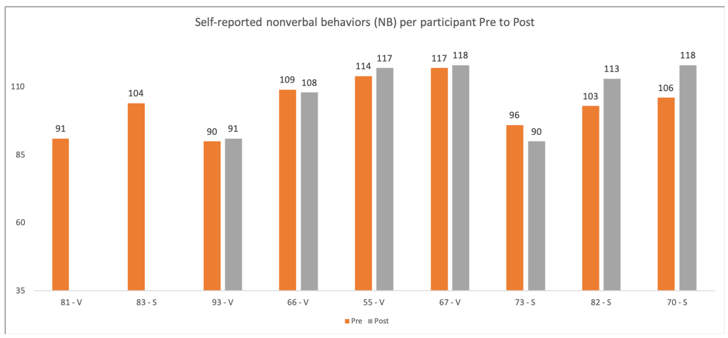
In relation to their self-reported nonverbal behaviors, the overall average in the post-questionnaire is still high (107.9 in the range 35 - 127) as seen in Figure 7-22(a). There is an increase from pre (103.3 and 105.0 over 9 and adjusted 7 participants respectively) to post (107.9). This indicates that teachers self-reported higher on their nonverbal behaviors in the classroom from pre to post. In relation to the social comparison and verbal persuasion conditions, there is an increase in the post score for both conditions, with the verbal persuasion post score being slightly higher. The increase from the average adjusted pre to the post score is highest for the social comparison group but that is an effect of the two groups having quite different adjusted pre-questionnaire average scores. In relation to the individual participants (Figure 7-22(b), the majority of instructors, 5 out of 7 participants increased from pre to post, while 2 participants slightly decreased. Overall, teachers' self-reported nonverbal behaviors are high in post and slightly increased from pre to post.

Motivation

When asked again in the post-questionnaire what decreases their motivation in trying to do their best in the classes they are teaching this semester, 4 out of 9 teachers responded similarly to the pre-questionnaire, that the lack of participation and their students' inattentiveness decreases their motivation. One teacher responded that other demands on their time can also be demoti-



(a) Average pre to post for self-reported nonverbal behaviors.



(b) Pre to post changes per participant.

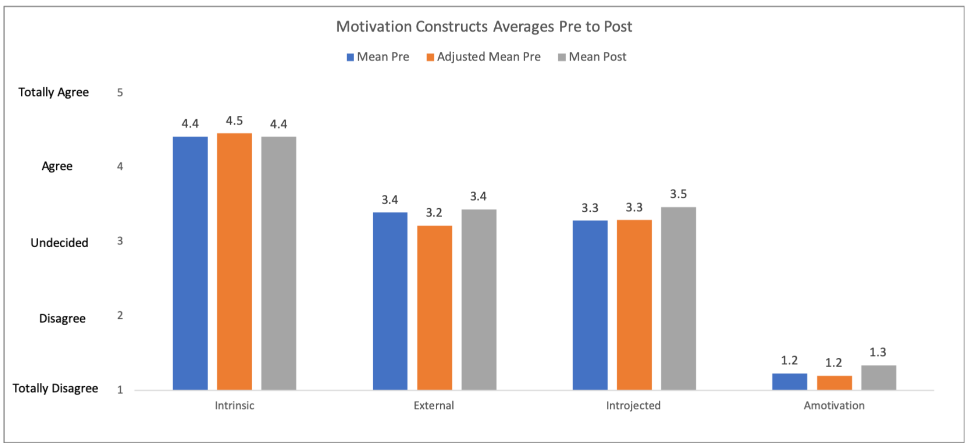
Figure 7-22: Pre to Post self-reported nonverbal behaviors.

vating. Similarly, when asked for what things motivate them, teachers' responded with student learning and retention as well as their interest and excitement in the topic. Those answers are similar to those in the pre-questionnaire and support the case for the importance of immediacy and nonverbal behaviors in creating a more comfortable and immediate classroom environment that helps students have more interest in the course and be more engaged and attentive in class.

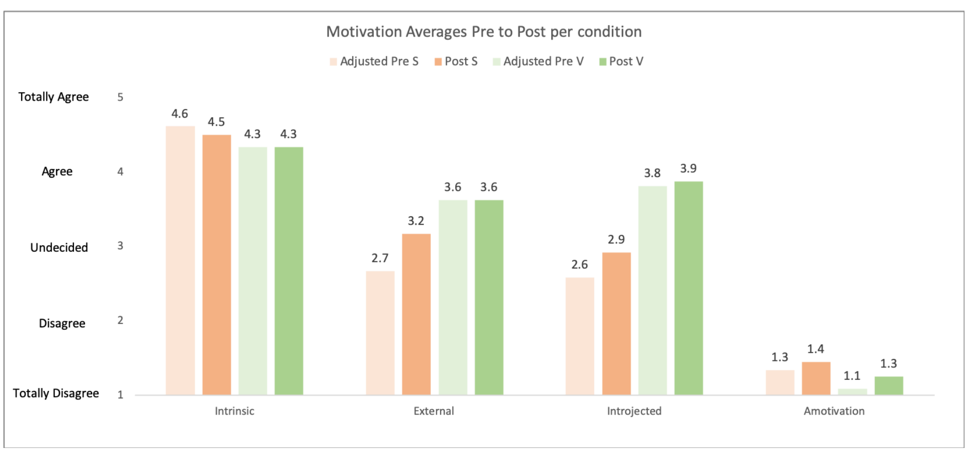
In Figure 7-23(a) I share teachers' average motivation in relation to teaching focusing on the intrinsic, external, interjocted and amotivation. It seems that from pre (adjusted average over 7 participants) to post there have been slight changes to the motivation constructs: a slight decrease in intrinsic motivation, and a slight increase in external, introjected and amotivation. However, overall those changes are quite small. This is also supported by the fact that this motivation questionnaire measured and assessed teachers' general motivation for teaching, which would be challenging to change by much due to one study only, as I do in this chapter. Overall, the average intrinsic motivation is quite high, scoring between "Agree" and "Totally Agree" on the scale while external regulation and introjected motivation score lower, between "Undecided" and "Agree".

When looking at the changes pre (the adjusted over 7 participants) to post based on the experiment condition (Figure 7-23(b)), the social comparison group has a slight decrease in intrinsic motivation while the verbal persuasion group does not change. In relation to their external regulation, the social comparison group has quite an increase while the verbal persuasion group again does not change. This might be explained by the fact that in the social comparison group the study is introducing external comparisons and rewards (comparison with other instructors) to motivate teachers, thus there is an increase in external motivation and a decrease in intrinsic motivation. In the verbal persuasion group the study is introducing verbal encouragement to motivate instructors, which might not have been as intrinsically or externally motivating. In terms of introjected motivation, teachers in the social comparison condition start of in the pre-questionnaire much lower than the teachers in the verbal persuasion condition. However both groups increase slightly from pre to post. Similarly, in amotivation, both groups start low and despite the small increase they remain close to the "Totally Disagree" scale.

In relation to the individual participants in the study, in terms of intrinsic motivation, 2 instructors did not change from pre to post, 2 others increased while the other 3 instructors decreased slightly. In terms of their external regulation, 2 instructors increased from pre to post, 4 did not change and 1 decreased in their motivation.



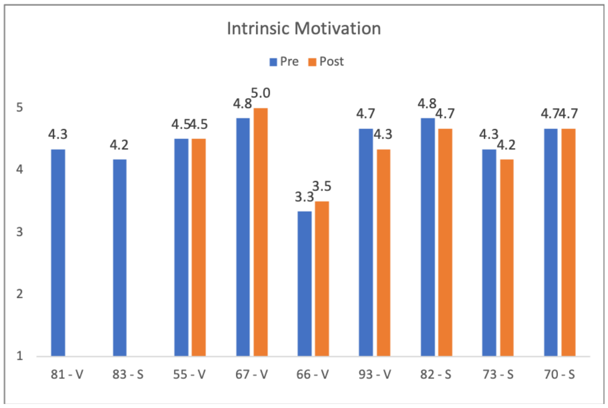
(a) Average motivation pre to post



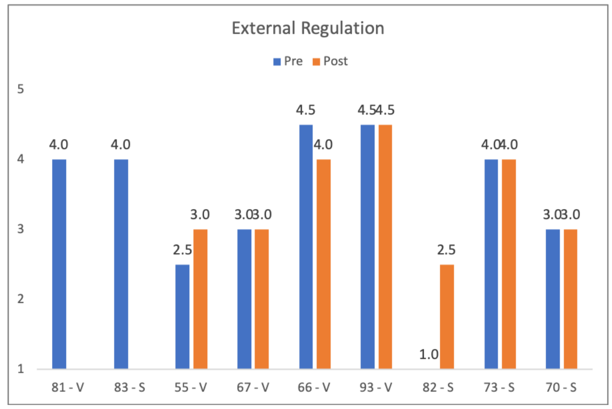
(b) Average motivation per condition

Figure 7-23: Pre to Post overall motivation.

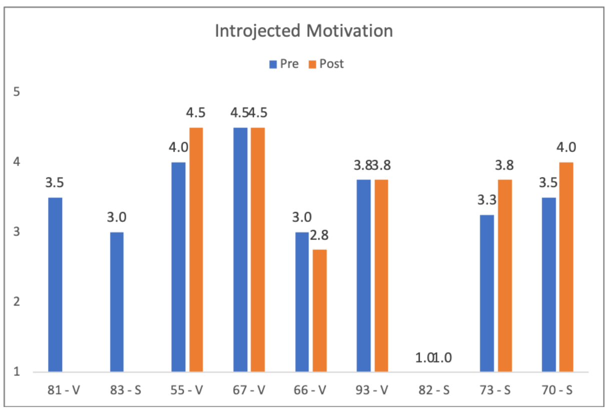
In terms of their planned effort, persistence as well as professional development aspirations, teachers scored quite high in the post-questionnaire with an average of 6.12 out of 7, closer to the "Extremely" score on the scale as shown in Figure 7-25(a). In relation to their PD



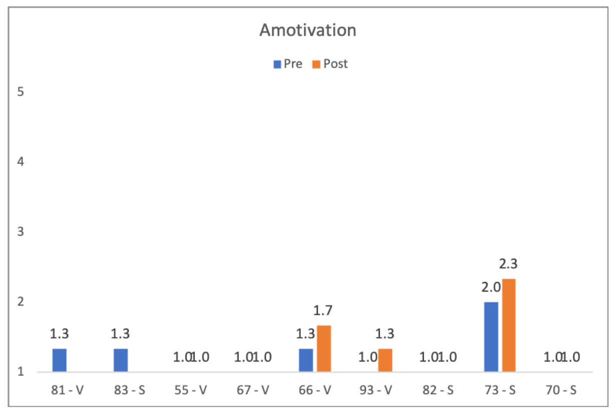
(a) Intrinsic motivation



(b) External Regulation



(c) Introjected motivation



(d) Amotivation

Figure 7-24: Each motivation construct shown pre to post per participant on a scale from Totally Disagree, Disagree, Undecided, Agree, Totally Agree.

Aspirations as well as Effort and Persistence, teachers scored high as well, with an average in the post-questionnaire of 5.97 and 6.21 respectively. From pre to post (considering both the average pre over 9 participants and the adjusted average over the 7 participants who completed both questionnaires), there is a slight decrease in the overall average from pre to post. Overall, the results in post are consistent with the pre results in terms of the average motivation, as well as in terms of PD aspirations and Effort and Persistence separately. This might be because these larger motivational constructs are general and not specific to this study (namely immediacy and nonverbals), and it makes sense that the study intervention did not majorly affect them.

Looking at the changes pre (for the adjusted pre with 7 participants) to post based on the experiment conditions (Figure 7-25(b)), overall, the social comparison condition scored slightly higher in pre compared to the verbal persuasion condition (average of 6.33 and 6.10 respectively). That seems to be because the social comparison group scored quite high in pre in their Effort and Persistence subquestionnaire. In post overall, there was a slight increase of the social comparison score and a decrease of the verbal persuasion score. Looking at the PD Aspirations, there is an increase in the social comparison group and a decrease in the verbal persuasion group from pre to post. On the other hand, in the Effort and Persistence subquestionnaire, there is a slight decrease in both groups. Provided those increases and decreases, it does not seem that the condition on its own affected the score changes.

Lastly, looking at the individual participants Figure 7-25(c), 3 teachers increased their score, 3 decreased it and 1 stayed the same. The increases, decreases and no change are mixed per condition thus, again, it does not seem that the condition on its own affected much the score of this questionnaire, as discussed above.

Last but not least, in the post-questionnaire, teachers were also measured on their motivation for participating in the specific task of engaging with the PD Module and looking at their own proxemic nonverbal data. As mentioned above, this task-based motivation questionnaire was adapted from [88] and the distribution of questions per motivation construct is shown in the Figure 7-26.

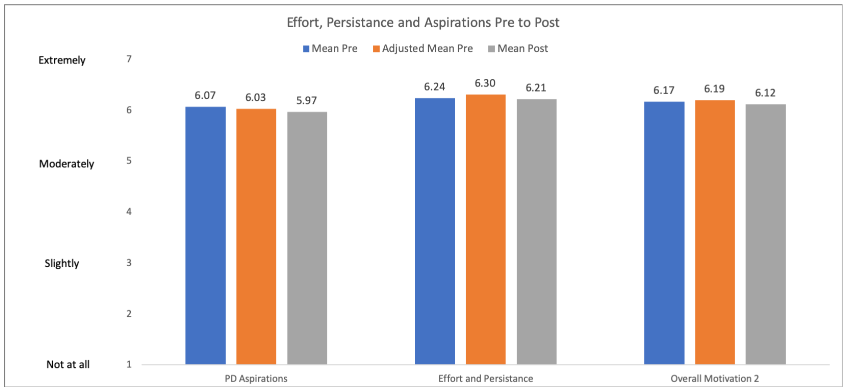
On average, as shown in Figure 7-27(a), teachers scored really high on their intrinsic motivation for this task (5 out of 7 with an "Agree"). This is to show that overall the participants in this study care about teaching and are motivated intrinsically to engage with activities that involve PD and engaging with data as in the current study. Teachers scored very low in terms of external motivation for this task, understandably as there was little to no external motivation for them to take part in this task. Teachers scored similarly low values for their introjected motivation and amotivation.

In relation to the individual participants, half of the teachers (4) scored equal to or higher than "Agree" in terms of their intrinsic motivation. The other three motivational constructs were quite low. In terms of conditions, both verbal persuasion and social comparison conditions scored similarly in terms of intrinsic motivation and external regulation, thus it seems that the condition may not have affected participants much in terms of their motivation for engaging with this task.

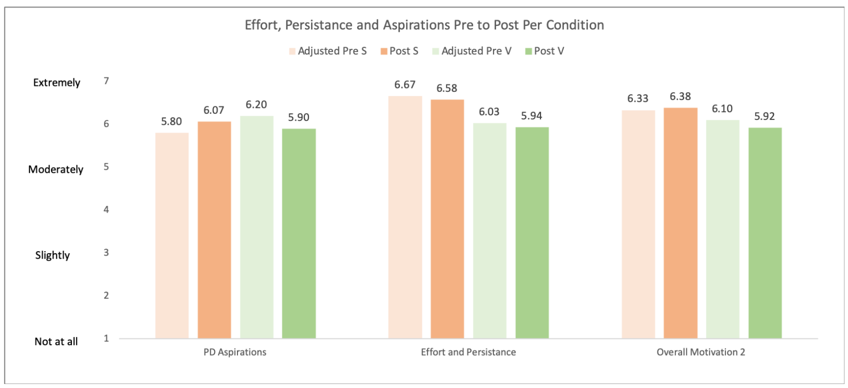
Teachers' Goals for Behavior Change

In the post-questionnaire, teachers were asked about their willingness and readiness to change their general as well as their specific proxemic behavior, after taking part in the study. In addition, teachers were asked in an open-ended question format if they would like to change something in their nonverbal behaviors in the classroom. If so, they were asked to list 2-3 ways and elaborate, and if not, they were asked to elaborate on why. All three of these questions were meant to be used as proxies for measuring teachers' behavior change. Namely, they measured teachers' intentionality to change which is both the first step in engaging in behavior change and a really good proxy for measuring behavior change (when behavior change on its own is not being measured).

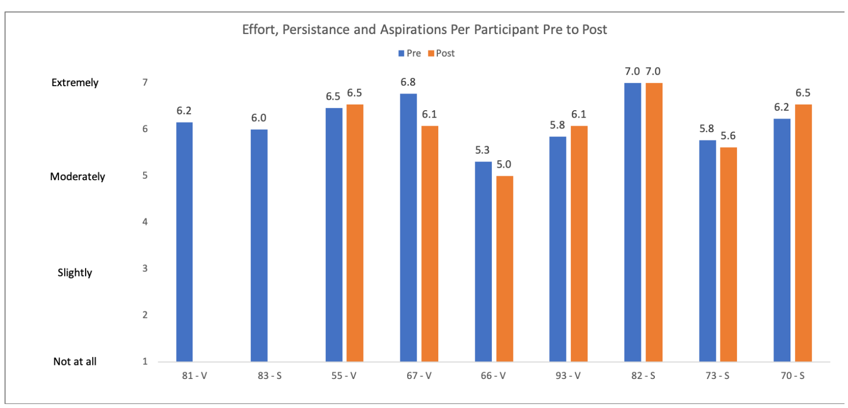
In relation to the willingness to change, teachers scored on average a 5.38 out of 7, which falls between "Agree" and "Agree Strongly" in the scale (Figure 7-28(a)). This shows that teachers were willing to work and improve on their nonverbal behaviors in the classroom after taking part in this study. Looking in more detail, it seems that both PD and seeing their own data affected teachers' willingness to change and for both of those two questions they scored an average of 5.43 out of 7, which is quite high. This shows that both PD and the data were useful to help and support teachers' willingness to change. Last but not least, the feedback received from ClassInSight on their performance also affected teachers willingness to change with an average of 5.29, slightly lower than looking at the PD and data but still high. To summarize, looking at PD, data and feedback from ClassInSight support teachers' willingness to change their nonverbal behavior with their students.



(a) Average teacher planned effort, persistence and professional development aspirations pre to post



(b) Average teacher planned effort, persistence and professional development aspirations per condition



(c) Teacher planned effort, persistence and professional development aspirations per participant.

Figure 7-25: Pre to Post overall teacher planned effort, persistence and professional development aspirations.

Taking a look at the individual participants in terms of their willingness to change, it seems that 4 teachers score on average 6 ("Agree Strongly") or above and the other 3 teachers scored between 3 and 5 ("Disagree" and "Agree") as shown in Figure 7-28(b) (one "Disagreed", one was "Neutral" and one scored between "Neutral" and "Agree Strongly"). Overall, 6 out of 7,

Intrinsic Motivation
- Because it is pleasant to carry out this task.
- Because I find this task interesting to do.
- Because I like doing this task.

Identified Regulation
- Because it is important for me to carry out this task.
- Because this task allows me to attain work objectives that I consider important.
- Because I find this task important for the academic success of my students.

Introjected Regulation
- Because if I don't carry out this task, I will feel bad.
- Because I would feel guilty not doing it.
- To not feel bad if I don't do it.

External Regulation
- Because my work demands it.
- Because the school obliges me to do it.
- Because I'm paid to do it.

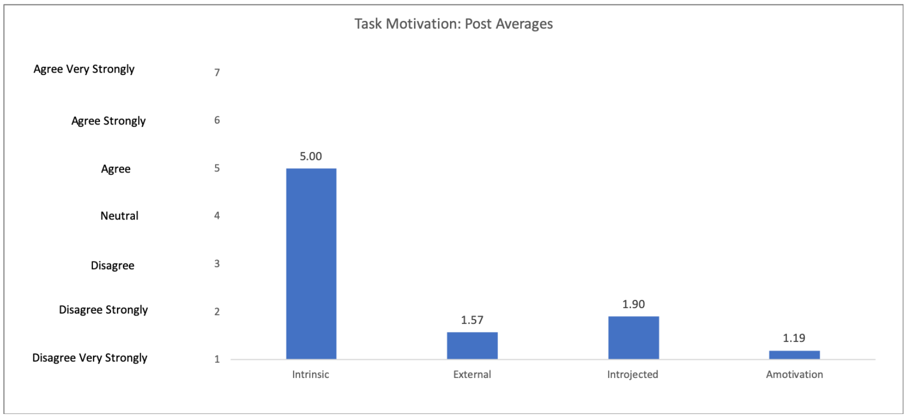
Amotivation
- I don't know, I don't always see the relevance of carrying out this task.
- I used to know why I was doing this task, but I don't see the reason anymore.
- I don't know, sometimes I don't see its purpose.

Figure 7-26: Task based motivation question and classification from [88]

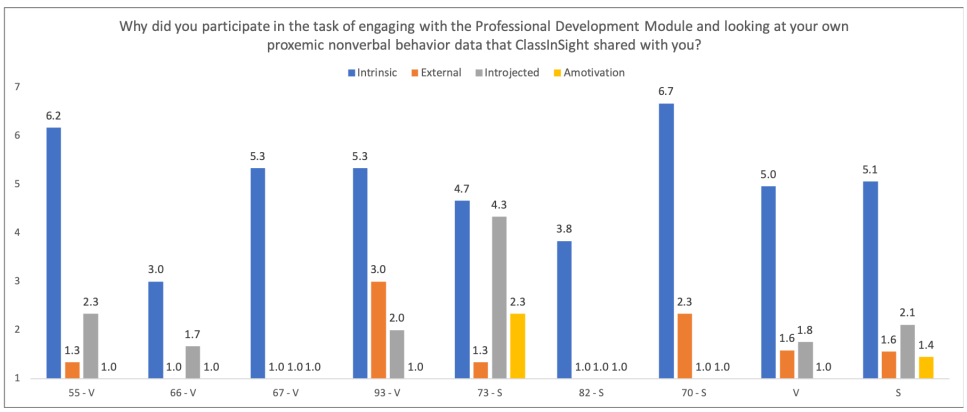
teachers gave the same score to all the three components of the study: PD, data and feedback from ClassInSight, which means that they found them equally important and helpful. One teacher scored the PD and data higher and the feedback from ClassInSight lower in this aspect. Looking at the verbal persuasion and social comparison conditions, the former scores slightly higher on average than the latter, however the differences between the conditions are quite small.

In terms of their readiness to change (Figure 7-29(a)), on average teachers scored a 6.64 out of 10 which is very close to the "Planning and making a commitment to it" score on the scale. This means that teachers in this sample are past the stages of "Not being ready at all to change their behaviors" and "Thinking about it" to a more planning and commitment attitude. Similarly, teachers are ready to change both their general nonverbal behaviors (an average of 6.71) and their proxemic nonverbal behavior (on average 6.57), both quite high. The slight difference in scoring between those two categories hints that teachers are ready to change their other nonverbal behaviors in the classroom, in addition to proxemics. It might also mean that they feel there are limitations to what they can change in terms of proxemics behavior, due to the physical layout of the classroom and any technologies they need to use as part of their teaching. I discuss these reasons in more detail in the interview analysis section below.

In relation to the individual participants (Figure 7-29(b)), 4 out of 7 instructors score an 8 or higher, with one instructor scoring a 10 and reaching the "I already do that" in the readiness to change scale. The other 3 instructors score between 2 and 5 with one being "Not ready at all" and the other two being between "Thinking about it" and "Planning and making a commitment". Teachers overall are ready to change their behaviors in the classroom, with most of them falling in the category where they are planning and making a commitment to their behavior change. This is a good indicator for teachers' actual behavior change in the classroom. In terms of condition, the verbal persuasion group scores slightly lower on average than the social comparison group in their readiness to change their general behavior but they scored slightly higher in their readiness to change their proxemic behavior. Overall, the average over the two conditions is quite similar.



(a) Average task-related motivation.



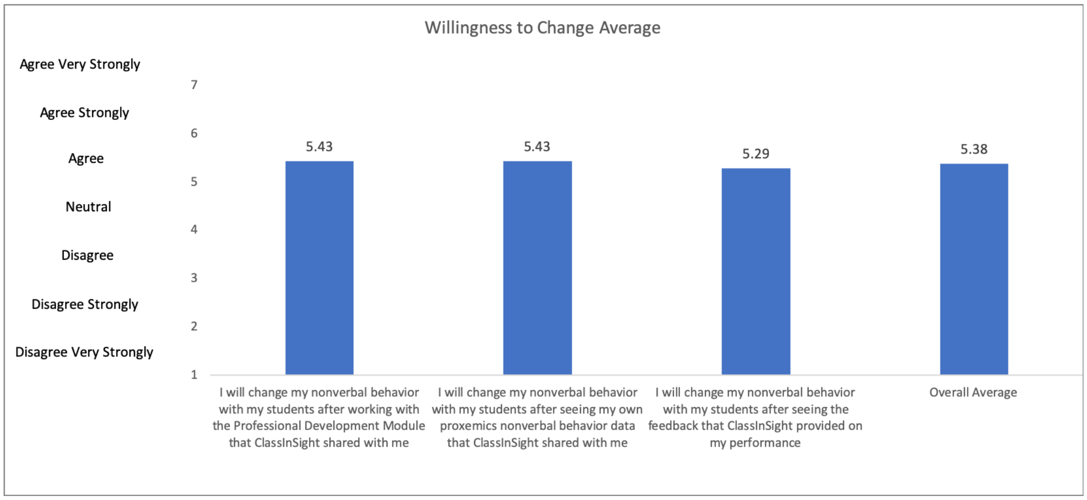
(b) Task related motivation per participant.

Figure 7-27: Teachers' motivation for taking part in the study (the task related motivation).

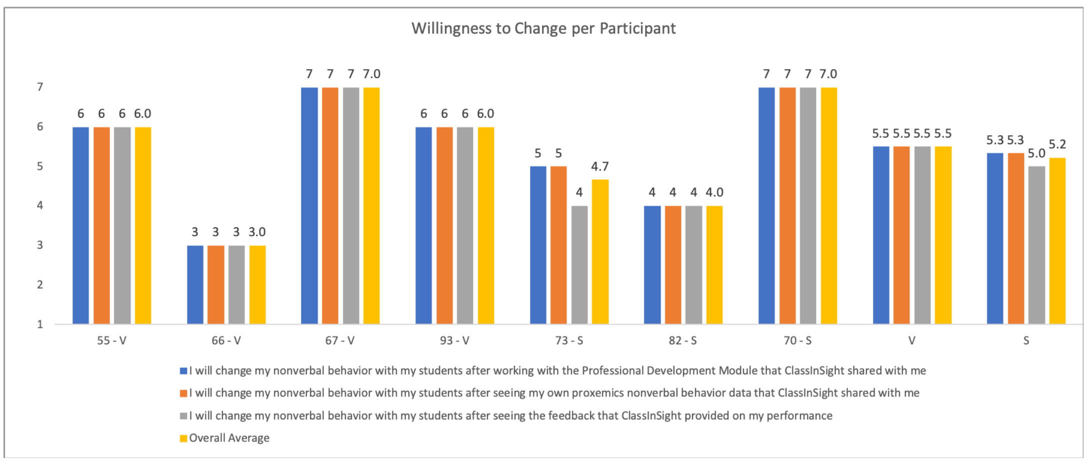
When asked if there was something they wanted to change in their nonverbal behavior in the classroom, 5 out of 7 teachers said that they were going to change something. One teacher said that they already do those kinds of behaviors but they know they can improve, thus listed some behaviors they wanted to change. And lastly, one teacher's answer was not answering the question, rather it was a feedback for the study and what the study could do better.

In terms of what specifically they wanted to change, 6 out of 7 teachers mentioned they wanted to change their proxemic behaviors as well as other more general nonverbal behaviors they learned in the PD materials. This included wanting to work more on proxemic behaviors such as:

- more movement, staying away from the laptop and looking for opportunities to get away from the board as well as stay more in front of the desk/podium in order to be closer to the students (3 teachers). For example, one teacher said: *ID 73: "Look for opportunities to step away from the blackboard/toward the students, because I think this will make me a more engaging lecturer."*
- having a proportional distribution of their movement in front of the room (2 teachers). For example, one teacher said: *ID 67: "I would more evenly distribute my time standing in front of my students ts instead of just dominating one part of the classroom."*



(a) Average willingness to change.



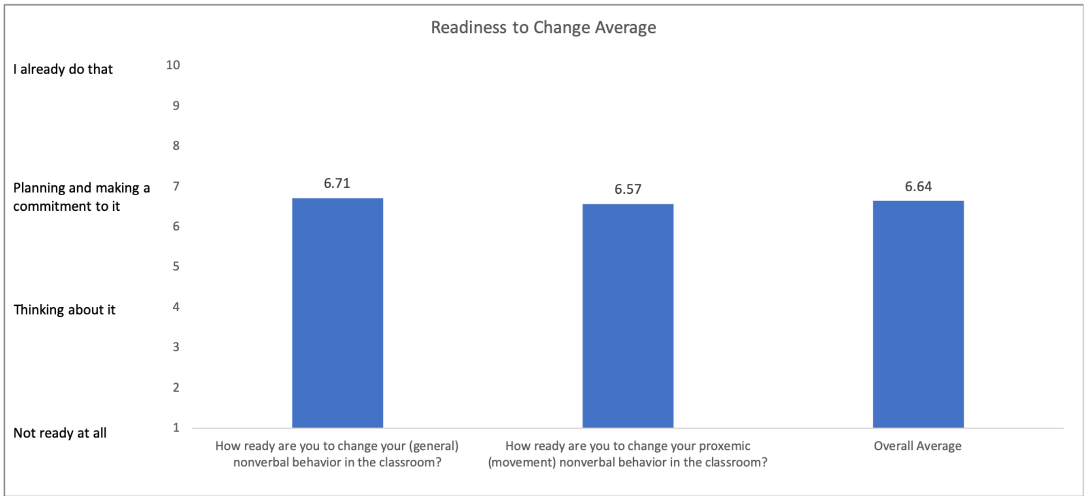
(b) Willingness to change per participant.

Figure 7-28: Teachers' willingness to change measured in the post-questionnaire as a proxy for behavior change.

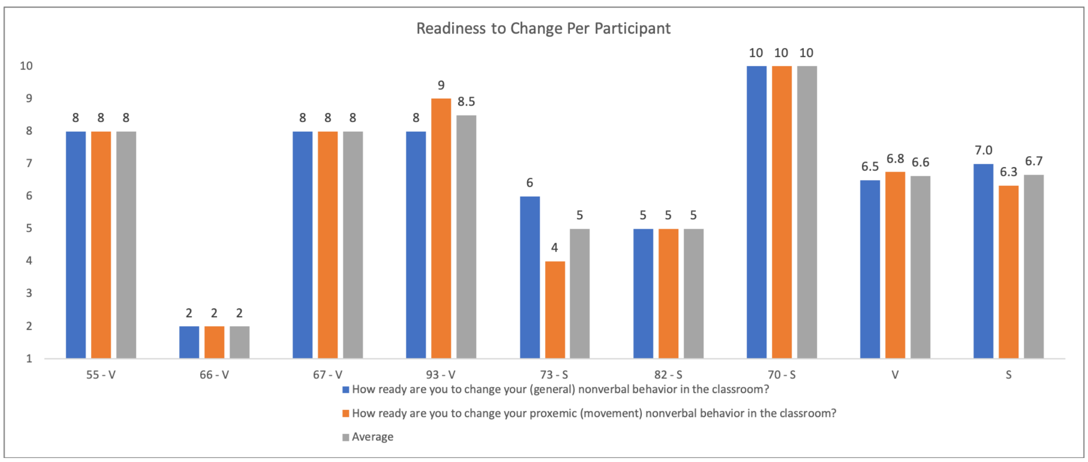
- using various combinations of proximity and position in the classroom (1 teacher)
- using a pointer to be more flexible with movement (1 teacher)
- moving more to support engagement, attention, retention and comprehension (1 teacher). For example, one teacher said: *ID 70: "Moving more because it helps hold different attention. Moving particularly when I'm changing topics or saying something important because it helps with retention and comprehension. Making an effort to stand in neglected areas of the classroom to help keep students engaged."*

Even though in the study teachers did not see data other than their proxemic behavior, 3 out of 7 teachers mentioned that they wanted to work on their gaze behavior. This likely came from teachers reading in the PD materials about other nonverbal behaviors and being asked in the questionnaires to assess their other nonverbal behaviors, including gaze. Specifically, teachers:

- wanted to be more aware of when they were looking at or away from the students (1



(a) Average readiness to change



(b) Readiness to change per participant

Figure 7-29: Teachers' readiness to change measured in the post-questionnaire as a proxy for behavior change.

teacher)

- wanted to make eye contact more with students (2 teachers)

Last but not least, there was another subquestionnaire in the post-questionnaire that measures yet another proxy for behavior change. In the section "Teachers' attitudes from the PD materials and data presented in the dashboard" discussed above, within the attitudes subquestionnaire, I measured teachers' (1) likelihood of enrolling in another PD of related content as well as their (2) likelihood of actually attempting to engage in the behaviors recommended in the PD (Figure 7-16(a)). Both those questionniorase while measuring attitudes, serve as proxies for the likelihood of teachers attempting behavior change. There is more detail in the section above regarding how teachers scored in the likelihood questions, but as a summary teachers scored the highest in their likelihood to enroll in another PD of related content. This is positive and shows that teachers see the PD as important and valuable. Similarly, the likelihood to engage in the behaviors recommended in the PD is quite high, showing teachers intentionality to try and change their behaviors to match what they learned in the study.

To summarize, even though in this study I did not measure behavior change, I measured several proxies that indicate intentionality for behavior change such as willingness and readiness to change, teachers' goals (if any) for what they wanted to change in the classroom as well as their likelihood to engage in certain behaviors or attempt further PD of similar content. The results showed that teachers overall are willing and ready to change their behaviors after the study, they set goals on what they want to change in relation to their proxemics as well as other nonverbal behaviors they learned about in the PD materials. In addition, their likelihood to engage in other similar PD and their likelihood to attempt such behaviors is high. In the interview analysis section below I discuss in more detail the brainstorming, planning and goals teachers set for themselves, as their first step towards behavior change.

7.3.3 Analysis of video interviews

There were 8 out of 9 teachers who took part in these interviews and the following analysis is based on these 8 data points.

Teachers' Perceptions of Nonverbal Behavior Data

During the interviews, all teachers (8 out of 8) expressed interest in immediacy and nonverbal behavior data. They found such data valuable and helpful, particularly as they are limited in what they can monitor during class. Some teachers expressed unawareness about certain data as they only have one set of eyes and cannot track everyone at the same time. They felt this type of data would still be challenging to collect with human observers and expressed that having it collected by a technology would be most helpful. As one teacher mentioned, *ID 55: "... I really like it. It's real time and very exact. It is there and it's a holistic view. Versus you're sitting in my classroom and you're looking at one person or couple people. Unless you're assigned to a certain task, you're not going to be able to capture as many things dynamically. Happening all at once. You would need more than one person."*

Teachers fell into different categories when it came to their awareness and perceptions about some aspect of their data or their students' data in the classroom. One teacher expressed they were clueless about certain data and they would find it very helpful to have a technology collect and share this data with them. In contrast, half of the teachers (4 out of 8) expressed that they are able to monitor some of their and their students' behaviors, but they were not confident in this ability. As one teacher said: *ID 73: "... This is something that I think I try to do. But I don't know how well perception matches reality, you know."* and another who mentioned *ID 83: "And again, I have my self-perception and I don't know if it's accurate."* Lastly, some teachers were pretty sure about certain aspects of their or their students' data (4 teachers) and one teacher even mentioned they did not need such data for their small classes, *ID 82: "In small classes like this, I know because I see them. And I have proof when they are not paying attention. So I don't think I need it for a group like this. So I can see them. I don't need an app."*

Overall, it seemed that teaches agreed that they are limited to what they can see and keep an eye on in the classroom and data from a technology would be helpful to them and their teaching. As one teacher suggested, *ID 55:"...again, I only have one set of eyes..."*

Teachers' Data Interest

Teachers expressed strong interest in various type of nonverbal data both unprompted (as they were looking at the PD materials or their own data) or prompted by the interview questions.

To begin with, all teachers were interested in **student data**. Specifically, they were interested in different aspects of student engagement, attentiveness and focus. For example, 3 teachers were interested in the students' engagement in relation to devices they were using in class, such as phones or laptops. Teachers wanted to know how much students were using these devices or how much they were on social media during class. Teachers thought these devices sucked students' attention from class. Another teacher was interested in the interactivity or the "back and forth" they had with their students, while two teachers were interested in student eye contact data. *ID 67: "I want to see the eyeball data... So I'd like to see a graph if you could put it in this form of their eyes. Were students looking this way or that way? Or down? And if they're looking down, were they writing at the same time? Or were they looking down at a screen or reading someone's comment [online]?"* This teacher also wanted to know if students were having random bursts of laughter because they were reading someone's comment on a forum instead of paying attention in class.

Two teachers wanted to know about students' body position as a proxy for engagement. Specifically, they wanted to know if students were slouching or if they were leaning forward on their computers, if they had their hands engaged in a writing position and how much they were taking notes, especially when it was unprompted by the instructor. One teacher wanted to see student leg positions as a way to tell if any of the students were completely closed off, or if they were open and relaxed. Another teacher was interested in what they called "emotional proxemics", *ID 83: "...if there is some way to sort out, I don't know if you guys have an official way of getting this but emotional proxemics versus physical proxemics, you know. If the person in the second row from the back feel fairly engaged, would they really feel a distance, you know? It would be interesting to see what the perceptions are from up of a big room with distance that you can't avoid in some ways."* Lastly, only one teacher mentioned that they were interested to know student performance on how much they did per class and how much knowledge they gained that day.

In addition to student data, teachers were interested in this broader category of **"student reaction data"**, namely how students react to teacher actions and behaviors in the classroom. Teachers thought that this kind of feedback could help them gauge how effective their own practices were. For example, if they stood at a certain location or if they used certain gestures, would that help them reach their goal of increasing student engagement? Two teachers were interested in how student attentiveness, engagement and gaze is relative to where the teacher is standing in class, and how students' body positions change when the teacher moves around in class One teacher was interested in a measure of interactivness between them and the students: *ID 73: "...if there is a way to measure how much interaction went back and forth... A measure of how much back and forth there is, speaking, would be useful."* Another teacher was interested in knowing how the imbalance in their position at the right, center and left sides of the classroom affected their students, in particular if that caused them to be less focused and inattentive. Similarly, another teacher was interested in when they smile less, if their students are paying more attention to please them or if that just gets them to tune out entirely. Last but not least, one teacher was interested in knowing how different students react differently to their actions and what do they respond better to: *ID 70: "So, I'd be kind of curious to see what the... how that changes some of these things too. You know, if younger students or students who are more anxious about being in the class responded better to one way or the other way."*

Teachers also expressed strong interest in data about **their own performance** in relation to immediacy and nonverbal behaviors in the classroom. They wanted more detail about proxemic data including what activity were they conducting left, center, right at the front of the classroom; were they writing on the board, lecturing in front of the projector, etc. (1 teacher). Teachers also wanted to know their distance from the board (1 teacher) and how students were distributed in the classroom, to determine where they need to spend more time at (2). One teacher mentioned that the study was not presenting a complete picture of the data as there were other aspects of proxemics that they deemed important but were missing from the data they saw (such as how close you are to students, are you sitting with them, are you standing and towering them, etc.). Specifically, the teacher mentioned: *ID 83: "But then I'm walking and I'm towering over people on these chairs. So I feel like I get more intimate communication when I'm sitting on a chair and talking them like we're in a circle... But then I'm not moving. So there are different ways of breaking this [proxemics] down. What kind of lack of movement is this? Is this just frigidity? Or is it something physical? Or is it compensating behavior, like you're sitting instead of towering over but standing? But then you're sitting, so you're not moving as much."*

Aside of proxemics and location information, half of the teachers (4) were also interested in their **eye contact and gaze** with the students. For example, one teacher was interested in how much they face the class versus the board, while another one was interested in having egalitarian eye contact and gaze with all students. Teachers were also interested in their **posture** data such as whether they were standing straight and showing enthusiasm (1 teacher), how their body language differed based on the classroom activity (1 teacher), and whether they had an egalitarian physical engagement with all students (1 teacher). One teacher was interested in knowing how much they **smile** and another was interested in **gesticulation** synchronized with other activities and speech, as a very important factor to second language acquisition (this case was very specific to the subject matter the teacher was teaching). Lastly, one teacher was interested in meta data such as do they interact more verbally or nonverbally with their students and do they interact differently with different genders *ID 83: "There are so many breakdowns you can do. Wouldn't it be fascinating to know that... It would be very helpful to some of us. Maybe. Do I interact verbally or do I have different interactions, even nonverbally? What are my interactions verbally and nonverbally? Is there a difference between how I interact with different genders? Do I have more conversation with guys? More conversation with women? More egalitarian? You know. Yeah. It's almost a kind of thing where I'm so clueless about that that the data would be helpful."* Another teacher was interested in knowing how their gender or age plays a factor in whether the teacher is standing behind or in front of the podium and class.

Lastly, teachers also expressed interested in other data in relation to the physical classroom that they taught in, the type of course, or the activities they were conducting during class. For example, teachers wanted to see if their proxemics (2) and data more in general changed when the classroom set up was different and if their data would look the same in every classroom they teach in or if it would be dependent on the classroom layout. In addition, one teacher wanted to know how the layout of the room (where the screen or board is) affected their location and proxemics. Further, some teachers were interested in course data. For example, two teachers were interested in the type of activity happening during class (lecture vs discussion or group work), how their proxemics or other nonverbals are affected by the activity and what patterns emerged in behaviors based on the activity they were conducting. Other teachers were interested in more detailed statistics such as average data over multiple or all class sessions in a semester to a get a well-rounded assessment of their performance and to track improvement over time (3 teachers). One teacher also mentioned this is necessary because their nonverbals might change from the beginning to the end of the semester: *"ID 70: "if it were to be an overall, like a more well-rounded assessment of how I spend the time, it would have to be recording the full 27 classes, or whatever it is. Because, I think that it definitely changes and the way that my body language and my interaction with the students changes because the first couple days of class it's sort- there's an expectation of people are in here wondering what they are doing in here, and there has to be some sort of level of seriousness, particularly because I am not anymore that close in age to the students, but I am younger I think than whatever... So, I would be curious to see how this, how my position evolved from like day one. When we were like, here's a class, we're going to read the syllabus, everyone stay in your seats and behave. And then by the end of the class where everyone is more comfortable and that sort of stuff too."* While some instructors were interested in having comparison data across other instructors, courses, subjects, and physical classrooms, others did not find it helpful to compare across peers, preferring to see only self-improvement. It was also very interesting to note that one teacher was interested in being able to download and share their data with students and other colleagues while another teacher wanted to share with the students the information the study shared with them.

Challenges to Using Nonverbal Behaviors

During the interviews, all teachers continuously expressed that there were challenges to using nonverbal behaviors such as proxemics in the classroom. There were a variety of factors that affected teachers' proxemics and their performance, and in many cases teachers mentioned that they would do better if such challenges were not there. Below, I share the main themes of concern teachers mentioned affected their proxemics nonverbal behaviors in the classroom.

To begin with, 6 out of 8 teachers expressed that **the layout of the classroom**, and where specific furniture was located creates physical barriers that inhibit or encourage teachers to stand or sit at certain locations. For example, where the podium is located can affect where the teacher stands to deliver their lecture. If the podium is heavy or if there is a long desk at the front, it is more challenging for the teacher to move those around in order to be able to stand in the front of them and closer to students. Similarly, the position of the projector screen inhibits the teacher from standing on that side of the classroom and the location of the board affects where they stand as they write on the board. Sometimes the screen of the projector covers the board and that affects where the teacher is going to be located if the want to use both the board and slides. Further, often classrooms are quite narrow, providing very little space for the teacher to move at the front. In particular, if the teacher were to rearrange the furniture in such classrooms, they would likely put it in a path where they have to walk in. In addition, sometimes the door of the classroom opens on the inside, making it hard for the teacher to stand in that place and not block student flow. And even if every furniture was easily movable and relocated, arranging all the furniture at the beginning of every class takes time and effort on the teachers' side. One teacher expressed their challenges with such issues in the classrooms: *ID 70: "But, you know, some of the challenges with standing in different spots for example, in this particular classroom the left side of the board is blocked almost by the doorway, and people trickle in or have to run out to go to the bathroom. Uhm, it reduces my ability to stand over there. Plus, one of the other things that weird about this particular classroom is that where the whiteboard is down, sorry when the projector is down, it covers a huge chunk of the board. So, there is no where for me to stand and write other than all the way at either extreme. So, I think if I am showing any kind of visual this probably leads me to be more anchored to one side as opposed to moving around. I don't want to stand in front of, you know, things that I'm sharing."* Another teacher shared an experience where they held their last class in a classroom different from the one they had worked in the whole semester. This classroom, unlike the original one, was set up in a conference format, where students could sit in a circle and face each other. This allowed the teacher to sit with them, instead of standing at the podium as they traditionally did, and allowed everyone to look at each other more, be closer and engage more in class. In summary, the physical layout of the classroom is really important as it affects the teachers' behaviors and decisions they make in class.

Second, in addition to the physical classroom, 6 out of 8 teachers mentioned that the other biggest challenge for them was the **technology** they used as part of their lectures, which pigeonholed teachers to specific behaviors and locations in the classroom. For example, one teacher used the document camera, which is attached to the podium, *ID 93: "One of the reasons why... Umm... I spent most time on the right is because of a document camera."* Similarly, other teachers would keep their laptops or tablets on the podium, to project their slides. Another teacher mentioned that they have to use the media in the podium and that does not make them happy, *ID 83: "...look at this. I don't look that happy behind that podium. I want that podium out of the way. I want to be sitting there with my students. That's what I really want to be doing. Look at my posture. It's like man, I don't want to be here. It's really funny seeing that. It's the way I feel too. I don't have much choice; I have to stand behind sometimes if I'm running media."* Yet another teacher mentioned that they need the console on the wall to plug their computer, while a last teacher mentioned that the board and where they wrote conditioned their location at the front of the classroom. Many teachers mentioned that they would like to have technologies that allowed them to be remote and move around freely without having to be stuck next to a technology. But even then, teachers foresaw challenges due to the physical layout of the room. For example, one teacher generally stood on the left, behind the podium, to deliver the lectures and noted that having a pointer could help increase movement. But even then, the teacher thought they would be stuck at the center-front of the class, as there would be no space to move to the right, due to the projector screen being there.

Third, 5 out of 8 teachers also mentioned that the type of class; subject matter or nature of the course, and the number of students in class affects their nonverbal behaviors and what they can do in relation to immediacy. Teachers claimed for example that a course such as math would require more facing away from the students towards writing on the board, while a more discussion based course could allow for more time facing the students. Teachers also mentioned they can do certain behaviors in a smaller class that would be harder to do in a bigger class, and vice versa. As one teacher said: *ID 82: "So immediacy, I understand what it means now. But if you have a large cluster of students, you cannot apply this. So the class size has a lot to do with how you can use this approach."* Another teacher mentioned that in big classrooms, it would be hard for them to use immediacy as effectively. Those classes would make it easy for the teacher to be locked in one mode in terms of nonverbal behaviors. *ID 93: "[in big auditoriums] I usually walk through... between the chairs, the chairs and desks. Uh, but I don't have to do that, uh, when there are only 2 students. [in a small class]"*

Connection to FCEs

Surprisingly, two teachers made unprompted connections between immediacy and FCEs (Faculty Course Evaluations). They said that FCEs, like immediacy, are based on student perceptions. As one teacher mentioned, *ID 73: "But this immediacy seem to be very tied to student evaluation kind of performance and less directly tied to student achievement, and mastery in the material."* This was quite interesting as both student learning and student evaluations of the course and instructor were equally emphasised in the PD materials (Appendix C.3). However, it seems that instructors perceive that immediacy is connected with FCEs but not so much with actual student learning in class. One hypothesis for this reasoning is that at CMU students' learning is not necessarily an issue provided that the students are highly motivated and highly achieving. While, FCEs are still quite an important part of "measuring" instructors and their teaching and often times used in promotions for teachers, even at CMU.

Teachers' self-assessment of their data and performance

When teachers saw their proxemic data in the study, 3 out of 8 teachers mentioned that this is what they expected and their performance was not a surprise. All teachers (8 out of 8) were able to reason through the data and explain why their performance appeared one way or another. Before seeing Part 3 of their data, with feedback from ClassInSight, 2 teachers thought their performance was decent and fair. There were 6 out of 8 teachers who mentioned they were not doing at their best but they blamed that due to other factors such as the physical layout of the classroom or the technology they needed to use (as described above). Those teachers mentioned that the study was not taking into consideration these factors. Another teacher mentioned that instead of the proxemic data the study was presenting, they considered other other types of proxemics as well as gaze more important to connect with their students.

After seeing Part 3 of their data with feedback from ClassInSight on their performance, teachers in general thought they were doing better. In the social comparison condition, 3 out of 4 teachers were glad they were doing better, even though they mentioned they did not want to compare themselves with others. As one teacher said in response to my question of how did they think they were doing, they said: *ID 82: "Fantastic!! I'm just looking at that and going like wow, okay. I am happy. I am doing something well."* The other teacher in this condition mentioned that everyone was doing as bad as him. In the verbal persuasion condition, one teacher completely disregarded the feedback saying it was not helpful to them as an experienced teacher: *ID 66: "That's why I was laughing, You're doing a very good job! I don't know. This made me giggle a little bit.... this would turn me off personally. It might be fine for someone else."* The other instructors thought in general the feedback was helpful. Overall, teachers thought there was room for improvement but again there were restrictions in the physical layout of the classroom or due to technology that did not allow them to do certain things.

Teachers' Goal Setting and Behavior Changes Intentionally

At the end of their interactions with the boundary object designs, we asked teachers if they wanted to change something in their behaviors and if so, how. Throughout the interview, teachers also brainstormed independently what they could and would change. Even though in this study I did not measure teacher behavior change, in the interviews, we tagged for themes that represented proxies for behavior change such as what teachers were thinking about or were interested in trying in the classroom as well as what they were going to change or pilot in the classroom.

Overall, looking at PD and their data was fruitful and productive and it helped teachers take a step back, reflect on their performance and brainstorm on what they could change or improve upon. In general, it seemed that teachers had always defaulted and taken the current physical classroom layout and technology as defacto and unchangeable and had never stopped to think how to get around these hurdles. As one teacher mentioned, *ID 66: "I have never even thought to check if they [podium and table] detach. [for the purposes of moving the table away from the podium]".*

All teachers (8 out of 8) set one or more goals of what specific behaviors they wanted to change. As one teacher mentioned *ID 93: "Like I said, after getting the data and objective evidence, that really makes me improve myself towards the better data... For example, about this time next year, I am determined to be better."* Another teacher mentioned that they think they have done some changes already in their nonverbals, after signing up for the study. Two teachers mentioned that the type of changes in relation to their nonverbal behaviors and proxemics were more mechanical, and easier to manage and implement.

Some teachers set goals to move more around the room (3) and not be locked down in one mode (2), lecture from different places (1). Teachers wanted to spend time on each side of the room (2), while equitably balancing their position in front of their students (2). One teacher committed to getting a pointer and another one to using a tablet to allow them to be more mobile in the classroom. Others planned to use movement to emphasize important points (1) and to stand closer to students by being in front of the podium/desk (2). One teacher said they would try to detach the podium from the desk, to get in front of the students more often, and another one planned to keep the podium at the center of the class, as a more equally distanced position from everyone in class. Others wanted to spend more time facing their students and not the board (1) or aimed to point things out more during lecture and stand closer to the projector (1). Some teachers wondered if they could make better use of their position and movement to keep students engaged (2).

Some teachers wanted to change how their students sit, including asking students to sit in a semi-circle and be equally distant from the teacher (1), asking students to sit in different parts of the classroom and position themselves in different proximities to the students (1), or asking the professor who teachers the prior class to set up the room in a certain way (1). They also mentioned they wanted to talk more to their students to get to know them better (1) and be more engaged as students are speaking during class (1). Lastly, some teachers contemplated reducing or adjusting the material they cover in class, leading them to spend less time behind

Overall, with the exception of one teacher, 7 out of 8 teachers wanted to see the PD material page with suggestions on what kind of behaviors they could try to implement. As described above, teachers brainstormed around those suggestions and some of them even set goals. Further, teachers mentioned they needed specific suggestions, customized to their classrooms, on what behaviors they could and should change, and how to implement those changes (3). For example, teachers wanted explicit suggestions on whether they should be smiling more or less (1), how should they use nonverbals in the classroom, how can they implement changes to their behavior (1), and how to foster more interactivity with students (1). One teacher mentioned that if they know a certain behavior is effective, they also want to know how they can overcome any challenges preventing them from using that behavior.

7.4 IRB Incidents

I would like to preface this section by saying that I, together with my team, are pioneers in the field of instrumenting classrooms with sensors and cameras as I describe in this study, automating data collection in an unobtrusive way and running studies with real, in the wild classrooms. Thus, a lot of the issues with the IRB mentioned in this section could not be foreseen and are things I learned how to deal with.

During the data collection of Summer 1 2019 semester, a couple of issues came up in relation to doing data collection on third unconsented parties. In one case, the instructor brought their children to class, who were minors. The instructor informed me about this matter only after a few class sessions. In another class, I ran into cases where a guest lecturer was running class or where third parties were Skyping into the lecture for a panel or as an invited lecturer. Lastly, I ran into a few cases where class was cancelled for one reason or another, without the instructor informing my team and I of this change. As a result, due to the data collection happening automatically at the start and end of class time, I ended up doing recordings in empty classrooms. The most problematic case was when students picked this empty classroom to do work or homework and they got recorded by mistake.

All the above instances were immediately reported to the IRB. As a result, the IRB temporarily shut down the project (for about 8 weeks). During this time, I closely worked with the IRB to introduce new regulations for the studies, which were applied in the Fall studies described in the next chapter.

One of the major regulations the IRB required the project to comply with was to remove automatic data collection and instead manually start and stop data collection. That required the project to have one student RA (research assistant) present in the classroom at all times. The student would start data collection only after confirming that class was happening and there were no third unconsented parties in the classroom as described above. The students were instructed to stop data collection immediately if someone in class did not comply with these regulations. Thsi change, unfortunately made it harder to run studies as described in the next chapter, and on its own, it was not the ultimate solution, as other issues came up during the Fall studies. I continued to work closely with the IRB to find a better solution in relation to those problems.

7.5 Conclusions

In this paper, I describe an exploratory and design study which aims to understand teachers' values, efficacies, motivations and interests around teacher immediacy and nonverbal behaviors. In addition, the study aimed to explore how these constructs change after the teachers see their own nonverbal data and what goals, if any, they set to change their behaviors in the classroom. Throughout the study, teachers were introduced to PD materials on such constructs and to their own proxemics data collected from their course with an instrumented classroom.

7.5.1 RQ1: What are teachers' familiarity, values, beliefs, assessment of their performance, their self-efficacy and motivations, etc., around teacher immediacy and nonverbal behaviors? How do such constructs change after teachers see their own nonverbal behavior data?

From the analysis of the pre-questionnaires, I found that the majority of the instructors taking part in the study were teaching faculty (5 out of 9). This can be explained by the fact that most of the faculty who teach over the summer semester are teaching faculty. Distinguishing the roles of the participants is important as for teaching faculty teaching is the primary focus of their job while, say for Ph.D. students or tenure faculty, the primary focus would be research. This could affect various measures in this study, as discussed in the findings section above. An example of that is the result where 7 out of 9 teachers in the current study self-reported they had had various types of Professional Development training, within and outside of CMU. This is something which is not common of instructors at the university level but makes sense for the population in this study, provided the majority were teaching faculty. I found that even though instructors had quite a bit of experience with other PD, they were not familiar with the concept of immediacy but they were familiar with nonverbal behaviors in terms of "body language".

In general, teachers who took part in the study scored high in all the measures in the pre-questionnaire. Despite this, they did not reach a ceiling effect and *there was still room for improvement*. Teachers scored high in their the value they saw in using immediacy and nonverbal behaviors in the classroom. Teachers also score quite high in their general self-efficacy (SE) and self-efficacy for nonverbal behaviors (SE for NVB). Despite the small sample size, the distribution of SE and SE for NVBs hints to a uniform distribution. In addition, SE and SE-NVB have very similar distributions, which is positive in particular as the questionnaire that measures teachers' SE-NVB was created by me for this study. Last but not least, teachers in this sample all scored very high in terms of SE and SE for NVB, with the majority of the instructors falling into the "high" SE and SE for NVB bucket.

In relation to motivation, teachers also had high intrinsic motivation, as well as moderately high external regulation. There were 8 out of 9 teachers who scored quite high in intrinsic motivation while only half of the teachers (5 out of 9) scored high in terms of external regulation. In their planned efforts, persistence and PD aspirations, teachers again scored very high in the pre-questionnaire. Provided that the majority of the instructors in the study were teaching faculty, this can indicate that due to the primary teaching focus of their jobs, they are more intrinsically motivated and less extrinsically motivated when it comes to teaching. In addition, they might also be more motivated in terms of the effort and persistence they put in their teaching as well as in terms of their PD aspiration in relation to their teaching.

In the post-questionnaire, teachers self-reported that they learned both from the PD materials and their own proxemic data. There was a small difference in learning from the PD module (slightly lower) than from seeing their own data and the dashboard module (slightly higher). This may suggest that teachers find value in both PD and data, but they perceive they learn more from seeing their own data and the dashboard than the PD module. In addition, to note is that teachers in this study had quite a bit of prior experience with PD and training for teaching, and they still self-reported they learned from the materials of this study. This shows that both PD and data on their own immediacy and nonverbal behaviors is something that teachers find valuable, learn from and need in their practice.

In terms of their values and beliefs around immediacy and nonverbal behaviors, there is not much difference between the conditions. However, overall there is a positive trend of increase in teachers' values and beliefs from the pre to the post-questionnaire. In terms of SE and SE for NVB, there is an increase in score from the pre to the post questionnaire. This shows that seeing PD materials on immediacy and nonverbal behaviors as well as getting data on their own behaviors helped teachers increase their SE for NVB from before to after the study. This is important as a higher self-efficacy will lead to higher motivation and goal setting which will directly affect their behavior change in the classroom (as described in Chapter 6). Looking at the conditions separately, it seems that the social comparison group had the highest post-questionnaire score overall (both in SE and SENVB) as well as the highest increase from pre to post in both questionnaires. The results hint in the direction that the social comparison intervention, namely seeing their data perform better than other instructors/peers, had the highest effect on increasing instructors' general SE and SE for NVBs from pre to post. This is consistent with prior literature (i.e., [35]).

Teachers had no major changes in the various motivational constructs (intrinsic, external, introjected, amotivation) or in planned effort, persistence and aspirations from pre to post. This might be because teachers are scoring quite high to begin with in the pre-questionnaire. But also, these larger motivational constructs are general to teachers' teaching and not specific to their immediacy and nonverbal behaviors, and it makes sense that this study intervention did not majorly affect them.

One interesting result was that the social comparison group had a slight decrease in intrinsic motivation while the verbal persuasion group does not change. In relation to their external regulation, the social comparison group has quite an increase while the verbal persuasion group again does not change. This might be explained by the fact that in the social comparison group the study is introducing external comparisons and rewards (comparison with other instructors) to motivate teachers, thus there is an increase in external motivation and a decrease in intrinsic motivation. In the verbal persuasion group the study is introducing verbal encouragement to motivate instructors, which might not have been as intrinsically or externally motivating. In terms of their motivation for participating in the study and in the tasks of engaging with PD and their own data, teachers scored very high in the intrinsic motivation scale and very low in the other scales including external regulation. This is understandable as instructors took part in the study voluntarily, without being affected by extrinsic factors.

7.5.2 RQ2: What data are teachers interested in?

In addition, teachers expressed interest in various types of immediacy and nonverbal behavior. To begin with, they were interested in data both about themselves and their students. For themselves, they wanted to have more detailed information on their location and movement, their eye contact and gaze, their body position and facial expressions. For students, they were very interested in data that showed whether their students are engaged or paying attention, for example based on whether they are actively taking notes, whether they are online on their phones or laptops, whether their gaze shows they are following the lecture, etc. Teachers' ultimate goal was to support and increase student attention and engagement in class. Teachers also wanted to know which of their behaviors supported students' engagement and which made students more distracted. More in general, they were interested in "student reaction data"; how students react to actions or behaviors the teacher takes in class. Teachers thought that this kind of feedback could help them gauge how effective their own practices were.

In relation to their perceptions of their and their students' nonverbal behaviors in the classroom, teachers seemed to fall into the following categories: clueless about some data, had some idea about some other data but were not always sure, and were confident about some other data. These results reinforce the need to provide teachers with data and feedback on their and their students' nonverbal behaviors in the classroom to support the teachers as they cannot keep their eyes and attention on everyone all the time.

Interestingly teachers mentioned major issues and challenges that affected their proxemic behavior in the classroom including the physical layout of the classroom (where various furniture such as the podium, tables, projector screens, etc., were located and their mobility), the technologies that instructors use that lock them in one position (including laptops, tablets, document cameras, media, etc.), as well the size of the classroom (smaller vs bigger classrooms). These factors affected both how instructors self-evaluated their data and performance in terms of proxemic nonverbal behaviors as well as the goals that they set for themselves and what they saw as feasible and not feasible based on these challenges.

7.5.3 RQ3: How did seeing their data affect teacher goal setting for changing their behaviors?

Teachers also engaged in brainstorming and set goals to change their behaviors, during the interviews and in the post-questionnaire. This involved using technology that would allow them to be more mobile, moving more in class, using movement and position to keep student attention, moving furniture to stand in front of the students, etc. In particular, teachers wanted to be more equitable with each part of the classroom, giving each student an equitable amount of attention and making more eye contact. Teachers also mentioned challenges that affected their behaviors including the physical layout of the classroom (the location of the podium or board), the technologies that locked them in one position (laptops, document cameras), and the type of classroom (subject matter and number of students)

Further, in the post-questionnaire, teachers scored very high in terms of their willingness and readiness to change their immediacy and nonverbal behaviors in the classroom. In addition, teachers' likelihood to attempt and engage in these behaviors and their likelihood to enroll in another PD of similar content was also high. Even though in this study I do not measure behavior change, these results show that teachers are thinking, planning and setting goals for changing their behaviors in the classroom, which is a first and very important step towards them changing their behaviors and practices as well as a good proxy for measuring actual behavior change.

To summarize, this study showed that teachers find some value in their immediacy and nonverbal behaviors. They are interested in such data to help support their instruction and improve on their practices. In particular, teachers want to use this data to keep and increase student attention and engagement in class and to create a more equitable classroom environment, by sharing their time and attention equally among the students. Further, the PD materials and data provided to teachers during the study provided them with the opportunity to reflect on their behaviors, brainstorm potential changes as well as set specific goals for things they want to change. Despite the small sample size, the results of the study show that teachers increased their performance from pre to post in various measures of efficacy and motivation and reported learning and positive attitudes about the study materials and their own data. The results support the usefulness of providing teachers with PD and data on their nonverbal behaviors to support their reflection-for-action, as a first important step towards actual behavior change in the classroom.

Designers of technologies should consider teachers' needs and wants about immediacy and nonverbal behaviors. They should enhance the data with PD and training materials to help the teacher contextualize and see the value of such data. Furthermore, designers should support teachers' goal setting and interest in behavior change, while also providing actionable and clear suggestions on how they can implement these behaviors and avoid the classroom layout or technology challenges. I will use the findings from this Chapter in the next study, where I aim to design a technology that will share with teachers their own data from an instrumented classroom to support their practices and help them improve on their immediacy and nonverbal behaviors.

Limitations

Even though the findings of the study as discussed in this chapter were very interesting and an important first step towards understanding teachers' data needs in terms of immediacy and nonverbal behaviors and how to support teachers to set goals and improve their practice, there were several limitations to point out, that should be explored further in the future.

To begin with, the sample size for the study was very small, which, even though hinted towards interesting results, it did not allow for measuring statistical significance. Thus, it is necessary for generalizability to run a study bigger study with a larger participant base. Further, the majority of the population in this study were teaching faculty, which bring a unique experience and motivation to the study. It is important to run a study where there is a more diversified participant base, with a good mix of teaching and tenure faculty. Lastly, the boundary objects in the study shared with teachers very limited data in relation to their proxemics. It is important to share with teachers a variety of their nonverbal, to better understand their interest and goal-setting in behavior change. In the rest of Part 2 of this thesis, I focus on addressing those limitations with a second study.

Chapter 8

ClassInSight for supporting teacher goal setting and behavior change intentionality in the classroom

Abstract: Teachers play a crucial role in supporting students' learning. However, little research has investigated how to best support teachers and help them improve their practices in the classroom. In this chapter, I aim to investigate how sharing with teachers their own data affects their reflection-for-action and their behavior change intentionality. Furthermore, I investigate how motivational feedback aimed at increasing self-efficacy affects teachers' values, efficacies, motivations, goal-setting and their intentionality for behavior change. Lastly, I aim to test for consistency compared to my prior studies. To conduct this investigation I created ClassInSight, a high fidelity professional development training and dashboard prototype designed based on findings from my prior work. Results from a classroom study with 16 instructors showed that ClassInSight affected teachers' goal-setting and intentionality for behavior change. Findings also show that teachers who receive motivational feedback from ClassInSight through social comparison score higher in proxies for behavior change compared to teachers who receive motivational feedback through verbal persuasion. Finally, I found that the results in this study were consistent with my prior studies. I discuss the implications of these findings for designing technologies that best support and motivate teachers' goal setting and behavior change.

8.1 Introduction

Teachers play a crucial role in supporting their students' learning in everyday activities in the classroom. It is crucial therefore to also support teachers in their day-to-day teaching as well as help them work and improve on their teaching practices. Traditionally, professional development (PD) has been used to provide training and feedback to teachers, as a way to support them improve their practices. While very common and highly effective (i.e., [30, 60, 84, 94, 147, 178, 216, 229, 240], etc.), PD tends to be repetitive and not personalized (i.e., seminars or workshops) or not scalable and infrequent (i.e., expert classroom observations) [120, 129]. In addition, at the university level, there exists a lack of training opportunities altogether leading to instructors learning how to teach on their own and feeling isolated [68, 112, 113]. This results in a gap and opportunity to make PD more personalized, less repetitive, with opportunities to support reflection and feedback [30, 118, 194].

As classrooms become increasingly instrumented with various technologies and sensors (i.e., [11, 186]), new opportunities emerge to provide teachers with more personalized, scalable and frequent support and feedback. Such technologies could collect and generate data both on teachers and students, which can then be presented to instructors as feedback or be used in conjunction with support from teaching professionals. This feedback can help support teacher reflection and goal setting (reflection-for-action [106, 140, 194]) to help teachers improve their practices and change their long term behaviors in the classroom.

Most of the prior work in this domain has mainly focused on technologies that support teachers' reflection and action in real-time in the classroom (i.e., [20, 21, 123]). While extremely helpful to instructors to manage their limited time and attention during class, these tools lead to temporary, short-term behavior changes. A small but growing body of work has started to look at how to support teachers' reflection-for-action outside of class, when teachers are preparing for the next class session. This practice would allow for more time and headspace for teachers and it would support a deeper reflection, that can lead to improved practices and long term behavior change.

In this chapter, I build on this body of work and my work and findings as described in Chapter 7. I aim to investigate how sharing with teachers their own data affects their reflection, goal-setting, their intentionality for changing their behaviors and how to best support teachers in this process. In this work, I did not measure actual behavior change on teachers, rather I measured proxies for behavior change that show instructors' desire and intentionality to improve their behaviors in the classroom.

Based on the findings from Chapter 7 on teachers needs and wants, I created a high fidelity prototype technology, ClassInSight that shares with teachers PD training on the value of immediacy and nonverbal behaviors, integrated with their own personal data on their nonverbal behaviors in the classroom. Further, I designed for ClassInSight to share with teachers motivational feedback in the form of verbal persuasion and social comparison, aimed at increasing instructors' self-efficacy. I ran a, similar to Chapter 7 but more improved, classroom study with 16 instructors at an R1 institution. The research questions of the study were the following:

- RQ1: How does ClassInSight affect teacher reflection-for-action (reflection and goal setting) and their intentionality for behavior change?
- RQ2: How does motivational feedback (social comparison or verbal persuasion) affect teachers' values, efficacies, motivations and their goal setting and intentionality for behavior change
- RQ3: What are teachers' values, data interests, assessment of their performance, their self-efficacy and motivations, etc., around teacher immediacy and nonverbal behaviors? How do such constructs change after teachers see their own nonverbal behavior data? How do these findings compare to the findings from Chapter 7?

Findings showed that ClassInSight affects teacher goal setting and various proxies for behavior change. After working with ClassInSight, teachers expressed interest and intentionality in changing their behaviors, scores moderately high on proxy measures for behavior change and set explicit goals for change. Teachers also mentioned various challenges in changing their behaviors in the classroom. Furthermore, we found that showing teachers motivational feedback through social comparison results in them scoring higher in proxies for behavior change compared to teachers who receive motivational feedback through verbal persuasion. The findings in this study are consistent and follow the general findings from Chapter 7, but with more opportunities for generalizability and testing for statistical significance due to the larger number of participants.

Through these findings, I contribute design implications for creating technologies that provide teachers PD training as well as share with them data about their own classroom behaviors with the aim to support their teaching and help them improve their practices. I discuss the types of data that teachers would find useful in such a tool as well as the type of motivational feedback that affects their reflection-for-action most. These findings are important to the HCI community for designing and building technologies that best match the needs of the users and support them in their reflection, goal setting and long term behavior change.

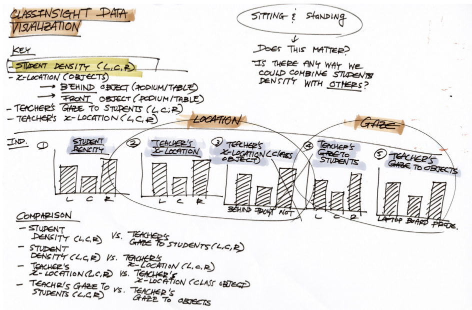
8.2 Designing ClassInSight

In Chapter 7, I found that teachers showed interest in their own nonverbal behavior data. They were interested in their proxemics data with more details on location and movement in the classroom. Similarly, teachers expressed strong interest in their eye contact and gaze data with their students. Lastly, instructors mentioned that they wanted to strive for proportionally splitting their attention among where their students sit. Based on these findings and the rich body of research that highlights the importance of teacher immediacy and nonverbal behaviors, I designed ClassInSight. ClassInSight is a high fidelity prototype technology that provides teachers PD training and data on their immediacy and nonverbal behaviors in the classroom. The ClassInSight materials were presented to instructors as paper prototypes to simulate the experience with an app.

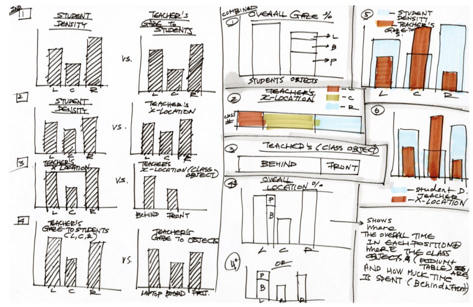
My team and I started iterating on the data visualizations instructors were presented with during the study in Chapter 7. We started with sketches of different ways to visualize the data, moved into low fidelity prototypes and further iterated those prototypes until we reached the final high fidelity dashboard (Figure 8-1). The final version of the dashboard that I used in this study is shown in Figure 8-2. Note that this dashboard is an example dashboard and the data is not real.

ClassInSight contains PD materials (a PD Module) aimed to introduce the concepts as well as the value of immediacy and nonverbal behaviors to teachers. An example of the PD Module is shown in the Appendix D.4. ClassInSight also provides teachers with final PD materials that share suggestions on what goals teachers could set for changing their immediacy and nonverbal behaviors and how they can plan and act to achieve those goals. I created those PD materials based on an extensive literature review as described in Chapter 6 and Chapter 7.

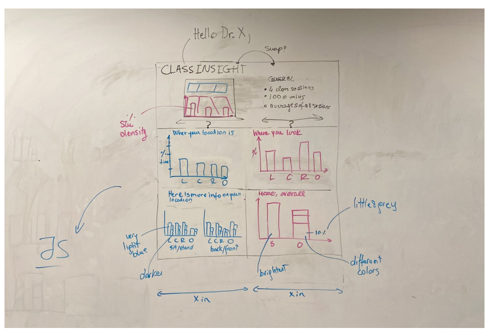
Further, at the top of the dashboard in ClassInSight, teachers were provided with an image of their classroom sectioned into left, center and right at the front of the classroom as well as the rest of the classroom where the students sit. This information aimed to make it easier and more readable to the instructors where their behavior was directed and how that mapped into the physical classroom. In addition, teachers were provided with a bar chart showing a the density in percentage of where the students are siting proportionally in class. This information aimed to help teachers determine where to proportionally spend more attention, as I showed in the findings of Chapter 7. Lastly, the dashboard shares a general summary of the course



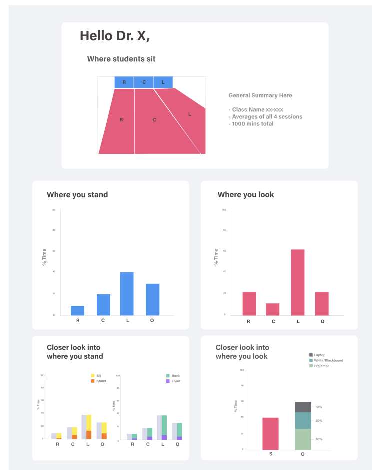
(a)



(b)



(c)



(d)

(e)

(f)

Figure 8-1: From sketches of data visualizations to low and high fidelity prototypes of a teacher dashboard.

number, the class sessions the data is based on as well as the total number of hours for these class sessions. All the percentages in the rest of the dashboard represented averages over all the class sessions I did data collection on.

In relation to their data, teachers were able to see both their location related data (proxemics) and the gaze related data (oculesics). Findings from Chapter 7 showed that teachers were very interested in both these two data types. For gaze in particular, there exists a large body of research that has investigated what effect gaze and eye contact has on teaching and the students. For example, direct eye contact and gaze can provide psychological closeness between teachers and students and is an important component of the teacher's immediacy. Similarly, good eye contact increases rapport [23, 25]. In addition, eye contact permits teachers to monitor and regulate their classes while simultaneously signaling warmth, attentiveness and immediacy [24]. High levels of gaze make students more attentive to the teacher [50]. Students in high eye contact availability are more likely to participate than those in low eye contact availability. On the other hand, the teacher who rarely looks at a student when talking is communicating that she/he is not very interested in that student and that the teacher is not approachable [50] while teachers who look at their students are perceived as more interested and more immediable [201]. Eye contact is such a basic immediacy cue that its absence makes the warmest teachers seem cold and distant [24]. [50] found that the absence of eye contact between teachers and university students usually produces negative feelings in students.

In the ClassInSight dashboard, for proxemics, teachers were provided with the percentage of time they spent at the right, center and left sides of the front of the classroom as well as the percentage of time they spent away from the front of the classroom, among the students (category "Other"). In addition, teachers were provided with the percentage of time they spend behind and in front of the podium when they are near the podium. Lastly, they were provided with the percentage of time they spend sitting versus standing in class.

In relation to their gaze, teachers were provided with the percentage of time they spend looking at students versus looking away from students, at "Other" locations in class. In addition, teachers were provided with the percentage of time they look at each part of the classroom (left, center, right) as well as the percentage of time they look at "Other" locations including their laptop/notes, the board, the projector screen or looking up/to the sides as they think or transition from one activity to the other.

Lastly, ClassInSight provided teachers with one of the two types of motivational feedback: verbal persuasion or social comparison. While prior work shows that both these types of feedback can help people reach a successful performance and support change in behaviors, it is not clear which of the two would be most helpful to motivating instructors to change their immediacy and nonverbal behaviors [34, 35, 38].

ClassInSight provided teachers verbal persuasive feedback in the form of a short paragraph that mentioned they have been doing a very good job and most certainly have the ability and skills to improve (Appendix D.4, page 15). ClassInSight implemented social comparison by presenting teachers their data compared with another instructor who was doing worse than them (prior work shows that seeing oneself surpass others strengthens self-efficacy [34, 35, 38]). The data was accompanied by a paragraph saying that their performance was very high compared to other instructors who had worked with ClassInSight in the past. An example of this dashboard is shown in Figure 8-3(b).

In summary, the final prototype of ClassInSight shares with teachers a PD module on immediacy

Figure 8-2: Teachers' dashboard that shares with them data on their own nonverbal behaviors in class.

and nonverbal behaviors, a dashboard with their own data from class, but with more details on their proxemics and new information on their oculesics and motivational feedback from ClassInSight. The ClassInSight dashboard encompasses the teachers' desires, needs and interests as described in the Chapter 7 findings.

8.3 Methodology

In Fall 2019, I ran a classroom study at an R1 institution (Carnegie Mellon University). This study was very similar to the study described in Chapter 7 but was more informed and designed slightly differently based on the findings and the new knowledge I had from the Chapter 7 work.

For example, unlike the Summer semester (as described in Chapter 7), the Fall semester runs over a longer span of time (15 weeks) from end of August to beginning of December. There are more courses offered during the Fall semester, and as a result, more instructors teaching. The class schedule runs over a normal 14-15 timeline (it is not compressed as over the Summer) and instructors have more time and bandwidth to participate in studies.

In this section, I will describe the methodology for the study I ran in Fall 2019. Many parts of the study were very similar to the study I ran I describe in Chapter 7. As a result, in this section I will only discuss the new and different parts of the study and refer to Chapter 7 for the similarities.

8.3.1 Sensors in the classroom

Classrooms Equipped with Sensors

For this study, I continued using the instrumented classrooms that the EduSense team had equipped with sensors, as described in the previous study. In Fall 2019, there were around 40 classrooms at CMU across different buildings that had been equipped with such sensors.

Data Collection with Humans in the loop

Due to the restrictions and new regulations set by the IRB as described in Chapter 7, the data collection for the Fall 2019 studies was very different from that of the Chapter 7.

To begin with, the data collection did not happen automatically and on schedule. Rather, due to the new IRB regulations, one student RA (research assistant, study team member) had to be present in the class session I was aiming to do data collection in. The study team member was supposed to start and stop data collections manually. To do that, one member of the EduSense team installed programming prompts on each RAs' computers that the RA would run to start and stop the sensors in class from doing audio and video data collection.

The purpose for having a team member sit in every class session was to avoid data collection when unconsented third parties were present in class. The RAs were instructed to not start data collection if third parties (apart from the instructor, students and TAs) were present in class and to stop data collection as soon as they noticed another party entered. RAs were responsible to not do data collection in other cases such as when class was not happening that day. The full protocol I created and used to train RAs is shown in Appendix D.1.

Obviously, having the process of data collection happen manually made it much harder to run this study. To begin with, it was challenging to find enough RAs that would be available during certain times in the day. RAs are generally students (undergraduates or masters) who also take classes most likely during the times that we needed to do data collection for these studies. For this study, 16 RAs and 3 other team members including myself helped with the data collection. As a result of the big number of study team members, coordinating the schedule for who would go to which class and do the data collection on any particular day was quite challenging. In addition, it was extra time and effort training the RAs of how to act in various scenarios and getting them to learn how to start and stop the sensors and data collection. Lastly, even though I advised the RAs to sit all the way at the back of the class, in the corner, to be the least disruptive for the class session, instructors were not happy to have an external person attend class every time. For example, in one small (5-7 people) discussion based class, the instructor complained to having the RA sit at the corner as everyone else would sit in the circle. The instructor also mentioned that the RA typing on the laptop was distracting to them and the students. All in all, the solution of doing manual data collection with RAs in the classroom turned out to be quite challenging and it made it hard to do data collection in multiple courses at the same time. Further, as I will describe later in this section, it only partially solved the issue with avoiding doing data collection with unconsented third parties in the classroom.

Data Processing with Humans in the loop

As described in Chapter 7, once the audio and video data is collected, it is saved in the EduSense system's database. Due to various technical challenges within the EduSense system at the time, I did not use EduSense for processing this data to generate the teachers' nonverbal behaviors. Rather, I resorted to doing human coding of the video recordings of the classroom sessions. Provided that I had a mini-army of RAs doing data collection as described above, it worked quite well to have some of them also do data coding.

To begin with, RAs were trained on how to do behavior coding and how to use the software for behavior coding. In Appendix D.2 I share the full protocol I created for training the RAs for this process. To begin with, I met with the RAs and we walked together through the instructions in this protocol. Then, together as a group we coded 10 minutes of a sample video recording of a real classroom session. Lastly, I asked the RAs to independently code 10 minutes of two other classroom recordings and to share with me the coding results as well as any uncertainties or questions they had during the coding. I then would check their results against my coding and other RAs' coding and if I found any major differences I would discuss it with the RA and understand what their line of reasoning was. In addition, during the process I would also answer any questions about coding the RAs were uncertain about. I did not do Inter Rater Reliability as there were no specific categories we were coding for, rather measuring the time the teacher was doing one behavior or the other.

For doing the data coding, I decided to use Boris [95] a software that allows for event-logging and coding of video and audio data. To code in Boris, the students had to upload a video recording of the class session, a protocol used for coding, and an overlay image of that classroom divided into left-center-right sections. Once everything was in the software, coding could be done easily using the keyboard keys (more details in Appendix D.2 below). Once they were done with coding, the RAs would export their coded data in a csv file and upload it into a shared Box folder.

I wrote a script in Python that would read these csv files, process them and provide the percentage of time the teacher spent doing certain behaviors in class. I included these results in an Excel spreadsheet and calculated averages percentages of time of such behavior happening across the different class sessions I had done data collection on. Lastly, I manually transferred the final values into the high-fidelity dashboard prototype for each individual instructor.

8.3.2 Recruiting Participants

The process of recruiting instructors and students for these studies was the same as the one described in Chapter 7. There were small changes and wording differences in the recruiting and consent forms in the current study that were required to comply with the new IRB regulations. However, those changes were minor and did not affect the recruiting forms and materials.

In addition, as described in Chapter 7, during the summer semester there was a limited number of teachers and ongoing classes, which resulted in a lower number of participants who were available and willing to take part in the study. In the current study, there were more opportunities for recruiting and for increasing the sample size of participants in the study. In addition, during a normal semester, I was expecting the distribution of the instructors who were teaching to be more representative of the actual faculty population, namely a majority of tenure faculty and a minority of teaching faculty (whereas in the Chapter 7, this distribution was reversed).

Participants Who took part in the study

I reached out and emailed around 40 instructors who taught in one of the EduSense instrumented classrooms during Fall 2019. Out of those, 17 instructors showed interest in participating in my study. There were various reasons why the rest of the instructors did not or were not able to take part in the study including: simply not being interested, or running the class for the first time or making major changes to the curriculum and did not have the bandwidth to take part in a study but were interested in working with us in the future, or interested in the study but 1-2 students from their class did not agree with running the study. One instructor was happy to allow the study to do data collection but mentioned that they did not have time to take part in the study. Lastly, some instructors I reached out to never replied back to my emails.

To note is that, similar to the study in Chapter 7, there is still a dilution on how many teachers I reach out to and how many teachers sign up for the study and then complete all the stages of the experiment. This again shows the level of challenge for recruiting enough instructors and students for a in-the-wild classroom study as well as the many parts of the process and the things that need to be taken into consideration. Further, as described above, the manual collection of audio and video data from classrooms made it more difficult to recruit a bigger number of participants in the study.

For the 17 instructors who were interested in the study and their students were on board, I did data collection on 17 classes for various numbers of class sessions. However, only 16 instructors took part in all the stages of the study while one instructor due to their limited time and other commitments did not complete any of the study stages after data collection. The classes that took part in the study were a mix of different subjects and fields including (Engineering, History, Chemistry, Calligraphy, Computer Science, Language, Physics, etc.) and different levels (from freshman introductory courses to higher level upperclassmen courses). In this study as well I did not filter by any criteria rather than whether the classroom where the class was being taught had EduSense sensors installed.

Lastly, due to delays in relation with the IRB for the study, and the lengthy process of recruiting and consenting participants, I was only able to start data collection towards the end of the semester and collect data only from a few class sessions per instructor (rather than do data collection for the whole semester). For each instructor I aimed to do data collection for 6-8 class sessions so that then I could filter and use data from 3-5 class sessions. Filtering involved only including sessions where the instructor was teaching and removing class sessions from which I could not extract any useful data on the instructors' nonverbal behaviors such as when there were student presentations in class or exam sessions and faulty recordings due to malfunctioning of the sensors. In very few class sessions, despite the new IRB regulations, I ran again into the issue of doing data collection on the unconsented third parties, this time in new and unforeseen scenarios as described below. Those data recordings had to be removed from the study as well. Ultimately, I kept around 3-6 class session recordings per instructor which results in around 80-90 hours of video data to be manually coded by the RAs, as described above.

8.3.3 Experiment Design and Study Materials

The overall experiment design of the current study followed the same steps as the experiment design in Chapter 7. However, I iterated on the various materials from the Chapter 7 study, including shortening the questionnaires to make them more concise for the instructors. I also redesigned the PD materials to provide new information on gaze and eye contact behaviors and more suggestions on ways instructors could change their behaviors. Further, I created a new interview protocol to better, more explicitly and more intentionally support teachers' noticing, reflection, assessment and goal setting as they were working with the PD materials and looking at their own nonverbal behavior data. And lastly, I added the new ClassInSight dashboard prototype as described above.

All the new and iterated study materials aimed to better help teachers' reflection and goal setting, with the purpose of supporting and being more helpful to them in improving their practices and changing their behaviors. Below, I discuss in detail those changes and additions.

Pre-questionnaire and Post-questionnaire

Many of the sub-questionnaires in the pre and post questionnaires in this study were similar to those in Chapter 7. However, I changed some of the sub-questionnaires to make them more concise and shorten the time it took instructors to complete them. A strong motivation for these changes were complaints from several instructors from the study in Chapter 7 that the questionnaires were too long, took a lot of time, and often were repetitive and seemed as they were trying to trick instructors, asking the same question multiple times in different ways. As I describe below, I focused on removing redundant and repetitive questions, and adding or modifying questions to include the location and gaze behaviors specifically. A summary for the questionnaires used in this study is shown in Table 8.1 and in Appendix D.3 I have included the full questionnaires. On average, the new pre-questionnaire took instructors 20 minutes to complete while the post-questionnaire took only 15 minutes.

The following questionnaires were exactly the same in the Chapter 7 study and the current study: general self-efficacy questionnaire, confidence, self-reported learning as well as the open ended question on the goals instructors were going to set for change. I entirely changed the self-efficacy for nonverbal behaviors questionnaire to make it more concise in wording and added some questions to focus on self-efficacy of location and gaze behaviors specifically. Similarly, I changed the self-reported nonverbal behavior questionnaire to only include questions in relation to location and gaze behaviors. The value and beliefs about immediacy and nonverbal behaviors questionnaire was also modified slightly to include gaze and location questions. The readiness and willingness to change questionnaires also generally stayed the same but I added one question to focus on gaze behaviors. All the motivation questionnaires were quite long and repetitive. Thus, I cut down the general motivation questionnaire as well as the task specific questionnaire to only include 5 questions, one for each motivational construct. Similarly, I cut down the number of repetitive questions in the planned effort and persistence questionnaire. I also removed the open ended question in relation to what demotivates teachers in their teaching. Attitudes were also drastically cut down and shortened focusing mainly on attitudes about the PD, dashboard as well as the location and gaze nonverbal data. Similarly, the questions on prior knowledge assessment, changes for nonverbal behaviors, demographics, on the course instructors were teaching as well as their experience teaching were cut down significantly and compressed in a few concise questions.

Questionnaire	Pre vs Post	Source	Original α	In study α
Self-efficacy (for teaching in general)	Pre: p5-7, Q1; Post: p8-10, Q1	From TSES [227]; Removed Q13 and Q22, kept all others in the same order as original source	0.94	Pre:0.93; Post:0.91

Self-efficacy for immediacy and nonverbal behaviors	Pre: p8-9, Q1; Post: p11, Q1	I created based on [40]	–	Pre:0.93; Post:0.94
Nonverbal immediacy self-report	Pre: p10, Q1; Post: p12, Q1	From [198, 200] kept only items related to location and gaze (4,8,10,16,17,21,22,23,24), added a new question to balance item 16, removed everything else. Change the wording to "while teaching"	0.9	Pre:0.87; Post:0.94
Motivation for teaching	Pre: p11, Q1-2; Post: p13, Q1-2	I created open ended question (items 1). Item 2 was adapted from Table 3 in [250] taking one question per motivation category	Q1: –. Q2: Intrin+Ident:0.79; Introj:0.66; Ext:0.68; Amot:0.748	Pre: Intrin+Ident:0.38; Introj:–; Ext:–; Amot:– Post: Intrin+Ident:0.00; Introj:–; Ext:–; Amot:–
Planned effort, planned persistence and professional development aspirations	Pre: p12, Q1-2; Post: p14, Q1-2	From Table 2 in [244]: kept only the questions in relation to Planned effort, Planned persistence and Professional Development aspirations (with slight modification to the language)	Eff: 0.91; Asp: 0.91	Pre:0.90(Eff:0.94; Asp:0.88); Post:0.82(Eff:0.94; Asp:0.88)
Confidence in teacher immediacy skills	Pre: p3, Q1; Post: p6, Q1	Confidence (Item 1) adapted from Readiness Rulers (RR) (for examples, see [92, 131, 228])	–	–
Value of immediacy and nonverbal behaviors	Pre: p4, Q3; Post: p7, Q3	I created beliefs about immediacy and nonverbal behaviors (Item 3)	–	Pre:0.91; Post:0.89
Around teacher nonverbal behaviors and immediacy	Pre: p3, Q2; Post: p6, Q2	I created open ended question (Items 2)	–	–
Prior Knowledge assessment of immediacy and nonverbal behaviors	Pre: p2	I created the questions	–	–
Demographics	Pre: p13	I created the questions	–	–

On the course you are teaching this semester	Pre: p14	I created the questions	–	–
Experience in teaching	Pre: p15	I created the questions	–	–
Motivation for taking part in study	Post, p15, Q1	From [88]	No alphas reported	Post: Intrin+Ident:0.23; Introj:–; Ext:–; Amot:–
Self-reported learning	Post: p2, Q1-2	From [199], changed from 0-9 to 0-10 scale, changed the wording to match the study activities	–	0.84
Attitudes	Post: P3-5 all questions	Adapted from Figure 4 in [63]	[63] no data, but other papers [102]=0.98, [168]=0.94	0.83
Goals	Post: p16-17	Item 1: readiness to change and Item 2 willingness to change were adapted from Readiness Rulers (RR) (for examples, see [92, 131, 228]), I created Item 3 specific goals set for change	–	Readiness:0.95; Willingness:0.93

Table 8.1: Pre and Post questionnaire big categories with sources

Interviews

After filling the pre-questionnaire, teachers met with me for a 1h interview where I shared with them the ClassInSight PD materials to introduce immediacy and nonverbal behaviors and their value. In addition, ClassInSight shared with them data about their own nonverbal performance in the classroom. Compared to the Chapter 7 study, I redesigned the PD materials in this study to be more concise and shorter and included additional PD on gaze and eye contact. The data shown to instructors was presented through the dashboard prototype described above. The full materials that teachers were presented during the interview are shown in Appendix D.4 and are listed below as well.

1. (*Introduction to Study*): Researcher reads to participant page 1
2. (*Professional Development*): Researcher hands participants pages 2-6 and gives participant time to read and ask questions
3. (*Instructions for seeing their data*): Researcher reads to participant page 7
4. (*Data Part 1: Your performance*): Researcher hands participant pages 8-10 and gives participant time to reflect on data, ask questions
5. Researcher asks participant questions on page 11
6. (*Data Part 2: Your performance compared to an Effective Teacher Standard*): Researcher

hands participant page 12-13 and gives participant time to reflect on data, ask questions

7. Researcher asks participant questions on page 14
8. (*Data Part 3: ClassInSight Feedback*): Researcher hands participant page 15 or 16-17 based on the experimental condition the participant is in (verbal persuasion - page 15, Social comparison - page 16-17) and gives participant time to reflect on data, ask questions
9. Researcher asks participant questions on page 18
10. Researcher asks participant questions on page 19
11. (*How you might work to change your proxemic nonverbal behavior in the classroom*): Researcher hands participant page 20-21 if they are interested in seeing some suggestions on how they can change their behavior

The data

The biggest change in this study was the interview protocol and the questions that the researcher (I) asked the instructors as they were working with the materials. To begin with, after reading the PD materials, I asked teachers to share what they thought their performance was in terms of location and proxemics. This was a question that I had not originally included in the study protocol, but decided to add during the interviews as a way to gauge teachers' self-perceptions of their own nonverbal behaviors before they saw any data on these behaviors.

Second, after every time the teachers saw their data (in Part 1, Part 2 and Part 3 respectively), I asked them the questions below. My aim for asking these questions, and another difference from the Chapter 7 study, was to explicitly support teacher in doing a deeper reflection and focusing on reflection-for-action, in particular goal-setting. I aimed to have a stronger focus on planning and goal setting to better support teachers in their first step towards behavior change. More specifically, through my questions, I focused on supporting teachers' (1) noticing of their data, (2) reflection and assessment of their performance as well as (3) planning and goal setting for behavior change in the classroom, as shown below. For goal setting in particular, I was interested in seeing if the teachers wanted to change, if so what did they want to change and how did they plan to change. I asked this question repeatedly throughout the interview rather than once at the end (as I did in the Chapter 7 study) to see the progression of goal setting and any changes in their intentionally for behavior change from the beginning to the end of the interview.

1. **Noticing**: What do you see? What do you notice?
2. **Reflecting**: What do you think about your data?

   How do you think you are doing? How would you evaluate your performance based on the data that you see?
3. **Planning**: Do you want to change anything in your behavior?

   What would you like to change?

   How would you change it?

Data Part 1: Your Data

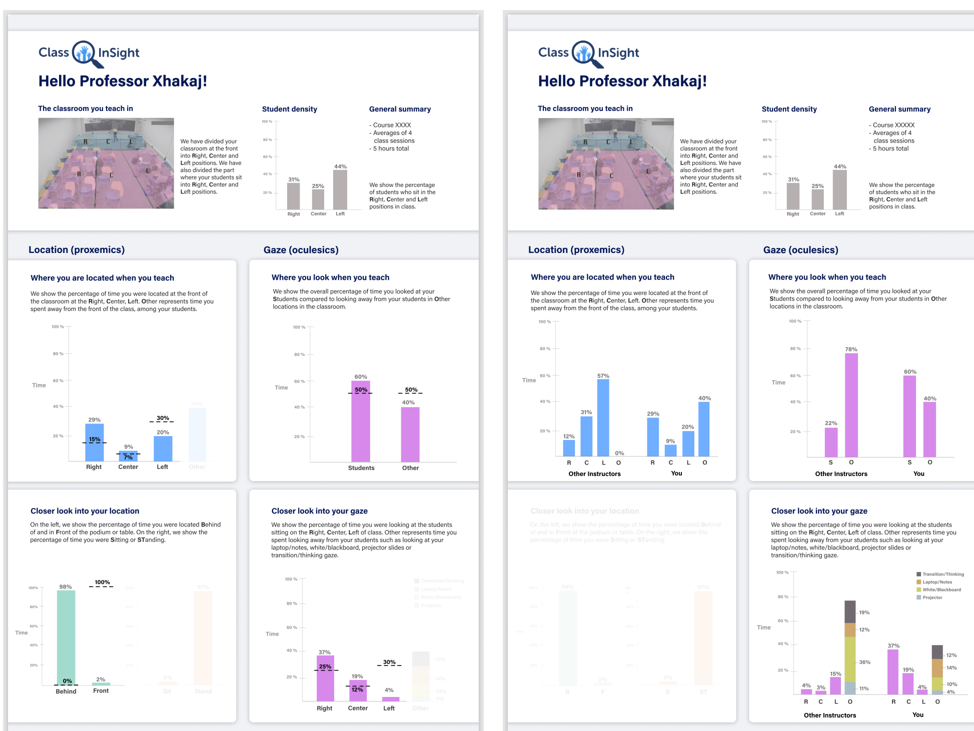
In Part 1 of the data teachers were presented with their "raw data" in dashboard form, as shown in Figure 8-2.

Data Part 2: An Effective Teacher Model

In Part 2 of the data, teachers were presented with a short text description of what the literature suggests an effective teacher model should look like in terms of their nonverbal behaviors in the classroom. The text was accompanied by a dashboard as shown in Figure 8-3(a) where the teachers' own data was shown against and effective teacher model.

This effective teacher model suggests proportionally dividing the instructors' time and attention among their students, based on where their students are sitting. The black dotted lines together with the percentages in bold black font represent where the effective teacher should be proportionally based on where the students sit in the classroom. For example, based on the student density shown at the top right of Figure 8-3(a), the teacher should be spending more time located at the left side of the classroom (30% of the time vs the current 20%) and should be spending more time looking at the left side of the classroom ((30% of the time vs the current 4%).

In addition, the effective teacher model suggests to spend less time behind the podium and table and more time looking at and facing the students. Provided that to the best of my knowledge there is not prior literature showing how much time would be ideal to spend in front of the podium or looking at your students, in this dashboard I suggested teachers to spend all the time in front of the podium and 50% or more of the time (half or more) looking at their students.



(a) Teachers' data against a suggested effective teacher model.

(b) Teachers' data against in a social comparison format.

Figure 8-3: Example of the dashboard teachers saw in part 2 and Part 3 of the interview.

Data Part 3: ClassInSight Feedback

In the third and last part of the study, similar to the Chapter 7 study, I provided teachers motivational feedback from the ClassInSight app as described above. Teachers received one of the two types of the motivational feedback based on the experimental condition they were assigned to randomly: verbal persuasion or social comparison. Except for this part of the study that introduced the two conditions, every other part of the study was exactly the same for all teachers. The motivational feedback was aimed at increasing instructors self-efficacy as described in Chapter 7.

At the end of the interview, I asked instructors a couple of final questions. First, I wanted to know what other data they were interested in having, in addition to what the current dashboard was providing. Second, I asked instructors for some feedback on the study and the materials presented to them. Lastly, I asked instructors if they wanted to see some suggestions on how they could change their nonverbal behaviors in the classroom. My aim was to first measure once again teacher willingness to consider behavior change as a proxy and first step before actual behavior change. Secondly, I wanted to provide teachers extra PD materials with suggestions and ideas of what they could change in their nonverbal behaviors in the classroom that were more actionable.

How you might work to change your location and gaze nonverbal behavior

The suggestions on how teachers could change their nonverbal behaviors focused specifically on location and gaze. I redesigned this part so that it was more concise compared to the Chapter 7 study version and easier to read and parse.

8.3.4 Data analysis

Analyzing the questionnaire data

My team and I conducted the analysis of the questionnaires and generated the following results and charts. To look up the questions in the questionnaires, in Table 8.1 I have included the page numbers for each questionnaire and the questionnaire itself can be found in Appendix D.3. The analysis below is based on the data collected from 16 teachers filling the pre-questionnaire. Out of 16 teachers, only 15 filled the post questionnaire while one instructor completed only a handful of questions in the post and left the rest blank. For this reason, I will not include this instructor data point in the post-questionnaire analysis. In total, 16 teachers took part in the interview sessions.

Cronbach's Alpha

In Table 8.1 I have calculated Cronbach's Alpha [69] for all the items in both the pre and post questionnaire. In the column next to the calculated Alpha, I have included the original Alpha found in the literature under the "Source" column. Note, that in this study, I changed the pre and post questionnaires to make them shorter and more concise. Thus, there were multiple items in both questionnaires that were individual questions, for which Cronbach's Alpha cannot be calculated. In addition, in many cases, the source of the questionnaire did not use or share a Crobach's Alpha thus the value is missing in the "Original Alpha" column. Lastly, the reader should keep in mind that, as described in the same table, the questionnaires were often modified and changed slightly or drastically to match the study goals.

With few exceptions, the calculated alphas are generally quite high (above 0.8) and match the original alpha when available. Even for the items that I created on my own, such as the self-efficacy for immediacy and nonverbal behaviors, the alphas are quite high. In the few cases when the alphas are on the lower end (i.e., the Intrinsic and Identified motivation tuple) and there is a decrease on the alpha value from the Chapter 7 to the Chapter 8 studies. The reason is mainly because there are only 2 items (questions) for this construct, which are insufficient to fit the assumptions for calculating the alpha as the literature recommends 3 items at least [169]. In addition, even though slightly bigger than the Chapter 7 study, overall the sample size in this study was small (only 16 participants). To summarize, provided that the questionnaires have been used and vetted in literature, the reduction in the number of questions as well as the small sample size in this study, the calculated Cronbach's Alphas are adequate for the following analysis.

Analyzing the interview data

There were on average 16h of video interviews recorded from the teacher interviews (on average 1h of interview per instructor). Research assistants in our team transcribed the interviews first automatically, using the Temi service. Then they manually double checked the transcriptions for accuracy. Similar to the analysis in Chapter 7, we then used Atlas.ti to conduct a deductive thematic analysis on the transcriptions. As the first step of the deductive thematic analysis, I defined a set of broad themes based on the study aims and research questions and the existing knowledge my team and I had from running the current studies and analyzing the studies in Chapter 7. The broad themes included teachers' interest around data, teachers' assessment of their performance, teachers' ability to monitor nonverbals in class, teachers' interest around setting goals and changing behaviors.

I created a Microsoft Word document with a description of each of those themes and examples from the interviews of what counted and did not count for each theme. My team (4 students) and I ran a thematic analysis and independently tagged with the major themes the same interview. We then came together and discussed discrepancies and uncertainties in the tagging. We repeated this process once again, at which point we had reached a common understanding of the major themes. We then split the interviews among ourselves, and once a week came together to discuss interesting findings or points of uncertainty. Once the interviews were fully tagged with the major themes, we came together to discuss potential patterns within each major theme which created sub themes. We reviewed and organized these sub themes in a second word document. Before writing this section, I did a full pass at all the thematic analysis findings and taggings on the interviews, adding any taggings and necessary and summarizing the themes. Based on this process I then wrote the following findings section.

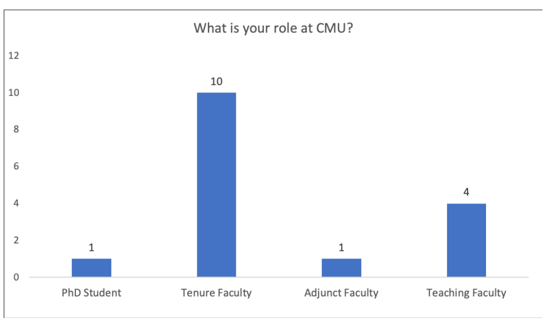
8.4 Findings and Discussion

In this section I analyze instructors' answers to the pre and post questionnaires and interviews they took as part of the study. To have a more coherent presentation and discussion, I have organized the findings based on the source of the data (pre, post questionnaires and interviews). In the Conclusions section, I bring back the research questions and summarize the findings and contributions of this chapter.

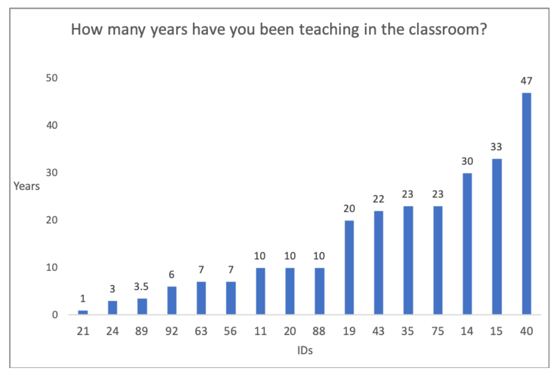
Note: In certain cases in the following analysis of the questionnaires, the data presented in the table might be slightly off in accuracy compared to the data shown in the charts. An example is the average of say `8.63` is presented as this value in the chart (calculated with Excel) but presented `8.62` when calculated in R. That comes from an R policy to round the actual value of `8.625` down to `8.62` and not up to `8.63`. Those differences are minor and do not affect the analysis.

8.4.1 General Analysis of the Pre-Questionnaire

From the 16 instructors who took the pre-questionnaire 11 were male and 5 were female. Similar to the Chapter 7 study, there is a majority of male faculty in the sample. This might be a result of the overall faculty population at CMU, namely more male than female faculty in general. In relation to their role, 4 instructors were Teaching Faculty, 1 was Adjunct Faculty, 10 were Tenure Faculty and 1 was a Ph.D. student (Figure 8-4(a)). The Ph.D. student was a TA who lead the recitation sections of a course taught by another instructor, who also took part in the study. The distribution of faculty roles in this study is also quite different from that during the Chapter 7 study where the majority of the participants were teaching faculty. The instructors' teaching experience varied from less than 10 years (6 teachers) to 10 years or more (10 teachers) (Figure 8-4(b)). Most teachers had experience teaching at the college level, and 2 of them had experience in K12 with middle and high school levels. None of the instructors in this sample had worked with me on prior studies in relation to this thesis work, thus for all of them it was the first time taking part in this type of study.



(a) Participant roles at CMU.



(b) Number of years instructors have taught in the classroom, regardless of the level taught.

Figure 8-4: Participant demographics.

In relation to their experience with professional development, half of the teachers, 8 out of 16, had no experience with working with the Eberly Center for Teaching Excellence and Educational Innovation at CMU. Only 7 teachers had attended workshops, taken seminars, or been involved in some other way with them. Lastly, one teacher's response was not clear in answering this question. This distribution in experience with PD, where the majority of instructors have not worked or been involved with Eberly, is very different from the distribution I found in the instructors who took part in the Chapter 7 study, where the majority there had worked with Eberly at various lengths. This might be an effect of the population in the current sample, where the majority of the teachers are tenure faculty and there is a smaller number of teaching faculty. For tenure faculty, unlike for teaching faculty, teaching is not necessarily the primary focus and concern of their job as other matters related to research or administration maybe their primary responsibility. In fact, looking at the data in more detail, the 7 instructors who responded "Yes" to having worked with Eberly were all 4 teaching faculty, 1 Ph.D. student, and 2 tenure faculty in our sample. The rest of the tenure faculty and the 1 adjunct faculty all responded "No" to this question.

Outside of PD from Eberly, 5 out of 16 teachers had not had any other training on their teaching or any type of professional development. One instructor responded "No" to this question but mentioned they follow research in this area, while a last instructor did not clearly respond to the question. Again, provided the population in this study, namely a majority of tenure faculty, these results are understandable. As one tenure faculty responded *ID75: "No. Ironically, college professors do not receive rigorous teaching instructions as K-12 teachers. We learn by trial and error."* In addition, there were 9 instructors out of 16 who mentioned they had taken part in some sort of PD at CMU or elsewhere, including on boarding when they were hired as faculty for the first time (1), having taken a course at some point in their careers (3), attending conferences in the field annually (1), a mentor providing comments on class sessions (1), attending various workshops and seminars (1), having had PD only from Eberly (2).

Familiarity with immediacy and nonverbal behaviors

When asked to self report on their familiarity with the concept of immediacy, most teachers (11 out of 16) said they had "No idea" what immediacy was. Another instructor said they had no idea but gave a close definition, while 3 instructors gave a definition that was totally off from the actual concept of immediacy. Only one instructor provided a definition that was relatively close to the actual definition.

On the other hand, when asked to about familiarity with nonverbal behaviors, all teachers expressed some level of familiarity with the term and they all could provide some examples of nonverbal behaviors. Provided that immediacy is a concept that mostly comes across in literature, it is understandable why the majority of teachers had no idea what it was. At the same time, nonverbal behaviors are more likely to come up in everyday conversations outside of teaching in terms of body language which is a more commonly used term. These results are consistent with the Chapter 7 study findings.

After asking the above questions to teachers, from this point on in the pre-questionnaire teachers were provided with definitions for immediacy and nonverbal behaviors at the beginning of each questionnaire. These definitions were meant to help them better answer the questions related to those terms.

Confidence in immediacy and nonverbal behaviors

When asked to quantify their confidence in their immediacy skills, most teachers responded they were quite confident in their teacher immediacy skills as shown in Figure 8-5. In total, 1 out of 16 teachers responded they were "Extremely Confident", 2 teachers responded they were "Very Confident" and 9 teachers responded they were "Moderately Confident" in their immediacy skills. Only 3 teachers responded they were "Slightly Confident". The overall weighted average was 3.13 out of 5 an average of slightly above "Moderately Confident"). Despite not being familiar with immediacy as a concept, many of the teachers in out sample, provided their many years in teaching experience, have made use of methods to help develop immediacy with their students in the classroom. These results are similar to the Chapter 7 study findings. It is positive that these results show teachers are quite confident in their skills, however there is room for improvement to move the teachers' answers from "Slightly" and "Moderately" to "Very" and "Extremely" confident.

Behavior Change Intentionality

When asked if they had any specific immediacy or nonverbal behaviors skills that they wanted to work and improve on their teaching, half of the teachers, 8 out of 16, responded "Yes" in that they wanted to work on behaviors such as facing the board less (1), using nonverbal behaviors more consciously (2) in particular to increase engagement in class (2), learn how to

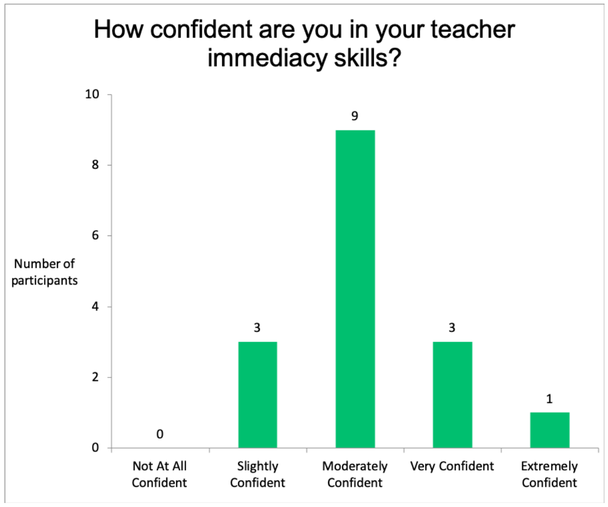


Figure 8-5: Teacher confidence in their immediacy skills.

handle specific classroom situations (1), equally engaging all students instead of focusing only on those who already show interest (1), in particular in cases where cultural differences play a role (2). Teachers recognize that there are certain aspects of these skills they want to work and improve on provided they have not had any training in particular on those skills. As one teacher responded to this question, *ID 20: "Yes, since none of mine [immediacy or nonverbal behavior skills] are trained or necessarily conscious".* The majority of the instructors who responded "Yes" were tenure faculty, while only 2 out of 4 teaching faculty responded "Yes" and the other 2 responded "No".

In addition, 4 out of 16 teachers responded "No" to this question, while one teacher responded "No" and another one "Not sure" but both were open to improvement. Interestingly, one instructor answered that they needed to have a better understanding of the value of immediacy to be able to say if they wanted to improve on anything. Lastly, a teacher mentioned that there are a lot of external factors that inhibit them from doing well or wanting to do well in terms of those skills.

Values and Beliefs around Immediacy and Nonverbal Behaviors

In Figure 8-6 I share teachers' values and beliefs around immediacy and nonverbal behaviors. Over all the questions in the questionnaire, teachers scored an average value of 5.35 which falls between the "Agree" and "Agree Strongly" in the scale. with the various statements. In particular, teachers score closer to "Agree Strongly" with the statement that immediacy and nonverbal behaviors have a significant effect on teaching effectiveness (average 5.63) but they score a little lower with the statement that these constructs have a significant effect on student learning (average 5.38). This is interesting as an effect on teaching would translate to an effect in student learning, but maybe the indirectness leads teachers to beleive such behaviors affect student learning less. Despite this, overall it seems that teachers see a value in immediacy and nonverbal behavior in the classroom.

When asked about specific nonverbal behaviors, teachers score lower in the value they see in the location and position behaviors in class (average of 5.00) while they score higher on the value that they see on the gaze and eye contact behaviors (average 5.56). A potential explanation

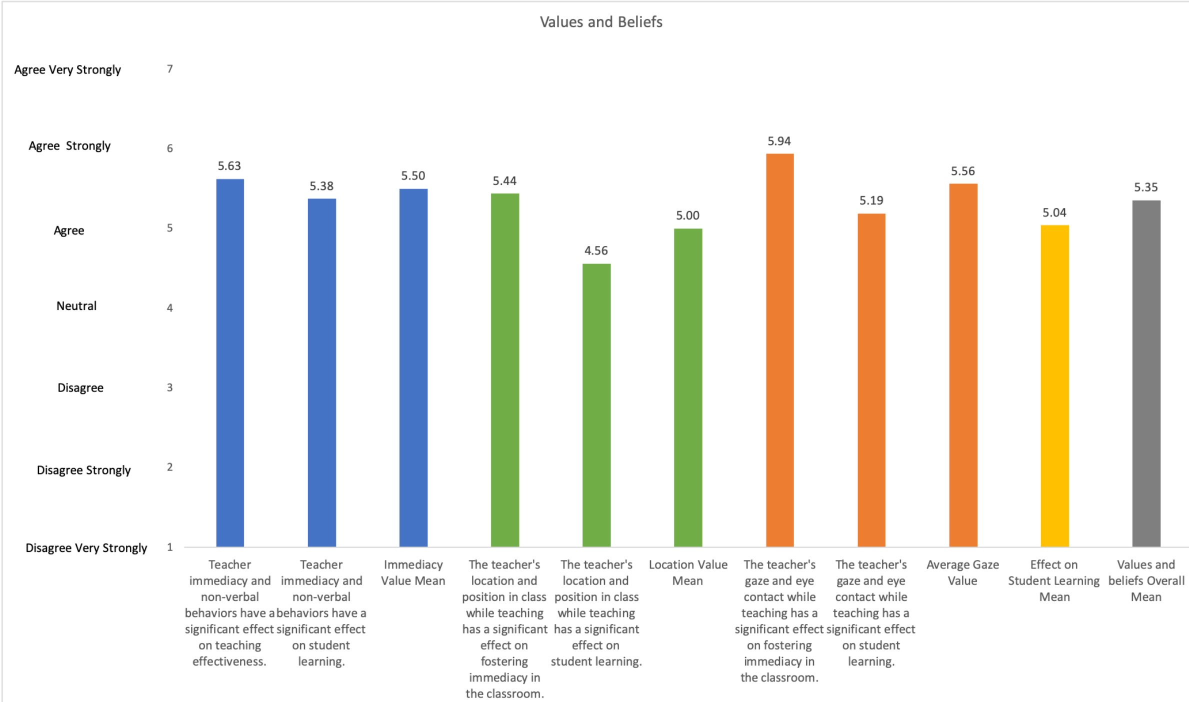


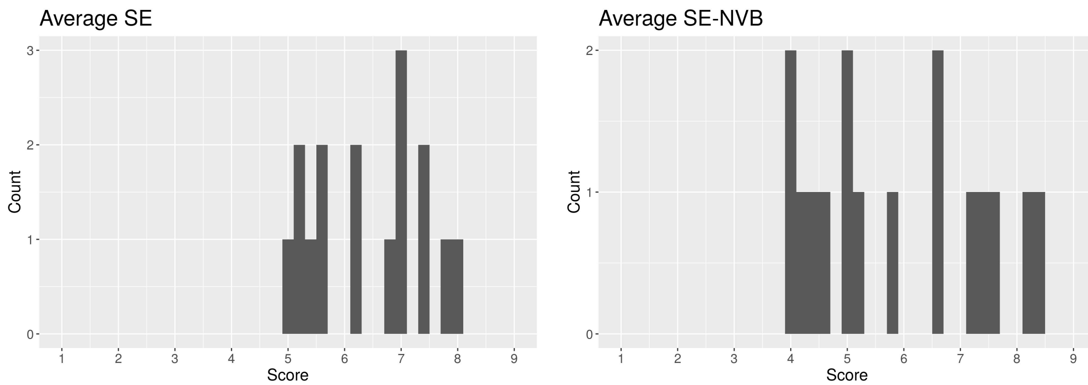
Figure 8-6: Teachers' values and beliefs around immediacy and nonverbal behaviors.

for this difference could be that teachers value gaze behavior and the connection through eye contact with their students much more than they value their location and position in class. In addition, for both location and gaze, teachers believe they have a significant effect on fostering immediacy in the classroom, while they score much lower on whether they agree with such behaviors having a significant effect on student learning. This gap is much more noticeable for location and position behaviors, even though it can still be seen in the gaze and eye contact behaviors (Figure 8-6). Overall, these results are consistent and in the same direction as the results in the Chapter 7 study, with the exception that the mean scores in this study are slightly lower per question compared to the mean scores per question over the Chapter 7 study.

General and task-specific Self-efficacy

In relation to Self-efficacy, the pre-questionnaire measured teachers' general self-efficacy for teaching (SE) as well as the self-efficacy for immediacy and nonverbal behaviors specifically (SE-NVB). In Figures 8-7(a) and 8-7(b) I plot the distribution to teachers' answers to each questionnaire. The x-axis represents the average score per teacher overall all the questions in the questionnaire, while the y-axis represents a count of teachers who got that score. At a high level, both charts hint at a uniform distribution of SE and SE-NVB. In addition, SE and SE-NVB have very similar distributions, which is positive in particular as the SE-NVB questionnaire was created by me, based on [40].

For SE, I split the 1-9 scale, from "Not at all" to "A great deal" into three buckets low [1, 3.66], mid [3.67, 6.33] and high [6.34, 9] and the participants fell into the mid and high buckets, respectively 8 teachers in the mid-SE and 8 teachers in high-SE bucket. In relation to SE-NVB, the teachers fell 9 into the mid-SENVB bucket and 7 into high-SENVB bucket. Unlike in the Chapter 7 study, where the majority of the teachers fell in the high-SE/high-SENVB groups, in this study there is a more equal distribution of the teachers in the mid and high SE/SENVB buckets. This can be explained by the population in the current sample size, namely the majority being tenure faculty.



(a) Teachers' general self-efficacy for teaching (SE). (b) Self-efficacy for immediacy and nonverbal behaviors.

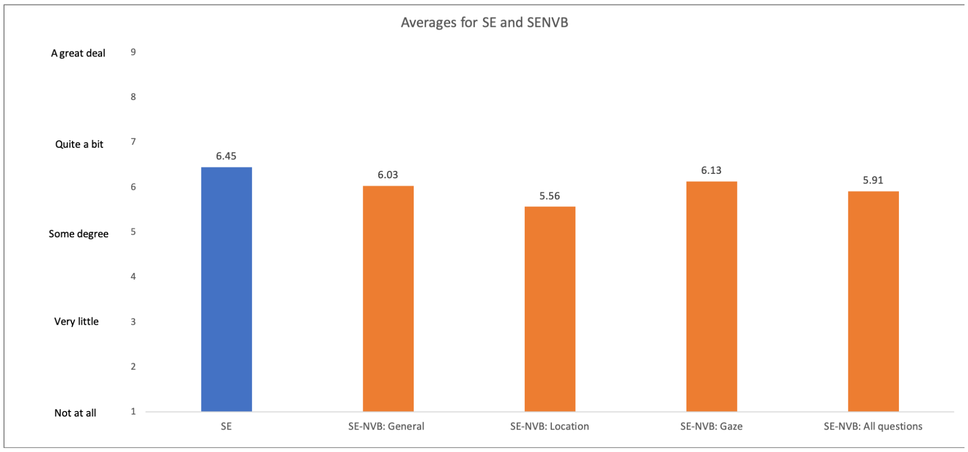
Figure 8-7: Teachers SE and SE for NVB distribution.

In Figure 8-8(a) I am sharing the average SE and SE-NVB scores across all participants as well as a breakdown of SE-NVB scores on the general, location and gaze related questions. In terms of SE, instructors score on average 6.45, a value between "Some degree" and "Quite a bit" in terms of their self-efficacy about their teaching. The average of SE-NVB is lower with a score of 5.91, while still between the "Some degree" and "Quite a bit" scale. It is interesting to note that those averages are lower than the respective averages of the Chapter 7 study (6.86 for SE and 7.14 for SE-NVB). One factor could be the different population distribution and the majority of tenure (instead of teaching) faculty in this sample. In addition, as described above, there are more instructors in this sample who fell into the mid-SE/SENVB group, thus bringing down the overall average.

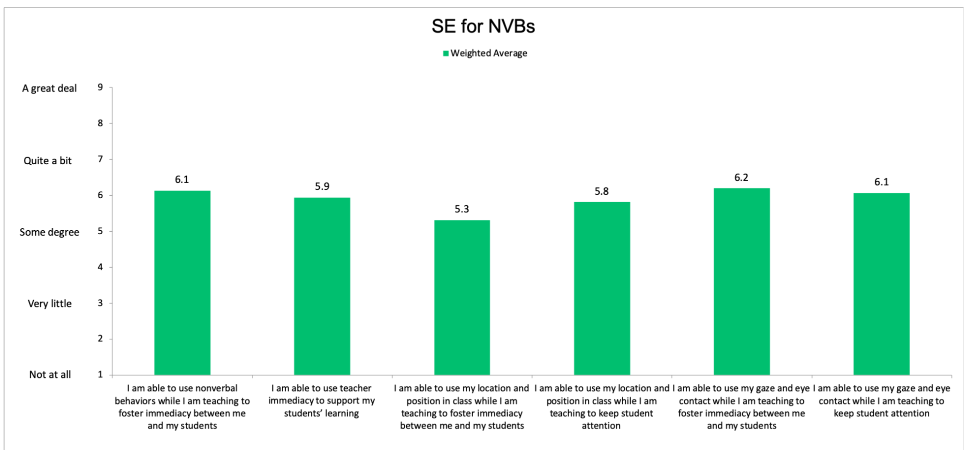
Taking a closer look at the average of SE-NVB for location and gaze respectively, teachers score on average much lower on questions related to location (average of 5.56) compared to questions in relation to gaze (average of 6.13). In Figure 8-8(b) I share the weighted average per question in relation to the questions in SE-NVB. Teachers score low on location related questions, however interestingly they score higher on the question of "using location and position to keep student attention". Teachers' answers on the gaze related questions are quite high, on both using gaze and eye contact to foster immediacy as well as keep student attention. It is interesting to see that these results are consistent with the above results of the values and beliefs teachers held about proxemics and oculesics, where they valued location and position much less that gaze and eye contact.

Self-reported nonverbal behaviors

In the current study, the modified questionnaire that asked teachers to assess their nonverbal behaviors (NB) ranges from a score of 58-98 (after the reverse scoring is taken into account). Note, this range is different from the Chapter 7 study due to changing the questionnaire by cutting down some questions to make the questionnaire shorter and more concise (as discussed in Table 8.1).



(a) Average SE and SE NVB score



(b) A breakdown by question on SE for NVB.

Figure 8-8: Teachers SE and SE for NVB statistics.

The average score for the pre-questionnaire was 85 and the standard deviation was 6.4, with lowest value being 73 and the highest one being 96 in the range 58-98. This shows the teachers in this study perceive they use nonverbal behaviors quite often in class, however they do not reach a ceiling effect, leaving room for improvement. In addition, despite the relatively small number of participants in the sample the distribution is showing a tendency towards normal (Figure 8-9).

Taking a closer look at the individual questions of this questionnaire, in relation to oculesics (gaze and eye contact) shown in Figure 8-10(a), teachers score quite high in how they perceive their oculesics behaviors in the classroom (slightly higher than "Quite a bit" in the scale). In relation to proxemics (location and proximity to students) shown in Figure 8-10(b), teachers self-report their perceived use of proxemics much lower (slightly above "Occasionally" in the scale). This result could be explained also by the fact that teachers value gaze more than location and their SE-NVB for location is lower than for gaze (as described above). Thus, instructors perceive they use gaze behaviors more than location related behaviors in the classroom.

Motivation

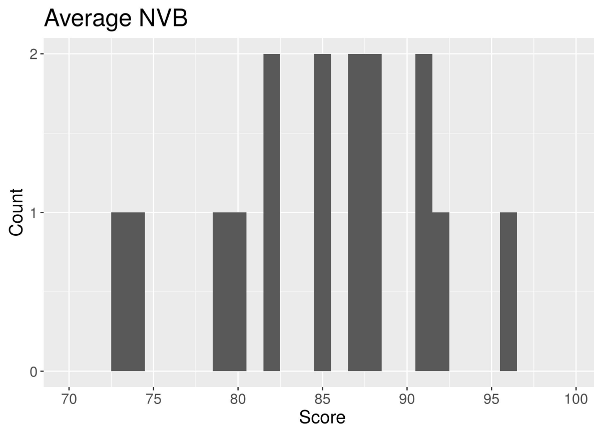
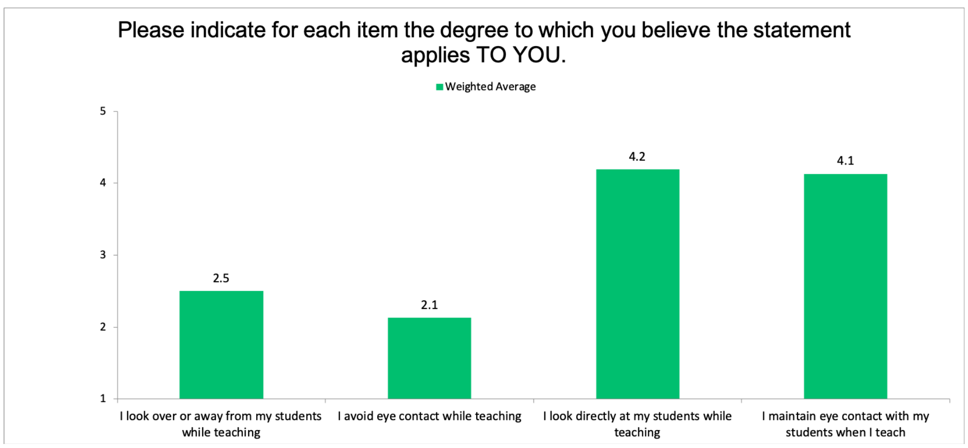
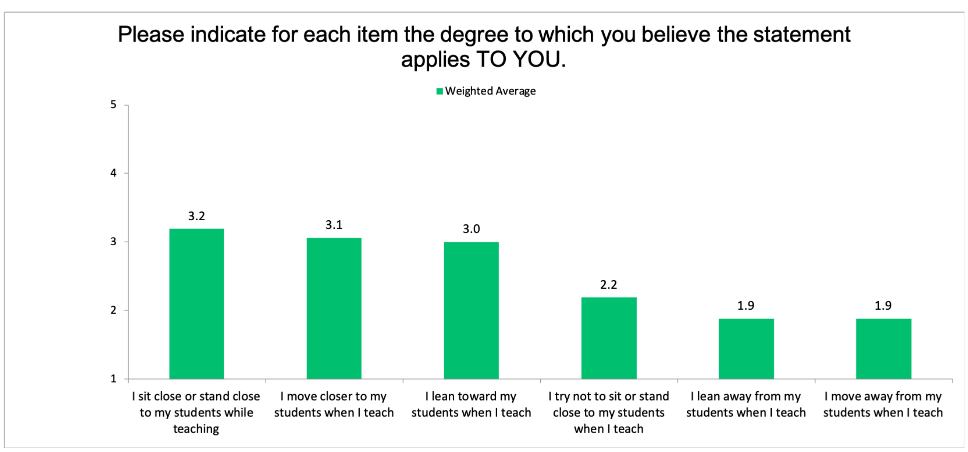


Figure 8-9: Score distribution in the nonverbal immediacy questionnaire.



(a) Self-reported nonverbal behaviors: oculesics



(b) Self-reported nonverbal behaviors: proxemics

Figure 8-10: Teacher self-reported NVB per question.

When asked what things motivate them in doing their best in the classes they are teaching this semester, instructors shared a variety of responses. To note is that those responses were quite

Table 8.2: Motivation constructs and the questions in the questionnaire

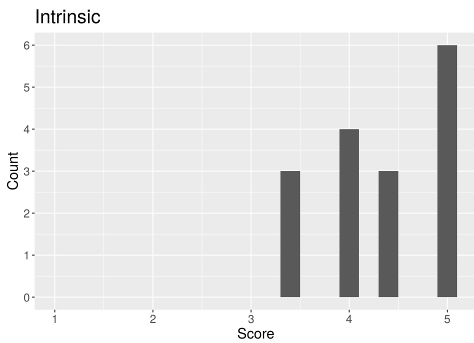
Intrinsic + Identified	• Because I derive much pleasure from teaching • Because I see my teaching as a significant contribution to my students' overall academic success
Introjected	• Because a good performance in teaching contributes largely to my self-esteem as a professor
External Regulation	• Because my employment contract demands me to teach
Amotivation	• I don't know, sometimes I don't see the actual purpose of teaching

different from the responses in the Chapter 7 study in that they rarely connected or referred to constructs related to immediacy and nonverbal behaviors. Some of the things that most instructors in this study found motivating included student learning (8 half of the teachers), for students to be successful and reach their highest potential (2) as well as the importance or beauty of topic the instructors were teaching (4). The latter motivator is understandable, in particular as tenure faculty, that compose the majority of the population in this study, often teach courses that lay in their areas of expertise and knowledge and that they find important and interesting. Constructs related to immediacy and nonverbal behaviors such as participation/engagement in class (2), student interest in the topic (1), student effort or (1) creating a supportive environment for students (1), were motivating for far fewer teachers, again opposite to the Chapter 7 study results. This could be an effect of the population in this study. Lastly, some teachers mentioned being motivated by the responsibility/obligation that comes with their job (2) or them liking the job (1).

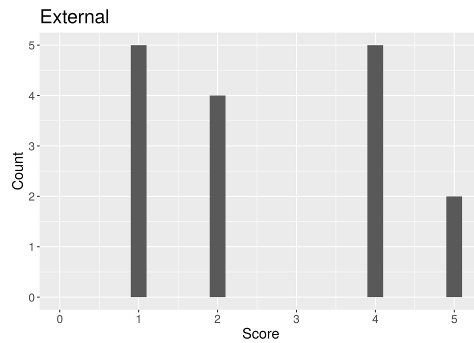
In relation to motivation, teachers were also asked to rate their agreement with statements that represented various reasons of why they teach. This questionnaire meant to measure teachers' motivation in relation to teaching focusing on the following constructs: intrinsic motivation (as a merge of intrinsic and identified motivations), external regulation, introjected motivation and amotivation. In Table 8.2 I list the questions of the questionnaire that measured each of those motivational constructs.

There are 13 out of 16 teachers who scored a 4 and above ("Agree" and above) on the intrinsic motivations questions and 3 teachers who scored between "Undecided" and "Agree" (shown in Figure 8-11). In external regulation, the distribution of instructors is more of a mixed bag; 7 out of 16 teachers, (almost half) scored 4 or higher, which means they were highly externally motivated, while the other 9 instructors score a 2 or lower (between "Disagree" and "Totally Disagree"), meaning they are not at all externally motivated. Similarly, for introjected motivation, there are 10 instructors scoring a 4 or above (between "Agree" and "Totally Agree"), 3 instructors scoring 2 or below (between "Disagree" and "Totally Disagree"), and 3 instructors scoring "Undecided". Lastly, in relation to amotivation, all instructors scored a 1 "Totally Disagree" except for 2 instructors who scored a 2 "Disagree" (as shown in Figure 8-11).

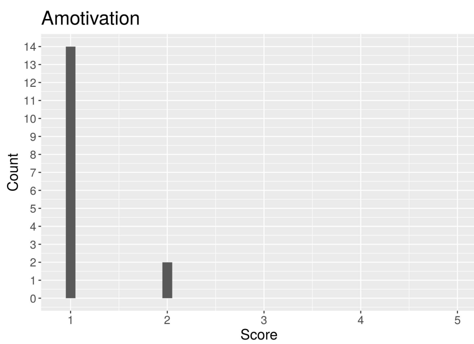
Based on these distributions, as well as the means shown in Figure 8-12(a), teachers on average score higher on the intrinsic motivation construct (an average of 4.4 out of 5 scoring between "Agree" and "Totally Agree" scale), compared to all the other motivational constructs. Amotivation scores the lowest (1.1 on average, close to "Totally Disagree"), followed by external regulation (2.7 on average, between "Disagree" and "Undecided"), lastly followed by introjected motivation (3.6 on average, between "Undecided" and "Agree"). The intrinsic motivation average is consistent (exactly the same) with the average found during the Chapter 7 study. The introjected motivation average is slightly higher here (3.6 here as opposed to 3.4 in the Chapter



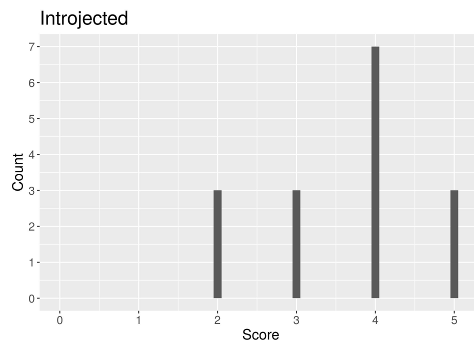
(a) Intrinsic Motivation Distribution.



(b) External Motivation Distribution.



(c) Amotivation Motivation Distribution.



(d) Introjected Motivation Distribution.

Figure 8-11: Score distribution for the 4 motivational constructs.

7 study) while the amotivation is slightly lower (1.1 here as opposed to 1.2 in the Chapter 7 findings). The biggest difference is in external motivation, where the average dropped from the Chapter 7 study (2.7 here compared to 3.4 in the Chapter 7 findings). These results show that cutting down the questions of this motivation questionnaire with the purpose to make it more concise did not affect the motivational constructs and the results, with the exception of external motivation, which might be more a factor of the population sample in this study rather than the questions being reduced.

Looking in more detail at each of the motivational constructs per faculty role at CMU, Figure 8-12(b) is showing the averages of each construct. Note that the averages are over different population sizes (there were 4 teaching faculty, 10 tenure faculty, 1 Ph.D. student and 1 Adjunct Faculty), and for this reason I will not focus the discussion on the Ph.D. student and Adjunct faculty provided there is only 1 data point. Rather, I will discuss the results in light of the tenure and teaching faculty responses. On average, teaching faculty scored higher than any other faculty in terms of intrinsic motivation (an average of 4.8 out of 5), while they scored the lowest in external regulation (1.5 out of 5). On the other hand, tenure faculty expressed lower intrinsic motivation than teaching faculty, but almost twice as much external regulation (3 out of 5). With the exception of the 1 data point (Ph.D. student) with the highest external regulation, tenure faculty have the largest score in terms of external regulation. These results could indicate that teaching faculty, whose job requires them to primarily teach, are more intrinsically motivated in relation to teaching. Whereas, tenure track faculty, for whom teaching is not their primary focus, might be less intrinsically motivated and more extrinsically motivated when it comes to teaching. Both tenure and teaching faculty score moderately high on introjected motivation and low on amotivation.

In Figure 8-12(c) I share the weighted averages per question in the current motivation questionnaire. Each question measures one of the 5 motivational constructs (with intrinsic and identified merged in the above analysis). Teachers score the highest in the questions measuring intrinsic and identified motivation ("Because I derive much pleasure from teaching" with an average of 4.25 and "Because I see my teaching as a significant contribution to my students' overall academic success" with an average of 4.50). Thus, instructors' interest and enjoyment in teaching is quite high, but the value they see in teaching for their students and their success is higher. Similarly, external regulation of extrinsic reward scores low, while the introjected motivation scores quite high (an average of 3.63). Introjected motivation involves the ego, in this case [articipants' self-esteem as a professor, and provided the population in this sample (mostly tenure track), their years in teacher (majority more than 10 years) as well as the institution they are teaching in (a well reputed school such as CMU) it is understandable for their introjected motivation to be high.

In terms of the planned effort and professional development aspirations, teachers on average scored a 5.74 out of 7, between "Moderately" and "Extremely" in the scale (Figure 8-13(b)). This value is slightly smaller than that found in Chapter 7 (6.2). The average of planned effort is slightly higher than that of PD aspirations, both relatively lower from the Chapter 7 averages (6.25 and 6.07 respectively). Overall, 14 out of 15 teachers scored higher than "Moderately", while only 2 of them scored between "Slightly" and "Moderately" (as shown in Figure 8-13(a)).

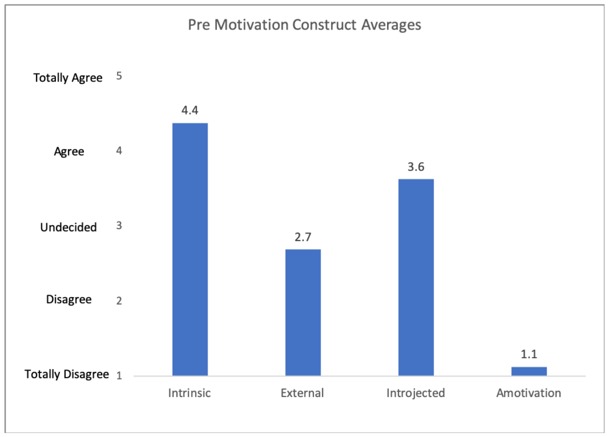
In terms of planned effort alone, all 16 teachers scored a 5 or above (above "Moderately"), with 8 teachers scoring between a score of 6-7 and 3 teachers scoring a 7 ("Extremely") (Figure 8-14(a)). This shows that teachers are willing to put in effort into their teaching and will strive hard to become an effective teacher, as shown in Figure 8-14(b). On average, teachers report they will strive hard to be an effective teacher (average 5.9 out of 7) and they will put effort into their teaching (average 6.0).

In terms of PD aspirations, the distribution was slightly shifted towards the lower extreme of the scale, with 14 teachers scoring "Moderately" or higher and 2 teachers scoring below "Moderately" (shown in Figure 8-14(c)). Of those 14 instructors, 7 scored between 5-6, 5 instructors scored between 6-7 and 2 instructors scored the highest, 7 ("Extremely"). Interestingly, teachers score high in their motivation to continue learning how to improve their teaching skills (average 6.0 out of 7 in Figure 8-14(d)), however they score lower on their motivation to undertake further professional development (average 5.3) or learn about current educational developments (average 5.5). This again might be a factor of the population in the current study, namely tenure faculty and their priorities and time restrictions when it comes to teaching.

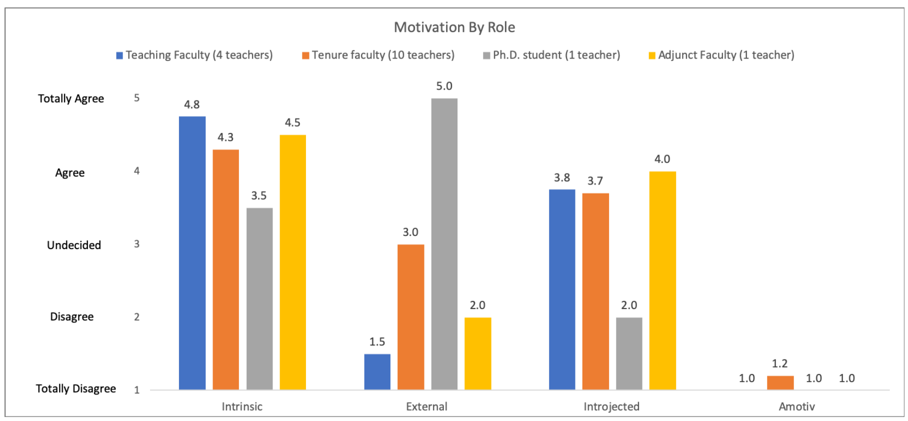
8.4.2 Statistical Analysis of the Pre-Questionnaire

In this section, I will focus again on the data from the pre-questionnaire of the study (16 participants). I will first describe correlations between various variables measured in the pre-questionnaire. Then, I will compare the data based on the roles of the instructors (teaching faculty versus other instructors) as well as the level of immediacy of the teachers (medium versus high immediacy).

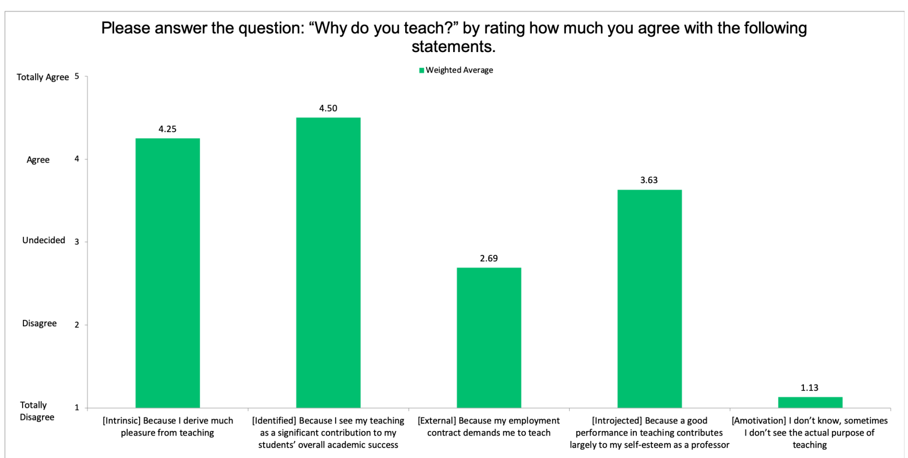
Correlation Matrices of Pre-Questionnaire Variables



(a) Average per motivational construct.



(b) Motivational constructs on average per type of role at CMU.

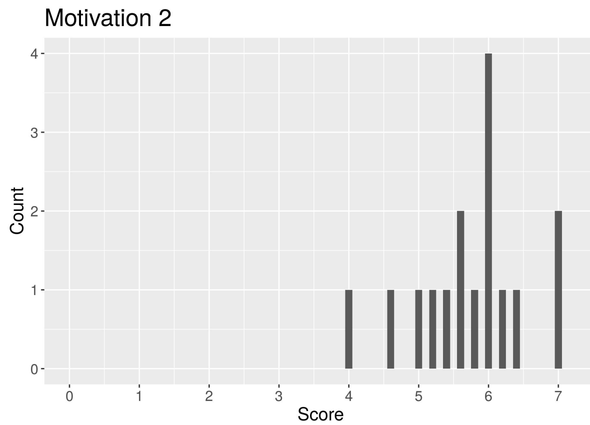


(c) Weighted averages of the motivation questions.

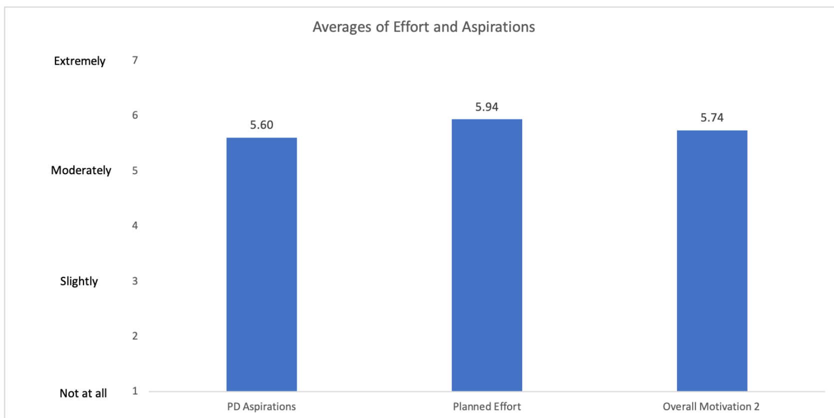
Figure 8-12: Score distributions of teacher motivation in the pre-questionnaire

In this section, I calculated the correlation matrix of the main variables measured in the pre-questionnaire including teachers':

1. confidence (`Confid`)



(a) Distribution of teacher planned effort, persistence and professional development aspirations.

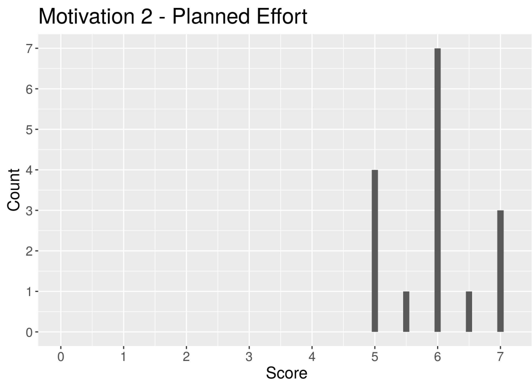


(b) Average of teacher planned effort, persistence and professional development aspirations.

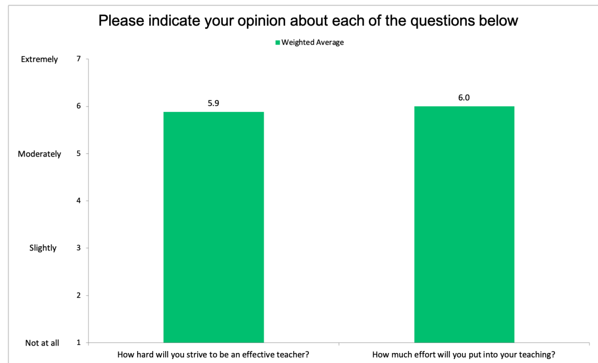
Figure 8-13: Information on teachers' planned effort, persistence and professional development aspirations.

2. value and beliefs (`Val`)
3. general self-efficacy for teaching (`SE`)
4. self-efficacy for immediacy and nonverbal behaviors (`SENVB`)
5. self-reported nonverbal behaviors (`NB`)
6. intrinsic motivation (`Intrin`)
7. introjected motivation (`Introj`)
8. external regulation (`Ext`)
9. amotivation (`Amotiv`)
10. efforts and aspirations (`EffAsp`).

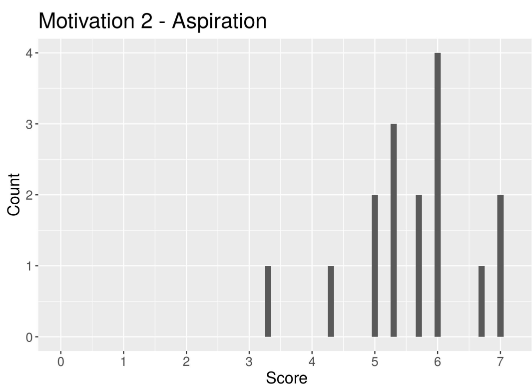
In Figure 8-15(a) I used the Pearson correlation to visualize the direction, strength and sig-



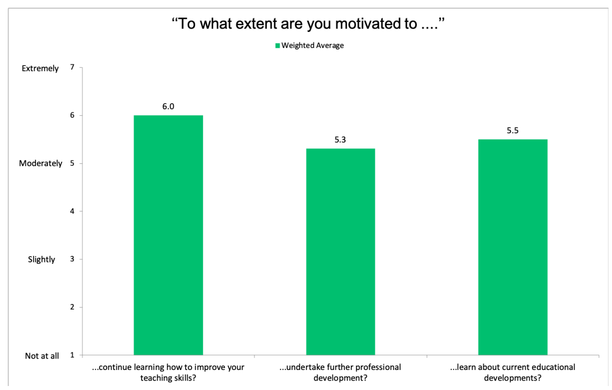
(a) Distribution of Planned Effort.



(b) Planned Effort weighted average per question.



(c) Distribution of PD Aspirations.

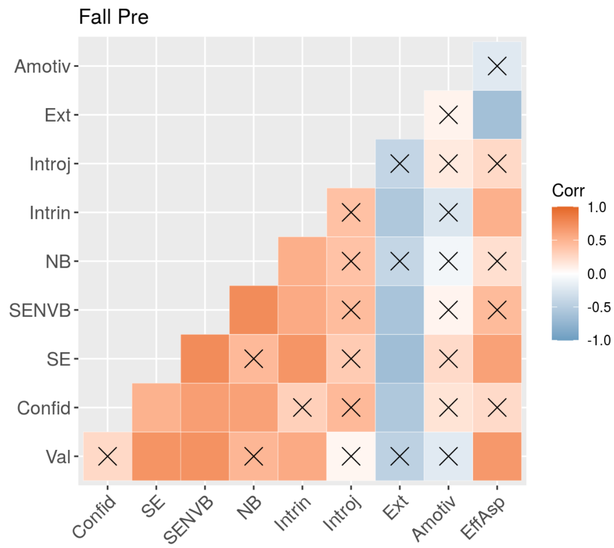


(d) PD Aspirations weighted average per question.

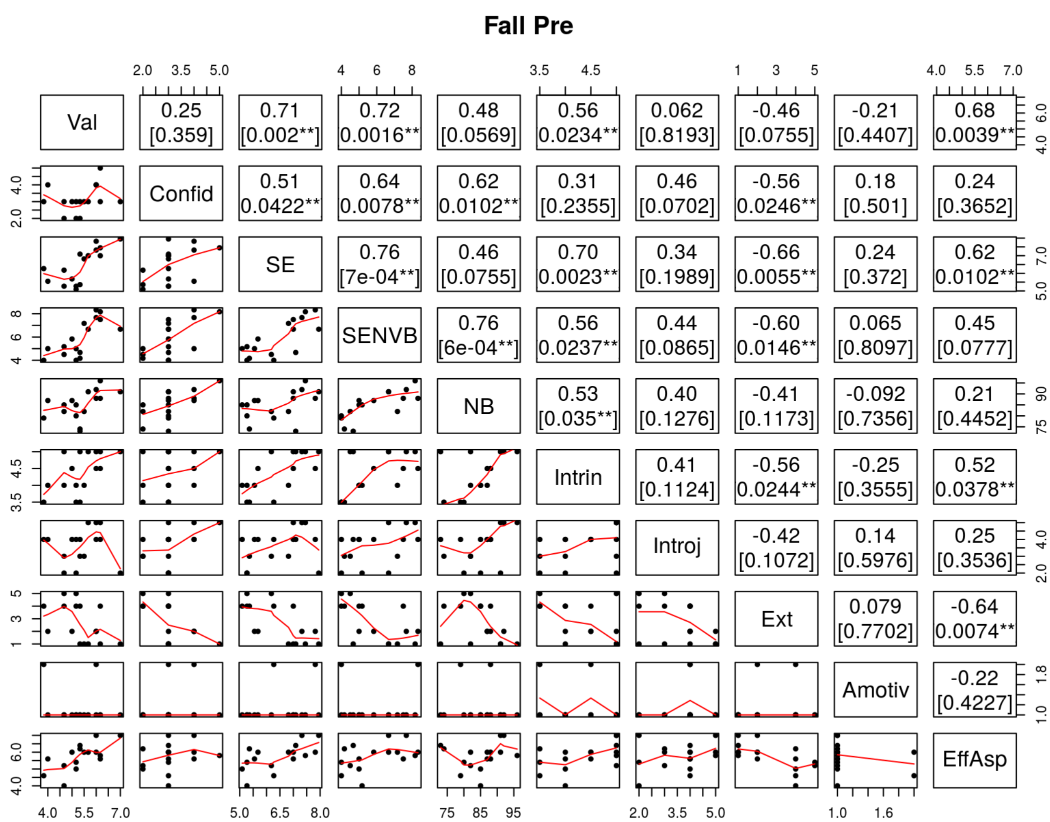
Figure 8-14: Information on teachers' planned effort, persistence and professional development aspirations.

nificance of the correlations between the variables in the pre-questionnaire. In this figure, the direction of the correlations is expressed by color, with orange denoting a positive correlation, blue denoting a negative correlation and white denoting no association. The strength of the correlation is indicated by the intensity of the color; the darker the color, the stronger the correlation, the lighter the color, the weaker the correlation. The significance of the correlation is represented by the cross "`X`" value in each box; if the correlation is statistically significant, then the box contains `no X`, while the existence of the `X` represents no statistical significance. The significance of the correlation was calculated using the t-statistics formula.

As shown in Figure 8-15(a), the predominantly orange color shows that there exist positive correlations among the different variables, with the exception of external regulation being negatively correlated with all the variables and amotivation fluctuating between being positively and negatively correlated with various variables. For example, `SE` and `SENVB` are positively correlated with each other as well as most of the other variables including `Confid`, `Val`, `NB`, `Intrinsic`, `EffAsp` and negatively correlated with `Ext`. In addition, regardless of the direction, the strength of the color in the different boxes shows which variables are strongly and weakly correlated (Figure 8-15(a). Examples of strongly correlated variables include `SE` and `SENVB` with `Val`, `SE` and `SENVB`, `SENVB` and `NB`, `SE` and `Ext`, etc. Lastly, a lack of "`X`" markings show significant correlations. With a few exceptions, it seems that many variables in the pre-questionnaire are significantly correlated.



(a) Correlation matrix of the main variables for the Fall pre-questionnaire data.



(b) An extended and more detailed version of the above matrix.

Figure 8-15: Correlations Matrices of the pre-questionnaire data.

In Figure 8-15(b) I share a more detailed view of the correlation matrix including (1) scatter plots for each pairwise correlation, (2) the strength of the correlation (`r`) together with the direction (positive `+` or negative `-`) as well as (3) the p-value for the significance (the number below the strength value, in square brackets `[ ]` accompanied by a `**` if the correlation is significant represents the p-value). In the analysis below, I consider a strong correlation `r>0.7` , a moderate correlation `0.5<r<0.7` and a weak correlation `r<0.5` .

Taking a more detailed look at the observations I shared above, `SE` and `SENVB` have a strong and positive correlation which is also statistically significant (`r=0.76, p=7e-04**`). Similarly `SE` and `Intrin` have a strong and significant correlation (`r=0.70, p=0.0023**`). `EffAsp` as well as `Ext` are moderately correlated with `SE` (`r=0.62, p=0.0102**` and `r=-0.66, p=0.0055**` respectively). Based on these results, teachers' general self-efficacy seems to be strongly and significantly correlated with a range of variables including motivation and self-efficacy for immediacy and nonverbal behaviors. Namely, a higher `SE` translates to higher motivation or self-efficacy in relation to immediacy and nonverbal behaviors.

Taking a look at `SENVB` , there is a strong and significant correlation with `NB` (`r=0.76, p=6e-04**`). This shows that teachers' self-efficacy in terms of their immediacy and nonverbal behaviors is strongly correlated with how they self-assess their use of such behaviors in the classroom. In addition, there is a moderate correlation of `SENVB` with `Intrin` (`r=0.56, p=0.0237**`) and `Ext` (`r=-0.60, p=0.0146**`). Along the same lines, `NB` has moderate correlations with `Intrin` (`r=0.53, p=0.035**`). The correlations of `NB` with the other motivational constructs and `EffAsp` are weak and not significant.

Looking at the motivation constructs more closely, `Intrin` and `Ext` are moderately correlated (`r=-0.56, p=0.0244**`), `Intrin` and `EffAsp` also moderately correlated (`r=0.52, p=0.0378**`), and lastly `Ext` and `EffAsp` moderately correlated as well (`r=-0.64, p=0.0074**`).

In terms of the value that instructors found in immediacy and nonverbal behaviors, `Val` is strongly correlated with `SE` (`r=0.71, p=0.002**`), `SENVB` (`r=0.72, p=0.0016**`). There is a moderate correlation with `EffAsp` (`r=0.68, p=0.0039**`) and `Intrin` (`r=0.56, p=0.0234**`). Based on these results, the more value instructors see in immediacy and nonverbal behaviors, the more they think they can do well, engage and are motivated to improve on those behaviors.

Not surprisingly, `Confid` is also moderately correlated with `SE` and `SENVB` (`r=0.51, p=0.0422**` and `r=0.64, p=0.0078**` respectively), as well as with `NB` `r=0.62, p=0.0102**` and `Ext` (`r=-0.56, p=0.0246**`).

Up to this point, I have provided the strength, directions and significance of each of the correlations. This shows the general direction of the results and findings, and in this section I will attempt to correct for the multiple comparisons using the Bonferroni Correction method. To determine significance in this analysis I used a p-value of `p<0.05` . Provided I did 36 comparisons, based on Bonferroni, the new p-value for significance should be `p<0.00139=(0.05/36)` . Bonferroni is very conservative and many of the previously described significant correlations will loose their significance in face of the new, corrected p-value value. Despite that, the following pairs are still almost significant or significant after the Bonferroni adjustment:

- Almost significant after Bonferroni: `SE` and `Val` , `SENVB` and `Val` , `SE` and `Intrin`

- Still significant after Bonferroni: `SE` and `SENVB`, `SENVB` and `NB`

These results show and emphasize the importance of constructs such as self-efficacy (`SE` and `SENVB`) and self-perceived nonverbal behaviors (`NB`), intrinsic motivation (`Intrin`) as well as the value teachers find in these constructs (`Val`). In particular, the correlations show the connection between these more general teaching constructs (`SE` and motivation constructs `Intrin`, `Ext`, `EffAsp`) to the specific constructs relative to this study that measure various aspects of teachers' immediacy and nonverbal behaviors (`Val`, `Confid`, `SENVB`, `NB`). As described in Chapter 6, expectancy and value constructs have an effect on learning and performance, by affecting motivation, which then directly leads to goal-directed behaviors that support learning and performance and ultimately lead to behavior change. Thus, the correlations and significant findings in this section show promise towards a path that leads to behavior change for teachers' practices in the classroom.

I must also mention that in this study, some of the questionnaires such as the confidence and motivational constructs questionnaires were single questions which lead to discrete values in teachers' answers. Despite that, as described in this section, there are some strong correlations among different variables, which in the majority of the cases are statistically significant. To note is that the Introjected and Amotivation constructs were weakly and non-significantly correlated with the other variables. For this reason, I will remove those two constructs for the following analysis.

Bucketing Instructors By Role

I was interested to investigate if there were any differences between the teaching faculty and other faculty who took part in the current study. For this reason, I bucketed instructors in two two categories as shown in Table 8.3, those who were teaching faculty (4 instructors) and those who were not (12 instructors). Each of the rows in the table represents the values of the variables listed on the left. In addition, for each variable, the table shows the average value together with the 95% confidence interval shown in parenthesis `( )`.

To begin with, I must note that teaching faculty were in the minority in this bucketing, a third in numbers compared to the other faculty. Despite the smaller number, teaching faculty consistently scored higher on averages compared to other faculty, with the exception of external regulation, where the other faculty scored higher. These results hint in the direction that teaching faculty score higher than other faculty in variables such as value and confidence in immediacy and nonverbal behaviors, as well as their efficacy and intrinsic motivational constructs.

In Figure 8-16 I share the box plots of the two populations. Note that both external regulation and efforts and aspirations are two distinct populations. In addition, intrinsic motivation, with the exception of the outliers, also shows two distinct populations that are not overlapping. Lastly, confidence and general self-efficacy show a little overlap but overall the populations seem quite distinct from. These findings again hint in the direction of teaching faculty having higher confidence, self-efficacy, intrinsic motivation and efficacy and aspirations and lower extrinsic motivation compared to other faculty. This is understandable as for teaching faculty, unlike for other faculty, teaching is the primary focus of their job.

Bucketing Instructors By General Self-Efficacy

Another aspect of the data I was interested in investigating was differences between teachers in high self-efficacy versus those in medium self-efficacy. In the correlations described above, SE

Table 8.3: Bucketing Instructors By Role

	Teaching Faculty	**Others**
Count	4	12
Value	5.58 (3.58 7.59)	5.28 (4.84 5.72)
Confidence	3.5 (2.58 4.42)	3 (2.46 3.54)
SE	6.98 (5.36 8.6)	6.27 (5.67 6.87)
SE for NVB	6 (3.75 8.25)	5.88 (4.84 6.91)
NB	85.75 (71.79 99.71)	84.75 (81.02 88.48)
Intrinsic Motivation	4.75 (3.95 5.55)	4.25 (3.88 4.62)
External Regulation	1.5 (0.58 2.42)	3.08 (2.09 4.08)
Effort and Aspirations	6.5 (5.44 7.56)	5.48 (5.06 5.91)

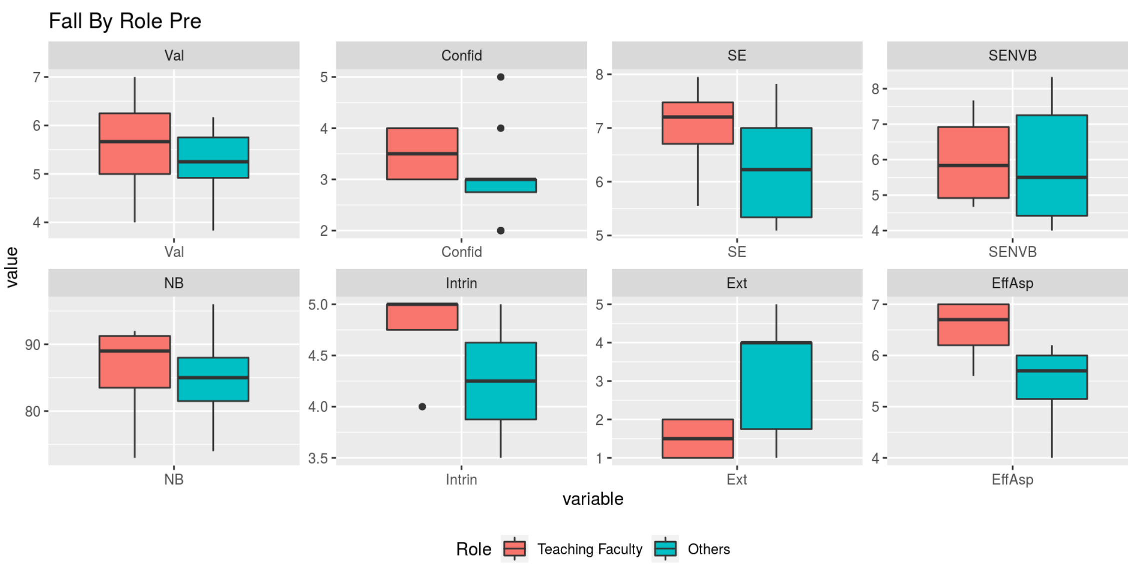


Figure 8-16: Box plots of two populations: teaching faculty and other faculty.

seemed to be strongly and significantly correlated with most of the other variables. Literature also strongly support SE as an important construct for motivation, goal-setting and behavior change, as described in Chapter 6 of this thesis. These reasons led me to conduct the current analysis. As described previously, I split the 1-9 SE scale, from "Not at all" to "A great deal" into three buckets low [1, 3.66], mid [3.67, 6.33] and high [6.34, 9] SE and the participants fell into the mid and high buckets (8 instructors in each). SE is uniformly distributed which makes it a good variable for bucketing as I do in this analysis. In Table 8.4 I share how on average the instructors in each of those buckets performed in relation to the various variables. In addition, I include in the table the difference of the means, together with the 95% confidence interval (shown in parenthesis `( )`).

The high-SE group consistently scores higher compared to the mid-SE group, with the exception of external regulation where the medium SE group scores higher. Overall, the high-SE group scores better in terms of their confidence, self-efficacy for immediacy and nonverbal behaviors, as well as their intrinsic motivation and their efforts and aspirations. Along the same lines, this group performs lower in external regulation. This result is consistent with the prior findings in the correlation matrices section. In Figure 8-17 I share the box plots of the two populations,

Table 8.4: Bucketing Instructors By General Self-Efficacy

	Medium SE [3.67-6.33]	High SE [6.34-9]
Count	8	8
Value	4.73 (4.26 5.2)	5.98 (5.55 6.41)
Confidence	2.75 (2.16 3.34)	3.5 (2.87 4.13)
SE	5.58 (5.22 5.95)	7.31 (6.96 7.65)
SE for NVB	4.71 (4.16 5.25)	7.11 (6.14 8.08)
NB	82.38 (78.58 86.17)	87.62 (81.65 93.6)
Intrinsic Motivation	4 (3.55 4.45)	4.75 (4.43 5.07)
External Regulation	3.75 (2.78 4.72)	1.62 (0.74 2.51)
Effort and Aspirations	5.25 (4.65 5.85)	6.22 (5.78 6.67)

mid-SE and high-SE. All the box plots and the populations of mid-SE and high-SE are distinct from each other and non-overlapping. These findings again support the prior findings that a high SE translates into a higher score on all the other variables.

These results again show the importance of the SE construct and how the two groups split based on SE only (high- and mid-SE) are scoring in terms of the variables of interest. Iterating on the argument from Chapter 6, self-efficacy is an important construct that affect motivation, goal-setting and ultimately leads to behavior change.

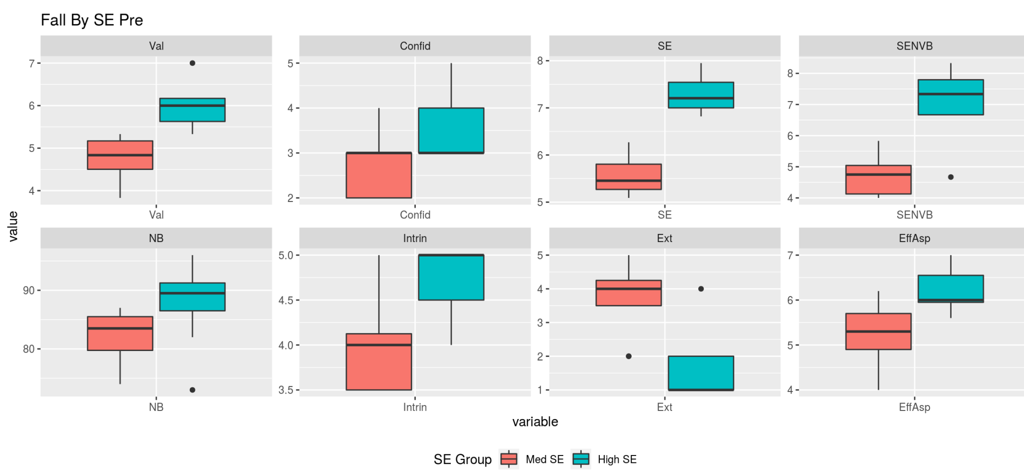


Figure 8-17: Box plots of two populations: medium SE and high SE.

8.4.3 Statistical Analysis of Pre vs Post-Questionnaires

In this section, I will analyze, investigate and discuss changes from the pre to the post-questionniare. Note that only 15 out of the 16 participants who took the pre-questionnaire also took the post-questionnaire. One participant took the pre-questionnaire and interview, and started the post-questionnaire, but only completed a handful of questions. As a result, the analysis of the post and pre to post data in this section are based on the 15 participants who completed all the stages of the study.

In the Table 8.5 I show per participant, the stages they completed and they did not complete, as well as the condition they were randomly assigned to. In the post-questionnaire, there were 7

Table 8.5: Participant completion of experiment stages as well as condition in the study.

Participant ID	**Condition**	**Pre-Q?**	**Interview?**	**Post-Q?**
63	Social Comparison	Yes	Yes	Yes
21	Social Comparison	Yes	Yes	Yes
88	Social Comparison	Yes	Yes	Yes
89	Social Comparison	Yes	Yes	Yes
11	Social Comparison	Yes	Yes	Yes
19	Social Comparison	Yes	Yes	Yes
92	Social Comparison	Yes	Yes	Yes
24	Social Comparison	Yes	Yes	Yes
40	Verbal Persuasion	Yes	Yes	Yes
75	Verbal Persuasion	Yes	Yes	Yes
15	Verbal Persuasion	Yes	Yes	Yes
43	Verbal Persuasion	Yes	Yes	Yes
35	Verbal Persuasion	Yes	Yes	Yes
20	Verbal Persuasion	Yes	Yes	Yes
56	Verbal Persuasion	Yes	Yes	Yes
14	Verbal Persuasion	Yes	Yes	Only a handful of questions

participants from the verbal persuasion condition and 8 participants from the social comparison condition.

Overall Pre vs Post Data Analysis

In Table 8.6 I share the mean score per variable in the pre and post-questionnaires. The scores are over the 15 participants who completed both questionnaires (the one participant who only completed the pre-questionnaire and the interview in the study but did not complete the post-questionnaire is not included in this analysis). Another way of showing the mean scores per variable from pre to post is shown in a bar chart visualization in Figure 8-18(b). Table 8.6 also shares the statistical significance of the difference between pre and post as well as the significance after a Bonferroni adjustment (for 8 comparisons).

There is no statistical difference between the various variable means in pre and post, with the exception of SENVB (`p=0.009**`), which after a Bonferroni adjustment (for 8 comparisons) is almost significant. Similarly, looking at the box plots (Figure 8-18(a)) the populations of pre and post are quite overlapping with not much distinction between them. These results make sense as constructs such as SE and Motivation are too large and broad constructs related to general teaching thus hard to change significantly through a single study, which was not focused on general teaching rather on a sub-aspect of it, namely immediacy and nonverbal behaviors. By the same argument, the construct of SENVB, which is related directly to the study, increased significantly (and almost significantly after a Bonferroni adjustment) from pre to post. This is important as it hints in the direction that showing teachers PD together with their own data in relation to immediacy and nonverbal behaviors could help increase instructors' self-efficacy in relation to those behaviors.

Table 8.6: Pre vs Post changes in all the variables

	Pre	**Post**	**Difference**	**Bonferroni: p<0.00625**
Value	5.45	5.51	0.07 [p=0.742]	–
Confidence	3.07	3.4	0.33 [p=0.055]	–
SE	6.5	6.49	-0.01 [p=0.942]	–
SE for NVB	5.97	6.7	0.73 [**p=0.009****]	almost significant
NB	84.87	83.47	-1.4 [p=0.294]	–
Intrinsic Motivation	4.4	4.27	-0.13 [p=0.217]	–
External Regulation	2.73	2.93	0.2 [p=0.531]	–
Effort and Aspirations	5.75	5.73	-0.01 [p=0.922]	–

In addition, there is a slight decrease in NB. Even though not significant, an explanation for this could be that instructors saw through their data in the study that they were not doing well in terms of their proxemics and oculesics. As a result, their self-perception of how much they use those behaviors also changed. Surprisingly, the value teachers see in immediacy and nonverbal behaviors did not change from pre to post, which could mean that the study materials (PD and data) need to do a better job at conveying and convincing the teachers of the value of such constructs.

Pre vs Post Data Analysis Per Condition

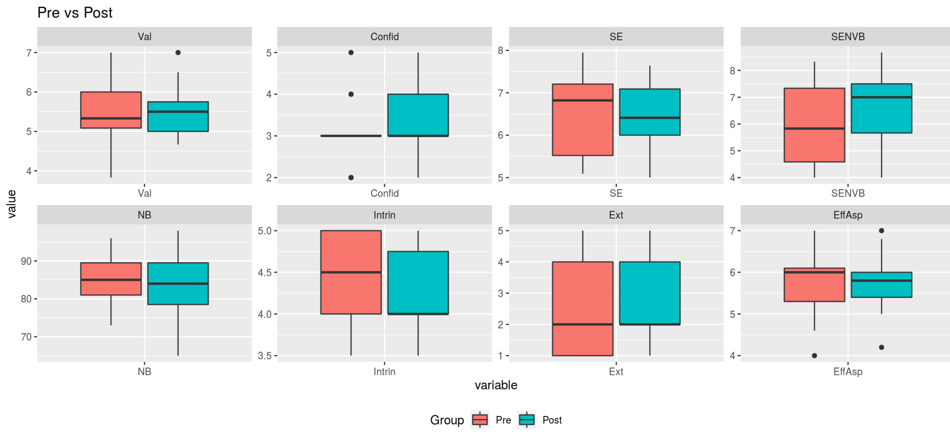
In addition, I analyzed if the two conditions in the study, social comparison and verbal persuasion, had an effect on changing teachers' scores on various variables.

The box plots of pre and post for both conditions (Figure 8-19(a)) show that the populations are quite overlapping and non-distinct. Looking at the bar chart comparisons (Figure 8-19(b)), there are some interesting trends to be noted per condition. For example, confidence and self-efficacy for nonverbal behaviors have an increase from pre to post for both conditions. Similarly, the self-reported nonverbal behaviors (NB) and the intrinsic motivation have a slight decrease from pre to post per condition. Finally, the difference from pre to post across the two conditions (Figure 8-19(c)) showed that the populations are not distinct and are overlapping.

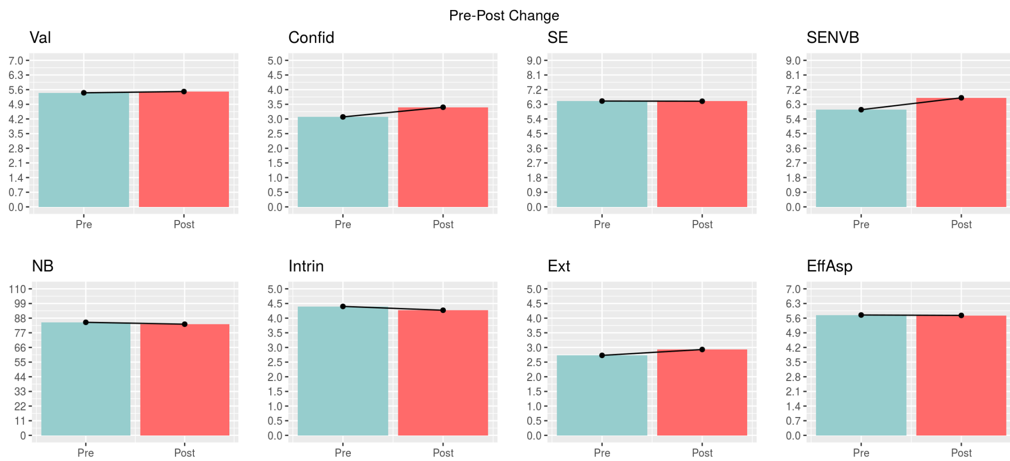
There might be a few reasons for these findings. First, the small sample size per condition (7 and 8 participants in each condition) is a big factor where even one outlier can skew the direction of the whole sample in one way or another. Second, teachers saw PD and data only once which might not be as effective as receiving this kind of PD many times, over multiple weeks. Lastly, there could be a need to iterate on and strengthen the study materials to make them more motivating for the instructors and to, in particular, strengthen the intervention per each condition while differentiating it as much as possible from the other condition. For example, in the social comparison group, I could remove the paragraph of text which provides some level of "verbal" encouragement, in order to make the conditions further different from each other.

Pre vs Post Data Analysis Per SE Bucketing

Lastly, I analyzed changes pre to post in the mid-SE and high-SE groups. As a reminder, for SE, I split the 1-9 scale, from "Not at all" to "A great deal" into three buckets low [1,3.66],



(a) Box plots of pre and post scores per variable.



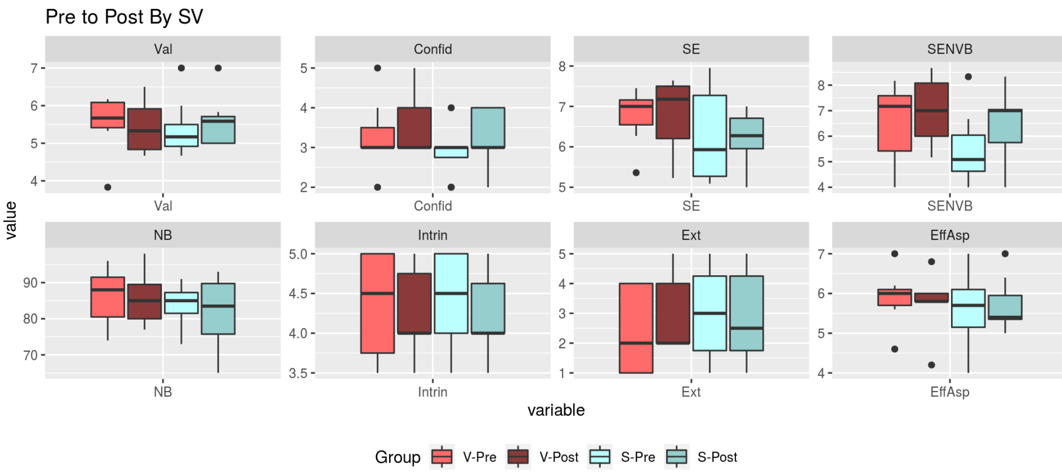
(b) Bar charts of the pre and post scores.

Figure 8-18: Pre and Post comparisons per variable

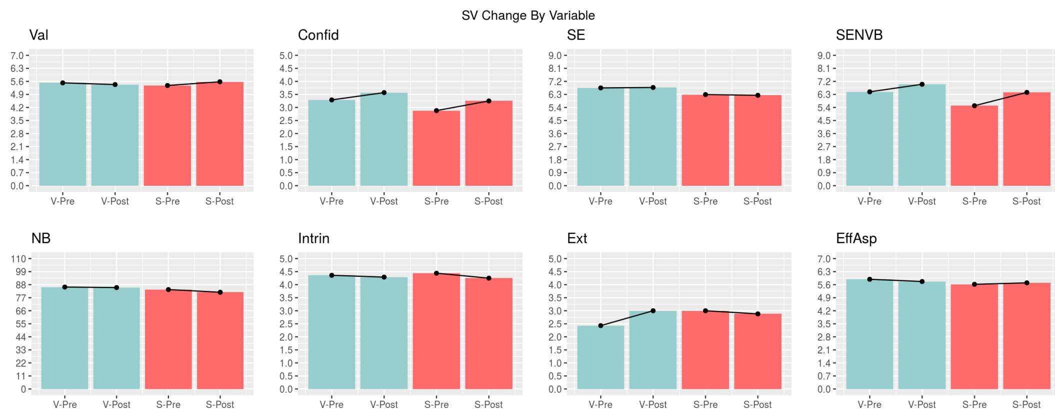
mid [3.67, 6.33] and high [6.34, 9]. The participants based on their pre-questionnaire score fell into the mid and high buckets, respectively 8 teachers in the mid-SE and 8 teachers in high-SE bucket.

For the mid-SE group, there were 8 participants in the pre-questionnaire however 1 participant did not complete the post-questionnaire. As a result, the following analyses are based only on the 7 participants who completed both pre and post. Overall, the 7 participants in the mid-SE group increased their mean scores from pre to post, with the exception of the self-reported nonverbal behaviors (NB) and external regulation, which had a slight decrease (Table 8.7). The changes of the mid-SE group from pre to post can also be seen visually in the bar charts in Figure 8-20(b). Looking at the box plots of the mid-SE group from pre to post in Figure 8-20(a), in addition to SE for NVB, the box plots for confidence, SE, external regulation and effort and aspirations are also distinct and non-overlapping populations.

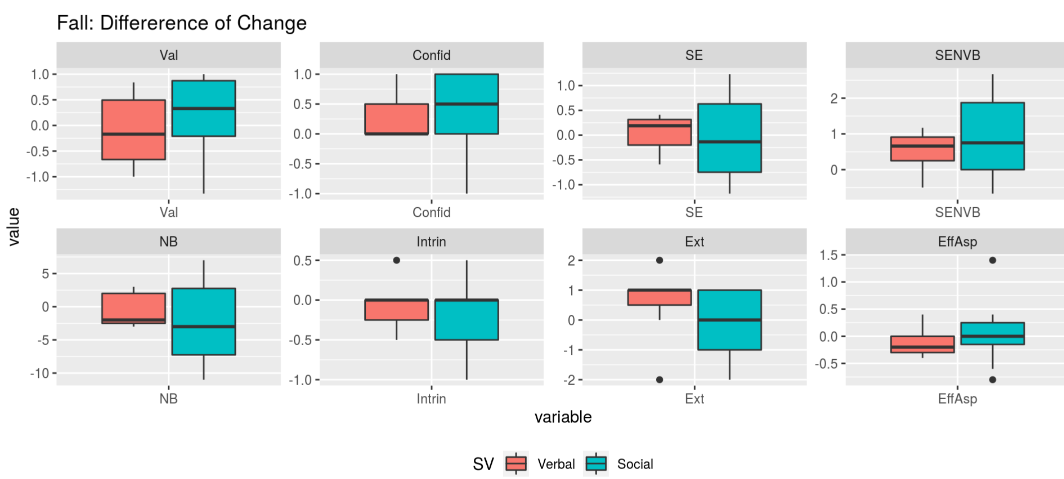
Regarding the high-SE group, the 8 participants had both increases and decreases in their scores from pre to post. Those changes overall were smaller than the changes of the mid-SE group, as also seen in Figure 8-20(b). Looking at the box plots of the high-SE group from pre to post in



(a) Box plots of the populations in S and V in pre and post.



(b) Bar chart of the values in pre and post of each condition.



(c) Box plots of the difference from pre to post per condition.

Figure 8-19: Comparing across conditions.

Table 8.7: Comparing changes pre to post for the mid-SE group

	Pre	**Post**
Count	7	7
Value	4.83 (4.36 5.31)	5.19 (4.75 5.63)
Confidence	2.57 (2.08 3.07)	3 (2.47 3.53)
SE	5.59 (5.15 6.02)	5.87 (5.29 6.45)
SE for NVB	4.67 (4.03 5.31)	6.1 (5.21 6.98)
NB	81.71 (77.59 85.84)	81.29 (74.15 88.42)
Intrinsic Motivation	4 (3.47 4.53)	4 (3.54 4.46)
External Regulation	4 (3.08 4.92)	3.71 (2.44 4.99)
Effort and Aspirations	5.2 (4.49 5.91)	5.37 (4.74 6)

Table 8.8: Comparing changes pre to post for the high-SE group

	Pre	**Post**
Count	8	8
Value	5.98 (5.55 6.41)	5.79 (5.17 6.41)
Confidence	3.5 (2.87 4.13)	3.75 (3.16 4.34)
SE	7.31 (6.96 7.65)	7.04 (6.61 7.46)
SE for NVB	7.11 (6.14 8.08)	7.23 (5.98 8.48)
NB	87.62 (81.65 93.6)	85.38 (76.96 93.79)
Intrinsic Motivation	4.75 (4.43 5.07)	4.5 (4.11 4.89)
External Regulation	1.62 (0.74 2.51)	2.25 (1.28 3.22)
Effort and Aspirations	6.22 (5.78 6.67)	6.05 (5.56 6.54)

Figure 8-20(a) only SE for NVB shows relatively distinct and non-overlapping populations.

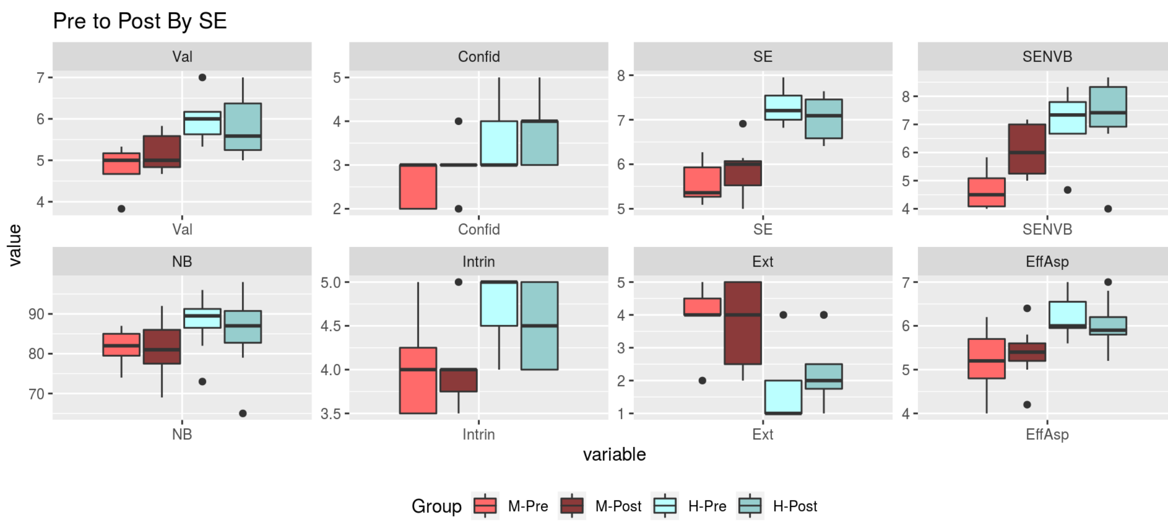
A more detailed view of the changes from pre to post compared against the mid-SE and high-SE groups is shown in Table 8.9. From the difference, it can be seen that the mid-SE group changed more from pre to post, than the high-SE group.

8.4.4 General Analysis of the Post-Questionnaire

In this section, I will cover a more general discussion and analysis of the teachers' performance in the post-questionnaires. For a more detailed discussion on changes pre to post per condition or per SE bucketing, please see the previous section on **Analysis and Discussion of Pre vs Post Questionnaires.**

Table 8.9: Comparing changes pre to post for the mid-SE vs the high-SE group

	Mid-SE changes	**High-SE changes**
Count	7	8
Value	0.36	-0.19
Confidence	0.43	0.25
SE	0.28	-0.27
SE for NVB	1.43	0.12
NB	-0.43	-2.25
Intrinsic Motivation	0	-0.25
External Regulation	-0.29	0.62
Effort and Aspirations	0.17	-0.18



(a) Box plots of the mid and high SE populations in pre and post.

(b) Bar chart of the mid and high SE in pre and post.

Figure 8-20: Comparing across the mid and high SE groups.

Teachers' learning from the PD materials and data presented in the dashboard

Before starting the analysis of this part, I would like to mention that the post-questionnaire question measuring self-reported learning from the dashboard module, due to a typo, was missing score "6" on a scale from 0-10 (thus the scale jumped from "5" to "7"). Despite that, the following analysis is done with the full scale.

Overall, teachers self-perceived they learned from taking part in this study where they were able to see PD materials in relation to immediacy and nonverbal behaviors as well as see their own proxemics nonverbal behavior data in the classroom. As shown in Figure 8-21(a), overall teachers said they learned on average 6.93 (on a scale 0-10), with the average learning from seeing the dashboard and their own data (7.53) being much higher than the average learning from PD (6.33). This difference suggests that teachers find both PD and data helpful to increase their knowledge and learning, but they self-perceive they learn much more from seeing their own data and the dashboard module. These results are consistent with the Chapter 7 ones where

Table 8.10: Comparing changes in learning across conditions.

	Verbal	**Social**
Count	7	8
Overall Learning	6 (4.4 7.6)	7.75 (6.39 9.11)
Learning from PD	5.71 (4.14 7.29)	6.88 (5.3 8.45)
Learning from Dashboard	6.29 (4.46 8.11)	8.62 (7.22 10.03)

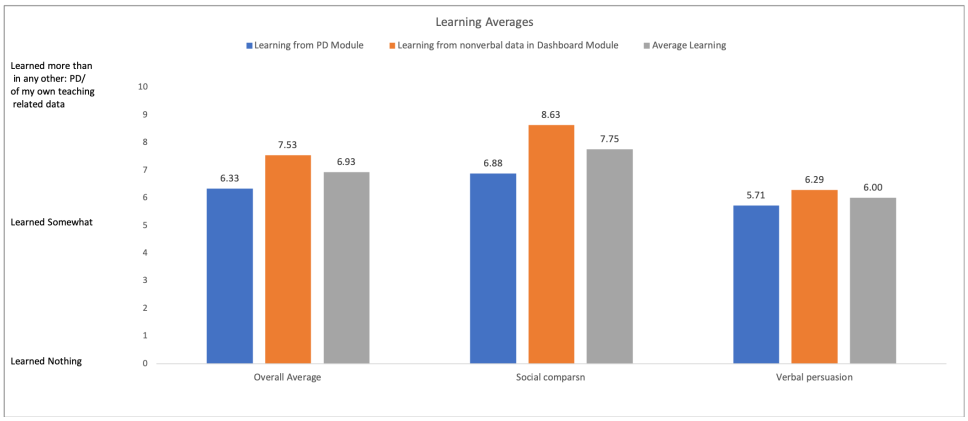
teachers self-perceived they learned more from seeing the dashboard and the data compared to when they saw the PD. However, for the Fall study, the overall average learning as well as learning from seeing their own data is higher than the respective averages from the Chapter 7 study (average 6.9 on learning from data and 6.6 on overall learning). This could be explained with the fact that the majority of the participants in the Chapter 7 study were teaching faculty who had more and broader experience with various professional development and training in relation to teaching. On the other hand over the fall, most of the participants were tenure faculty, who had fewer such experiences, thus overall learning more from this study.

In the same Figure, in terms of conditions the social comparison group scores much higher on average than the verbal persuasion group. In particular, the social comparison group scores quite high (average 8.63) in terms of learning from seeing their own data and the dashboard. They score slightly lower on learning from PD, however those averages are higher than what the verbal persuasion group scores on. In Table 8.10 I compare the differences between conditions on the overall learning, as well as learning from the PD module and learning from the dashboard module.

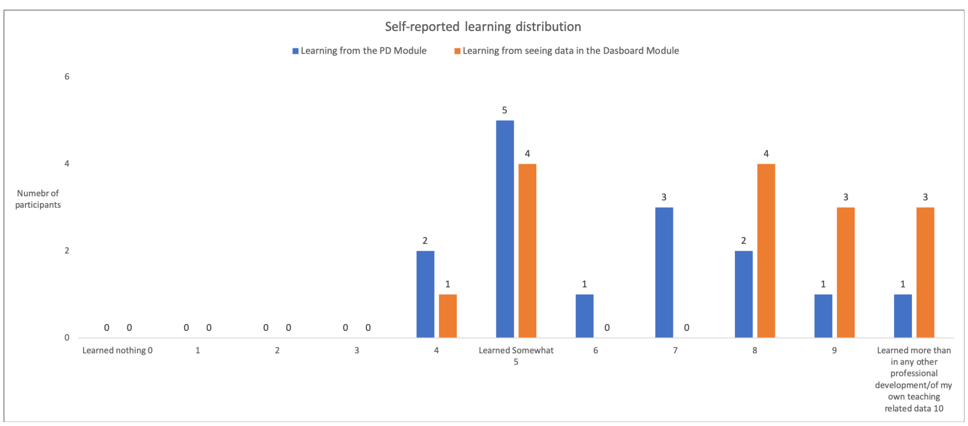
Taking a look at the box plots of the verbal persuasion and social comparison conditions in Figure 8-22, the box plots for learning from the dashboard (title: LearnDash) are distinct and non-overlapping. Similarly, the box plots for overall learning (title: Learn) are almost non-overlapping. This shows that the social comparison group perceived they learned more in the study, in particular in relation to seeing their data and the dashboard. These higher results for the social comparison group hint in the direction that seeing their own data perform better compared to other instructors helps instructors report learning more both from the study overall and the data specifically. Similarly, receiving a paragraph of text with persuasive and encouraging words (in the verbal persuasion condition) does not seem to help increase teachers' self-reported learning.

Taking a look at the distribution of teachers' answers (Figure 8-21(b)), only some of the teachers (4 out of 15) replied with a score of 8 or above to learning from the PD module, while the majority of them (10 out of 15) replied with a score of 8 or above to learning from the data and dashboard module. In fact, 1 instructor self reported that from the PD module in the study they "*Learned more than in any other professional development*" and 3 instructors self-reported that from seeing their own data in the Dashboard module "*Learned more than in any other of my own teaching related data*". Again, the higher self-reported learning score on the data and dashboard shows that teachers self-perceive they learned much more form the data than the PD on its own. This hints in the direction that seeing data on their performance is absolutely necessary for teachers, and PD is a nice addition, but not what drives their self-perceived learning.

Along the same line of reasoning, the teachers who scored slightly lower on their self-perceived learning of PD, maybe had other PD or training in their lifetime, not related to immediacy and nonverbal behaviors, that was very useful to them. That does not mean they did not learn from the PD in this study, rather their learning compared to their prior experience was one way or another. Similarly, maybe they received other data, even from the Eberly center for example, that they learned more than the subset of their nonverbal behavior data shown in this study. Again, that does not mean they did not learn from their own data, but that their self-perceived learning was respective to their prior experience on this matter. In summary, based on the results in this section, it seems that teachers self-report high levels of learning both from the PD module as well as the data and dashboard they saw in ClassInSight.



(a) Self-reported learning averages overall and per condition.



(b) Distribution of participants' answers to the self-reported learning prompt.

Figure 8-21: Self-reported learning in the post-questionnaire.

Teachers' attitudes from the PD materials and data presented in the dashboard

In this section I will analyze teachers' attitudes in various dimensions. Note that the attitude questionnaire, with the exception of the likelihood questions, had two subscales per question ranging from negative to positive and vice versa. For the analysis, I reversed them so that all subscales worked from negative to positive including Good/Bad, Valuable/Worthless, Fair/Unfair, Likely/Unlikely, etc. The likelihood questions on a scale from 1-7 for this analysis will represents from Unlikely (1) to Likely (7).

In Figure 8-23 I calculate the average attitudes for each of the questions in the attitude questionnaire. I also present an overall average across all the attitude questions. Overall, teachers

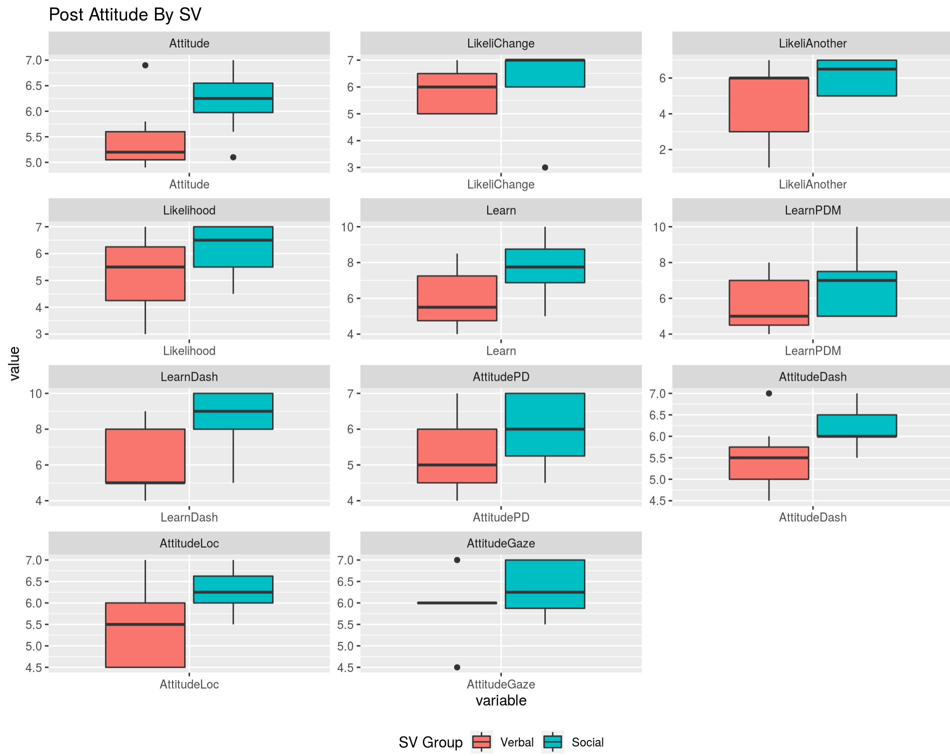


Figure 8-22: Box plots of learning and attitudes per condition.

scored quite high in relation to their attitudes (average of 5.85 out of 7.00). Even though slightly less than the Chapter 7 average, this average shows that instructors in this study have positive attitudes towards the PD module and data they saw in this study. In addition, teachers scored the highest in their attitude about their oculesics (gaze) nonverbal behavior data (average 6.13) followed by their attitude about their proxemics (location) data (average 5.90). Again, this shows that teachers have a generally more positive attitude towards eye contact related data than to location related data. This might be because for location, the restrictions of the physical classrooms can pose challenges for them to use their proxemics effectively. Lastly, teachers have a higher average attitude about the dashboard module (average 5.87) compared to their attitude about the PD module (average 5.63). As seen in the self-reported learning section as well, teachers have a more positive attitude towards seeing their data, and prefer that over seeing the PD materials.

Teachers score quite high in their likelihood to engage in the behaviors recommended in the PD (average 6.07), showing that the PD module in the study incentivized teachers to attempt and engage in the recommended behaviors. Their likelihood to enroll in another PD module of related content, provided they had the choice and their schedule permitted it, was much lower (average 5.40). This might be explained by the fact that the majority of the instructors in this sample were tenure faculty, and they do not necessarily have the time or the priority for teaching and professional development in relation to teaching.

In relation to the two conditions in the study, overall, on average the social comparison condition scores much higher than the verbal persuasion condition (averages of 6.19 and 5.47 respectively). In addition, in all the questions in this questionnaire, the social comparison group scores higher

Table 8.11: Comparing changes in attitudes across conditions.

	Verbal	**Social**
Count	7	8
Overall Attitude	5.47 (4.83 6.12)	6.19 (5.68 6.69)
Attitude about PD	5.29 (4.22 6.35)	5.94 (5.06 6.82)
Attitude about Dashboard	5.5 (4.74 6.26)	6.19 (5.8 6.57)
Attitude about Location	5.43 (4.53 6.33)	6.31 (5.87 6.76)
Attitude about Gaze	5.93 (5.25 6.61)	6.31 (5.77 6.86)
Likelihood to engage in behaviors	5.86 (5.03 6.69)	6.25 (5.09 7.41)
Likelihood to enroll in another PD	4.57 (2.45 6.7)	6.12 (5.3 6.95)
Overall Likelihood	5.21 (3.83 6.6)	6.19 (5.38 6.99)

than the verbal persuasion group. This difference is the highest in the teachers' likelihood of enrolling in another PD of related content (average for social group is 6.13 while for the verbal group is 4.57). This could mean that seeing their data perform better when compared against other instructors (the social comparison group) provides a more positive attitude for instructors overall than seeing only a paragraph of motivating text as feedback (verbal persuasion group). In particular, it makes them more likely to enroll in PD of similar content.

In Table 8.11 I compared the averages per condition. Looking at the box plots of those two populations in relation to attitude in Figure 8-22 the overall attitude (title: Attitude) shows two distinct and non overlapping populations. Similarly, the attitudes towards the dashboard and the location data (titles: AttitudeDash and AttitudeLoc) are also non overlapping and distinct. Lastly, the likelihood box plots, both the individual and the average one, are slightly overlapping. To note is that provided the small sample size in those comparisons, outliers have a strong effect in pulling the population one way or another.

In summary, overall teachers had high and positive attitudes in relation to the dashboard and PD modules. Similarly, they had positive attitudes towards gaze data as well as location data. In terms of likelihood, they scored quite high in their likelihood to attempt and engage in the suggested behaviors, which is positive and a proxie for behavior change. Overall, the social comparison scored consistently higher than the verbal persuasion group. The populations are quite distinct and non-overlapping in many cases, as described above.

Confidence in immediacy and nonverbal behaviors

In the post questionnaire, almost all the teachers (14 out of 15) assessed their confidence in their immediacy and nonverbal behaviors distributed between "Moderately Confident" (8 teachers), "Very Confident" (5 teachers) and "Extremely Confident" (1 teacher), while only 1 teacher assessed it as "Slightly confident" (Figure 8-24(a)). The weighted average of teachers' self-reported confidence in the post-questionnaire was 3.40 which, even though lower than the Chapter 7 weighted average (3.71), it is still quite high. Comparing it to the pre-questionnaire in Figure 8-24(a) (only the 15 participants who completed both pre and post shown here), teachers' confidence has increased from pre to post (with the weighted averages from 3.07 to 3.40 respectively). Similarly, as it can be seen in Figure 8-24(a), the distribution has shifted towards the "Very" and "Extremely" confident spectrum of the scale.

In relation to the condition (Figure 8-24(b))), the verbal persuasion group had a slightly higher

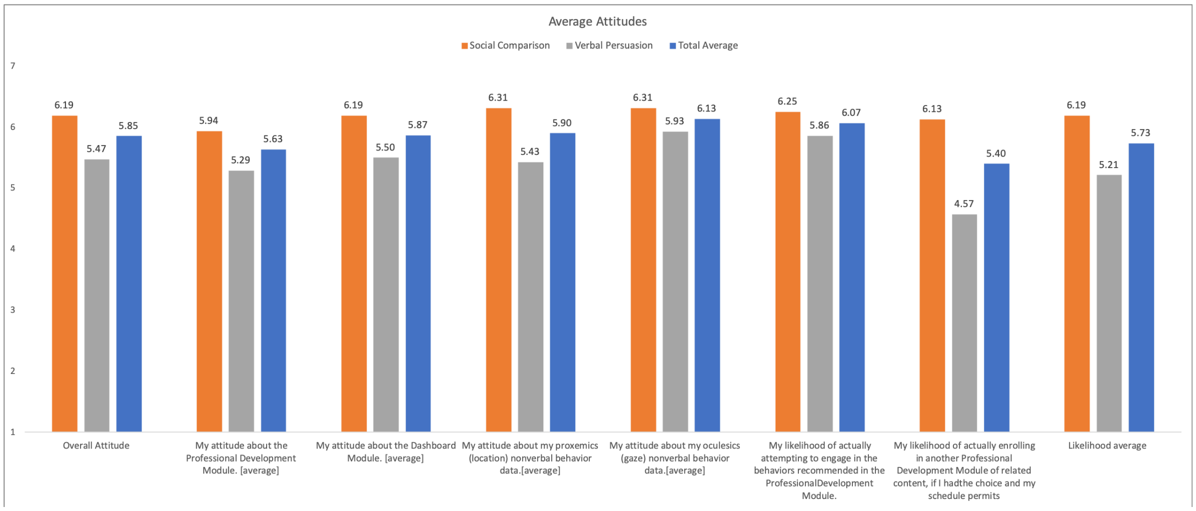


Figure 8-23: Average attitude per question and overall.

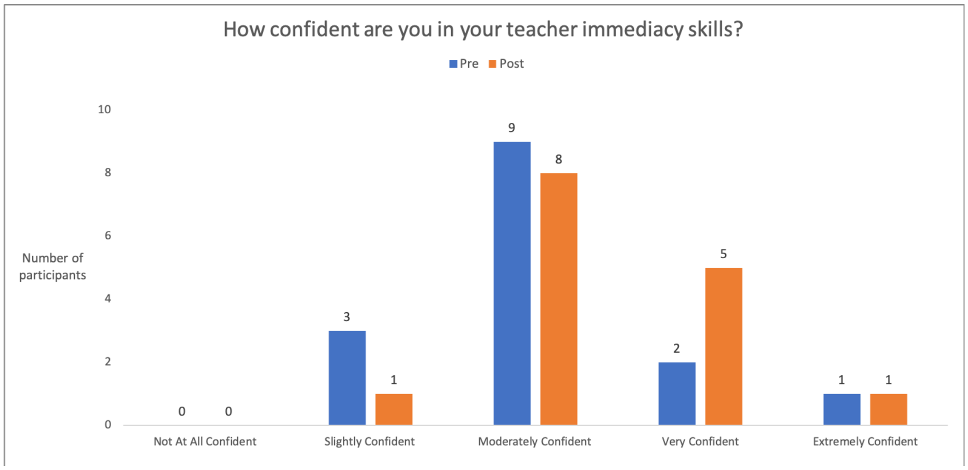
average (3.29) in the pre-questionnaire compared to the social comparison group (2.88). However, in the post-questionnaire, both groups increase their score almost the same, with the verbal persuasion group reaching an average of 3.57, slightly higher than that of the social comparison group (average 3.25). Again, those averages are based only on the 15 participants who completed both questionnaires. These results show that the social comparison group had the highest increase in confidence in pre-to-post compared to the verbal persuasion group, even though both groups increased. The higher increase in the social comparison group could indicate that seeing their data perform better compared to other instructors at CMU increased teachers' confidence in their own immediacy skills.

Behavior Change Intentionality

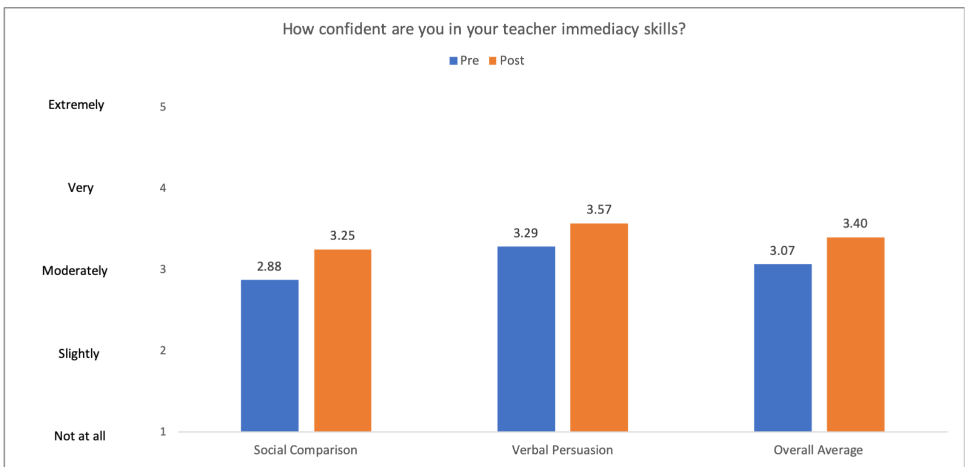
In the post-questionnaire, the majority of teachers (9 out of 15) said that they had specific immediacy and nonverbal behaviors they wanted to work and improve on, while 1 teacher said that they had already started trying to change their behavior after the study *ID24: "I have been trying to move around the room more and ask questions from different areas of the room since this study."* In addition, 3 teachers responded "No" to this question, 1 teacher responded it depends based external factors, while 1 teacher mentioned that everything could be improved on.

From the pre-questionnaire, 1 teacher who responded "No" changed their answer to "Already started trying to change their behavior after the study", while another teacher who said in pre they would change only if they found immediacy valuable, responded "Yes' to this question in the post-questionnaire. Similarly, one teacher who in pre mentioned they did not want to change any behaviors but were open to improvement, responded with "Yes" in this question and had specific behaviors they wanted to change. Only one teacher changed their answer from "yes" in pre to "No" in post. Overall, it seems that the study helped some teachers see and decide on behaviors they want to change, or find value in immediacy and nonverbal behaviors.

In relation to the behaviors that they were interested in working and improving on, teachers mention both proxemic and gaze related behaviors. This included: more eye contact with students (3), moving more (3), engaging the classroom more uniformly (3), in particular with



(a) Pre-post confidence distribution and weighted average.



(b) Pre-post confidence per participant and averages.

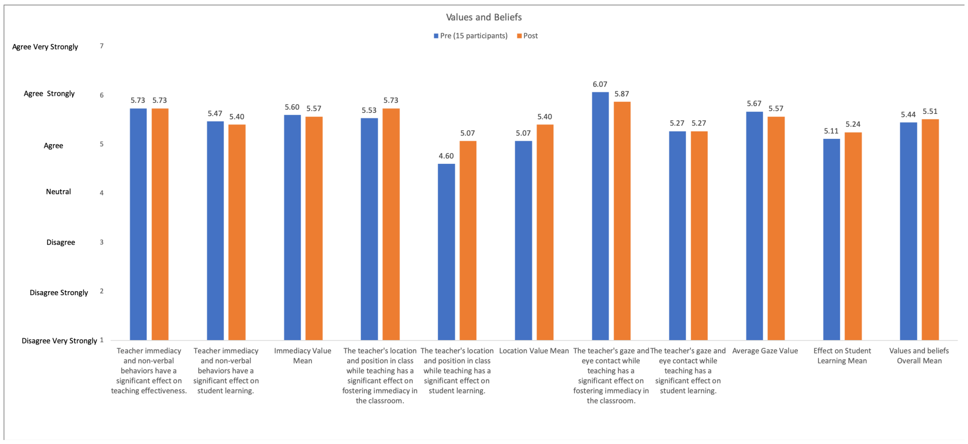
Figure 8-24: Teachers' self-reported confidence.

poses and facial expressions (1), using a clicker to spend less time behind podium (1), stand closer to students (2), better locate where students sit in class (1), and more generally work on their location and position in class (2) and gaze (1).

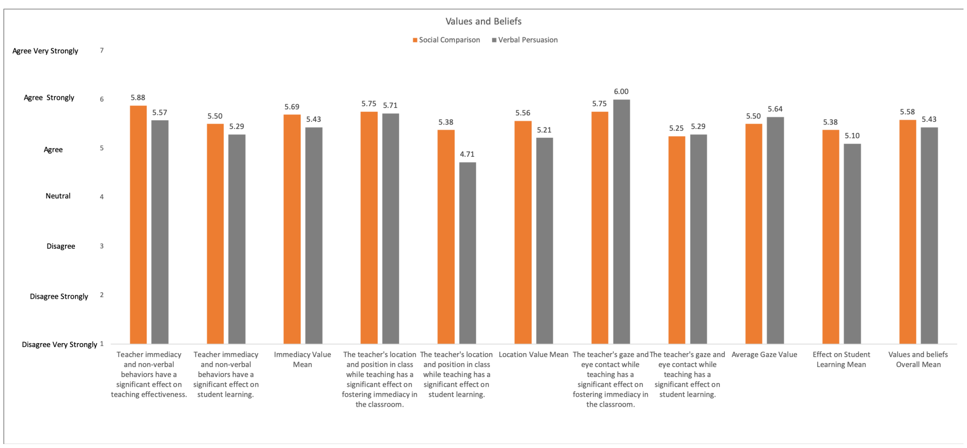
Values and Beliefs around Immediacy and Nonverbal Behaviors

In relation to the value and their beliefs around immediacy and nonverbal behaviors, teachers still score quite high in the post-questionnaire (average 5.51 out of 7 as shown in Figure 8-25(a)). The highest score in post is in relation to teachers' beliefs on gaze and eye contact having a significant effect on fostering immediacy in the classroom (average 5.87) followed by location and position having this effect (average 5.73). The value that teachers see in immediacy and nonverbal behaviors has not change from pre to post, but the average that these behaviors have an effect on student learning has increased slightly from pre (average 5.11) to post (average 5.24), even though the value is the lowest compared to all the other questions. This emphasizes that teachers see a value in immediacy and nonverbal behaviors, but they believe their effect on student learning is not that significant. As shown in Figure 8-25(a), there are slight increases and decreases as well as no changes from pre (15 participants) to post. Overall, there is an increase in values and beliefs from pre to post.

Taking a look at differences in post per condition (Figure 8-25(b)), overall and in most questions, the social comparison condition scores higher than the verbal persuasion condition. In terms of the value of gaze and eye contact on teaching and student learning, the verbal persuasion group scores the highest.



(a) Pre-post values and beliefs around immediacy and nonverbal behaviors.



(b) Pre-post values and beliefs per participant, on average as well as per condition.

Figure 8-25: Values and beliefs around immediacy and nonverbal behaviors.

General and task-specific Self-efficacy

In relation to SE, there was a slight decrease in the average SE score from pre (15 participants) to post as shown in Figure 8-26(a). This change was not statistically significant as described in the previous sections. Again, this is understandable as the SE questionnaire was measuring a larger, more general construct, that of SE in terms of teaching, which would be hard to change by the current study. On the other hand SE for nonverbal behaviors had a much higher change from pre (average 5.97) to post (6.70), which is statistically significant (p=0.009**) before a Bonferroni adjustment, and almost significant after it (for more details, please see Table 8.6 and the discussion above). This is positive and shows that the study helped increase teachers' self-efficacy in relation to their immediacy and nonverbal behaviors specifically. This result is normal and understandable provided that self-efficacy as a construct is very task specific [36]. As shown in Figure 8-26(a), the highest increase was in teachers' SE in relation to their gaze behaviors, while their SE in terms of location, even though it increased form pre-to post, it was the lowers out of all the other SE measures. Lastly, their SE for nonverbal behaviors and immediacy more in general increase from pre (average of 6.10) to post (average of 6.70). These results overall show that seeing PD as well as data on their immediacy and nonverbal behaviors did not affect much teachers' general SE, but significantly affect the SE for the nonverbal behaviors specifically.

In Figure 8-26(b) I present the differences pre to post per condition (including in pre only the 15 participants who also completed the post). As described in the above sections, the social comparison condition scores consistently lower than the verbal persuasion condition in the post-questionnaire. That might also be an effect of the social comparison group having a lower pre-questionnaire score, even though the conditions were randomly assigned to participants, and the comparison of the verbal and social pre scores in section **Pre vs Post Data Analysis Per Condition** above showed no statistical changes. Additionally, the social comparison condition had the highest increase from pre to post in terms of SE for NVB. The results hint in the direction that the social comparison intervention had the highest effect on increasing instructors' SE for NVB in relation to their teaching from pre to post. This is consistent with prior literature (i.e., [35]).

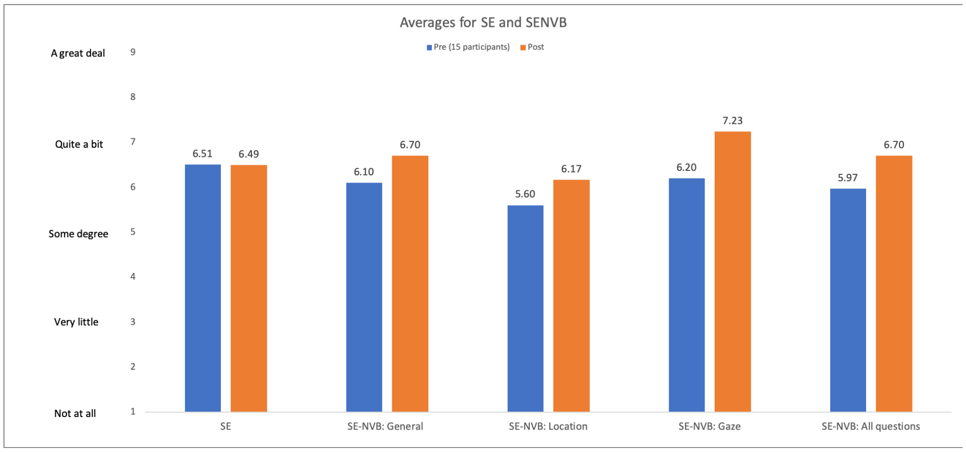
Self-reported nonverbal behaviors

In relation to their self-reported nonverbal behaviors, the overall average in the post-questionnaire is still high (83.47 in the range 58 - 98) as seen in Figure 7-22(a). There is a decrease from pre (84.87 over 15 participants) to post (83.47), which is not significant as described above. This result hints in the direction that seeing their own nonverbal behavior data in the study made teachers more aware of their performance, thus self-reporting lower and more accurate values for the nonverbal behaviors they use in the classroom. In relation to the two conditions in the study, the social comparison condition scores slightly lower than the verbal persuasion condition in the post-questionnaire, even though both groups had a decrease from pre to post.

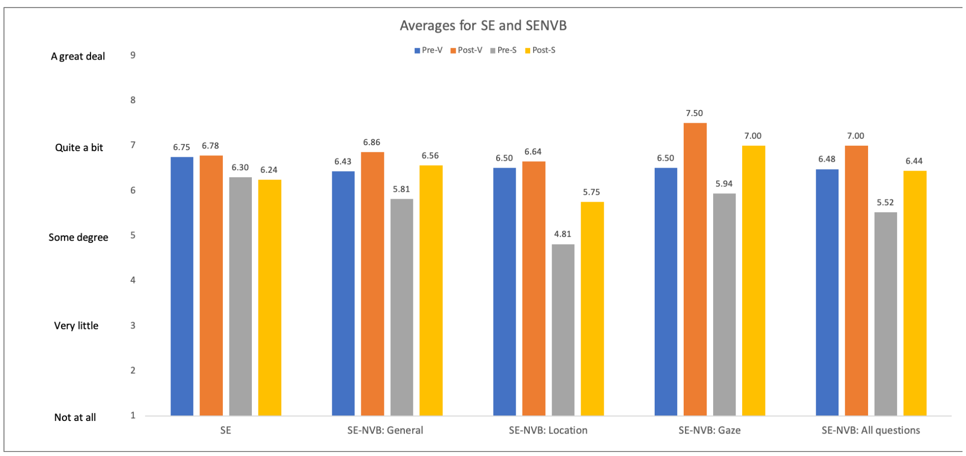
Motivation

When asked again in the post-questionnaire what motivates them in doing their best in the classes they are teaching this semester, instructors shared a variety of responses including student learning and improvement (5) and critical reasoning (1) in the course, subject matter and topics or materials covered in the course (4), sharing the knowledge (2). One instructor mentioned student engagement (1) and another instructor mentioned creating an open and friendly environment for the students (1). Other answers included doing things well and deriving gratification (2), enjoy teaching and students deserve it (2), ability to relate to students (1), become better at my job (1). To note is that those responses, similar to the pre-questionnaire, were quite different from the responses found in the Chapter 7 study in that they rarely connected or referred to constructs related to immediacy and nonverbal behaviors.

In Figure 8-28(a) I share teachers' average motivation in relation to teaching focusing on the intrinsic and external constructs. From pre (adjusted average over 15 participants) to post there have been slight changes to the motivation constructs: a slight decrease in intrinsic motivation, and a slight increase in external regulation. However, overall those changes are quite small and not significant, as described in the above sections. This is also supported by the fact that this motivation questionnaire measured and assessed teachers' general motivation for teaching, which would be challenging to change by much due to one study only. Overall, the average



(a) Average pre to post for SE and SENVB.



(b) Pre to post changes per condition in SE and SENVB.

Figure 8-26: Pre to Post SE and SENVB metrics.

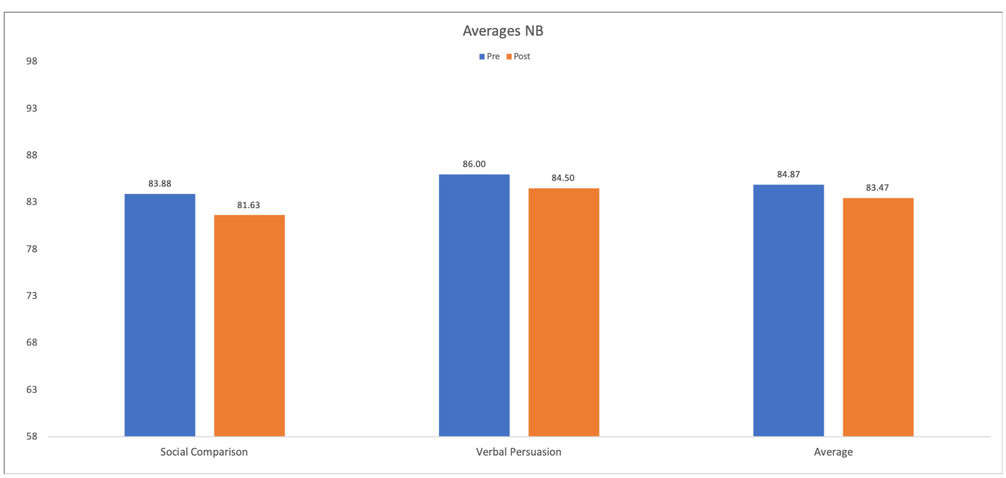
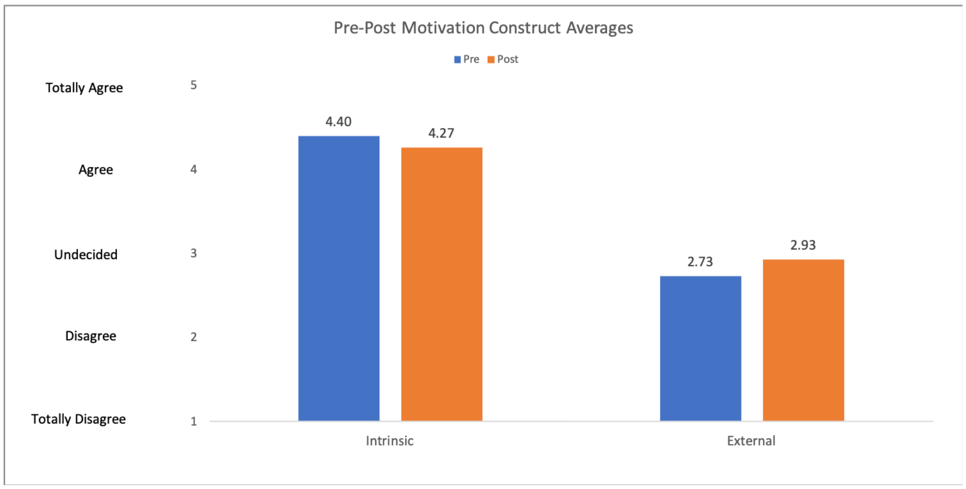
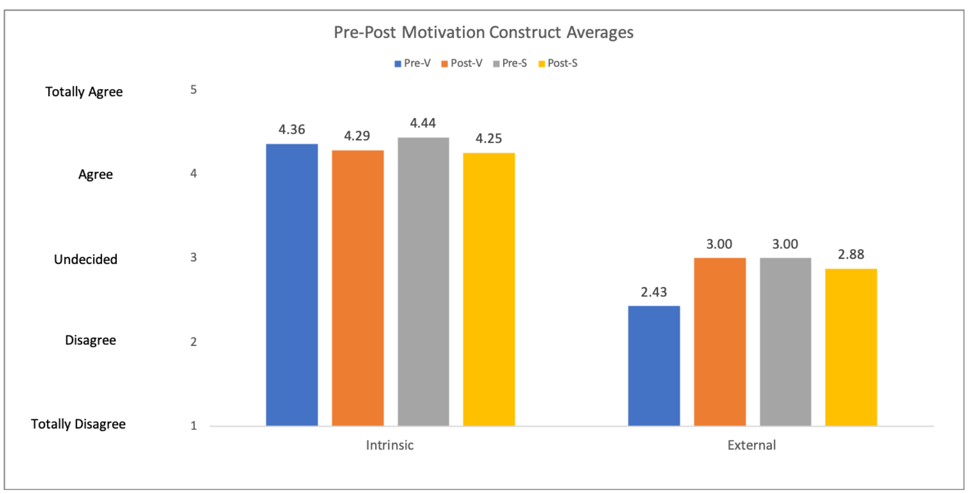


Figure 8-27: Average pre to post changes, and per condition, for self-reported nonverbal behaviors.

intrinsic motivation is quite high, scoring between "Agree" and "Totally Agree" on the scale, while external regulation scores lower, between "Undecided" and "Disagree". When looking at the changes pre (the adjusted averages over 15 participants) to post based on the experiment condition (Figure 8-28(b)), the social comparison group has a slight decrease in intrinsic motivation in the post-questionnaire while the verbal persuasion group does not change. In relation to their external regulation, the verbal persuasion group has quite an increase while the social comparison group has a slight decrease.



(a) Average motivation pre to post



(b) Average motivation per condition

Figure 8-28: Pre to Post motivation.

In terms of their planned effort and professional development aspirations, teachers scored quite high in the post-questionnaire with an average of 5.73 out of 7, between the "Moderately" and "Extremely" score on the scale as shown in Figure 7-25(a). In relation to their PD Aspirations as well as Planned Effort, teachers scored high as well, with an average in the post-questionnaire of 5.53 and 6.03 respectively. To note is that those values are slightly lower than the Chapter 7 study values, potentially due to the population in this sample being tenure faculty mostly, as compared to the Chapter 7 study where the majority of the faculty was teaching faculty. Lastly,

Table 8.12: Task specific motivation questions.

Intrinsic + Identified	• Because it is pleasant to carry out this task. • Because I find this task important for the academic success of my students.
Introjected	• To not feel bad if I don't do it.
External	• Because I'm paid to do it.
Amotivation	• I don't know, I don't always see the relevance of carrying out this task.

the average score teachers received in PD Aspirations was slightly lower than that of Planned Effort, both in pre and post. This shows that teachers in general are more motivated to work hard and put a lot of effort in their teaching but their are less motivated in terms of their PD aspirations such as undertaking further professional development.

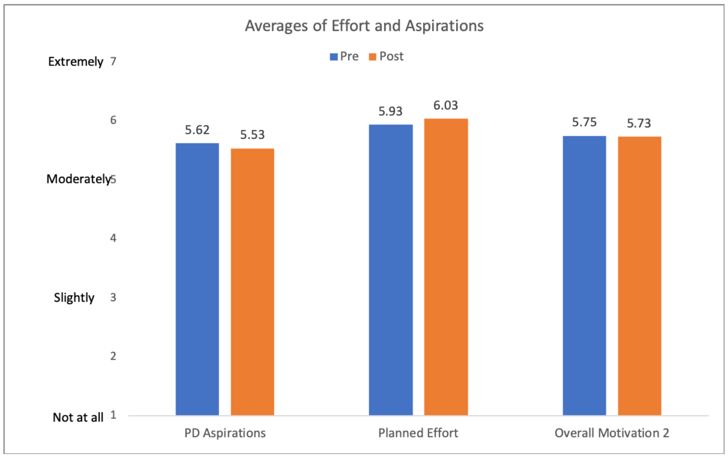
From pre to post (considering the adjusted average over the 15 participants who completed both questionnaires), there is a slight decrease in the overall average and PD Aspirations, and a slight increase in Planned Effort, even though as discussed above, those differences are not significant. This might be because these larger motivational constructs are general and not specific to this study (namely immediacy and nonverbals), and it makes sense that the study intervention did not majorly affect them.

Looking at the changes pre (for the adjusted pre with 15 participants) to post based on the experiment conditions (Figure 8-29(b)), overall, the social comparison condition scored slightly lower in pre and post compared to the verbal persuasion condition. In post overall, there was a slight increase of the social comparison score and a decrease of the verbal persuasion score. Looking at the PD Aspirations, there is an increase in the social comparison group and a decrease in the verbal persuasion group from pre to post. These results are consistent with the Chapter 7 study. On the other hand, in the Planned Effort sub-questionnaire, there is a slight increase in both groups.

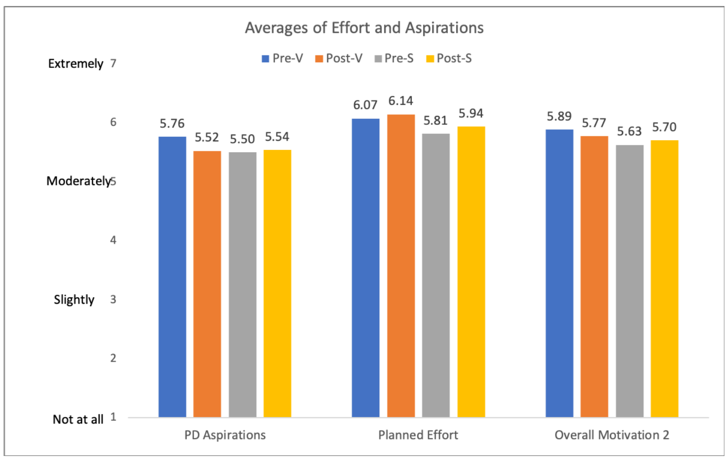
Last but not least, in the post-questionnaire, teachers were also measured on their motivation for participating in the specific task of engaging with the PD Module and looking at their own proxemic nonverbal data. As mentioned in the previous chapter, this task-based motivation questionnaire was adapted from [88] and the distribution of questions per motivation construct is shown in Table 8.12.

On average, as shown in Figure 8-30(a), teachers scored relatively high on their intrinsic motivation for this task (4.57 out of 7 close to "Agree"). This is to show that overall the participants in this study are motivated intrinsically to engage with activities that involve working with PD and engaging with data as in the current study. Teachers scored very low in terms of external motivation for this task (average 1.67 out of 7, close to "Disagree Very Strongly"), understandably as there was little to no external motivation for them to take part in this task.

In terms of conditions, the verbal persuasion condition scored much lower than the social comparison condition in terms of their intrinsic motivation and external regulation. These results are different from the Chapter 7 findings, and might show that the verbal persuasion group is less motivated than the social comparison group in terms of this task-based motivation. Looking at the box plots (Figure 8-30(b)), the verbal persuasion and social comparison groups are distinct, non-overlapping populations in terms of their intrinsic motivation. This might be an



(a) Average teacher planned effort and professional development aspirations pre to post



(b) Average teacher planned effort and professional development aspirations per condition

Figure 8-29: Pre to Post overall teacher planned effort and professional development aspirations.

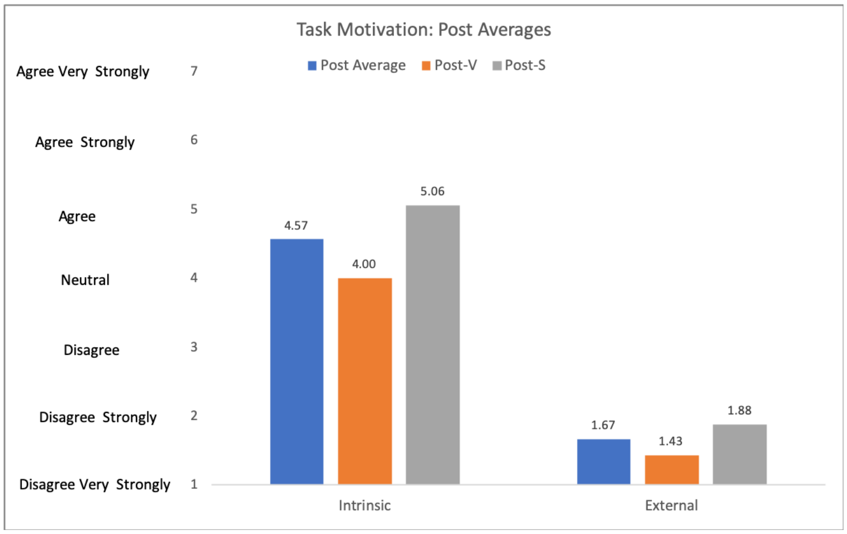
effect of the condition, where the paragraph with encouraging text the verbal persuasion group got was not as motivating as seeing their own data perform better than other instructors (as the social comparison group did).

Teachers' Goals for Behavior Change

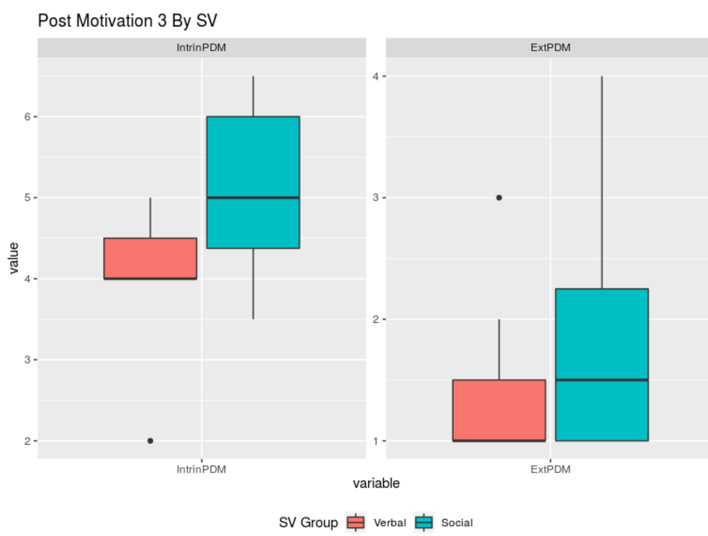
In the post-questionnaire, teachers were asked about their willingness and readiness to change their general, proxemic and oculesic behavior in the classroom, after taking part in the study. In addition, teachers were asked in an open-ended question format if they would like to change something in their nonverbal behaviors in the classroom. If so, they were asked to list 2-3 ways and elaborate, and if not, they were asked to elaborate on why. All three of these questions were meant to be used as proxies for measuring teachers' behavior change. Namely, they measured teachers' intentionality to change which is both the first step in engaging in behavior change and a really good proxy for measuring behavior change (when behavior change on its own is not being measured).

Table 8.13: Comparing differences in task based motivation across conditions.

	Verbal	**Social**
Count	7	8
Intrinsic Motivation	4 (3.11 4.89)	
External Regulation	1.43 (0.7 2.16)	



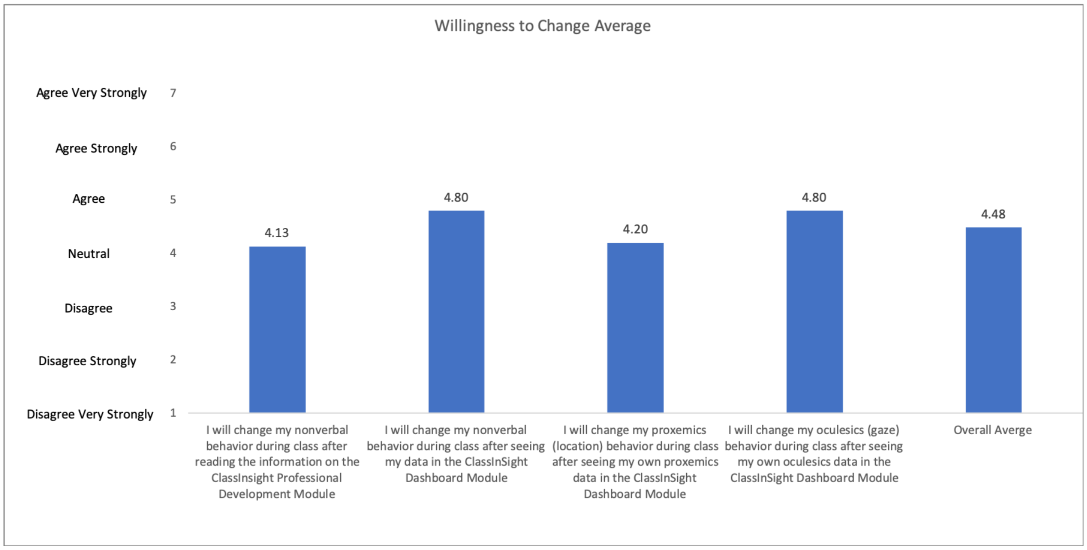
(a) Average task-related motivation.t



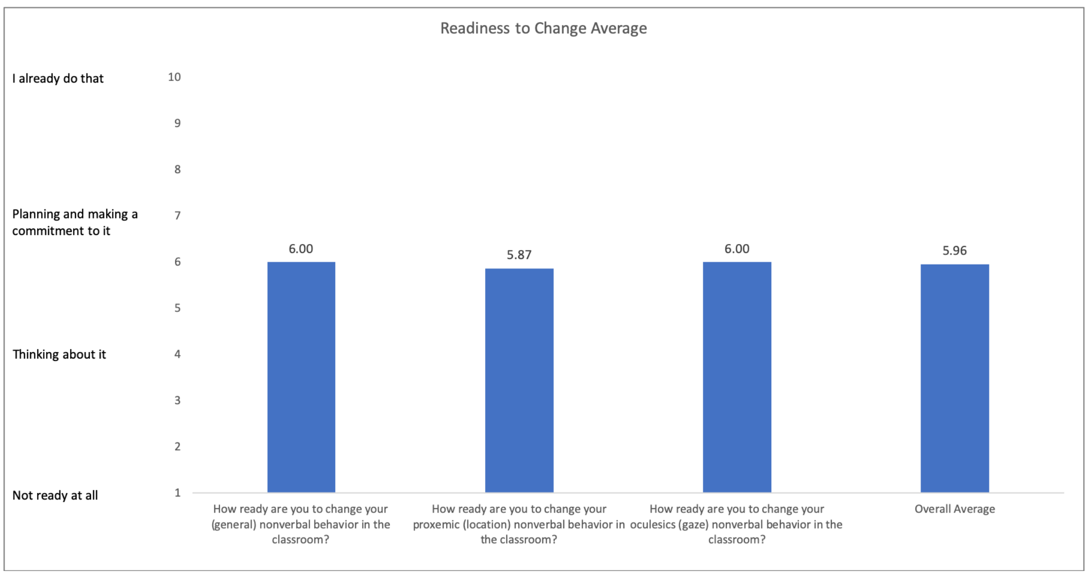
(b) Box plot of task related motivation per condition.

Figure 8-30: Task based motivation

In relation to the willingness to change, teachers scored on average a 4.48 out of 7, which falls between "Neutral" and "Agree" in the scale (Figure 8-31(a)). This value is quite lower from the one during the Chapter 7 study (5.38 out of 7 between "Agree" and "Strongly Agree") and shows that teachers in this population were less willing to change their general and specific nonverbal behaviors in the classroom. Despite this, it shows that teachers are more on the



(a) Average willingness to change.



(b) Average readiness to change

Figure 8-31: Teachers' willingness and readiness to change measured in the post-questionnaire as a proxy for behavior change.

positive and agree side of the scale in terms of their willingness to change their behaviors. On average, teachers were more willing to change after seeing their data in the dashboard (4.80 out of 7, almost "Agree" on the scale) rather than after reading the information on the PD module (4.13 out of 7, slightly higher than "Neutral" on the scale). This again is different from the Chapter 7 study, where instructors in that sample found both data and PD equally helpful and shows how teachers in this sample were particularly compelled, and maybe even convinced, only after seeing data about their own performance. Looking at teachers' willingness to change specific nonverbal behaviors, teachers seem most willing to change their oculesic (gaze, average 4.80) behaviors than their proxemic (location, average 4.20) behaviors, after looking at the

Table 8.14: Differences of willingness and readiness to change based on condition.

	Verbal	**Social**
Count	7	8
Readiness to Change	4.71 (1.89 7.54)	7.04 (5.54 8.54)
Willingness to Change	3.64 (2.01 5.28)	5.22 (4.59 5.85)

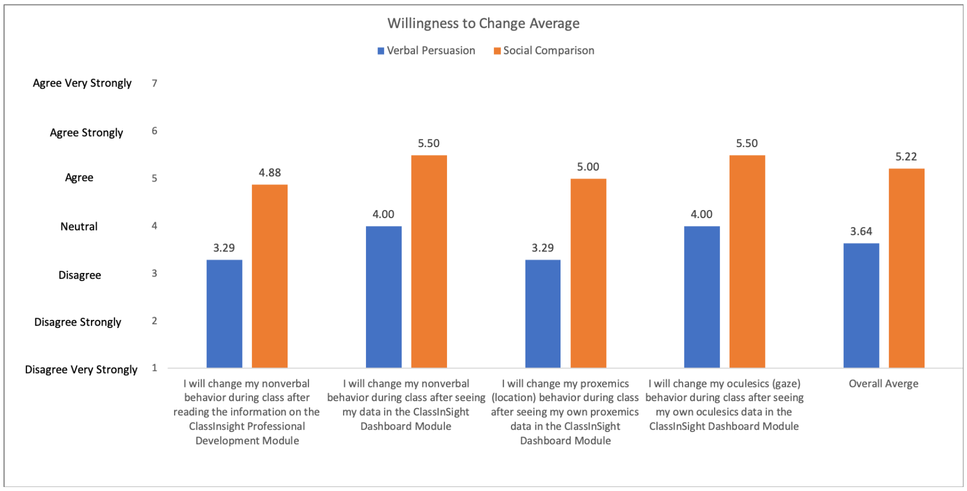
data. Again those averages are between "Neutral" and "Agree" on the scale, and much lower than their Chapter 7 counterparts. To summarize, teachers in this study did not disagree with changing, rather they scored between "Neutral" and "Agree" in their willingness to change.

In terms of their readiness to change (Figure 8-31(b)), on average teachers scored a 5.96 out of 10 which is between "Thinking about it" and "Planning and making a commitment to it" score on the scale. This value is again lower than the one in Chapter 7 findings (6.64 out of 10) and shows teachers in this population were less ready to change their behaviors. Despite that, the results also show that teachers in this sample are past the stage of "Not being ready at all to change their behaviors" and are "Thinking about it" towards making planning and commitment to this change. On average, teachers seem equally ready to change their general behaviors as well as location and gaze specifically, with the location average being slightly lower than the general and gaze one. In addition, the willingness and readiness to change were strongly and positively correlated and the p-value shows significance `p-value=0**`.

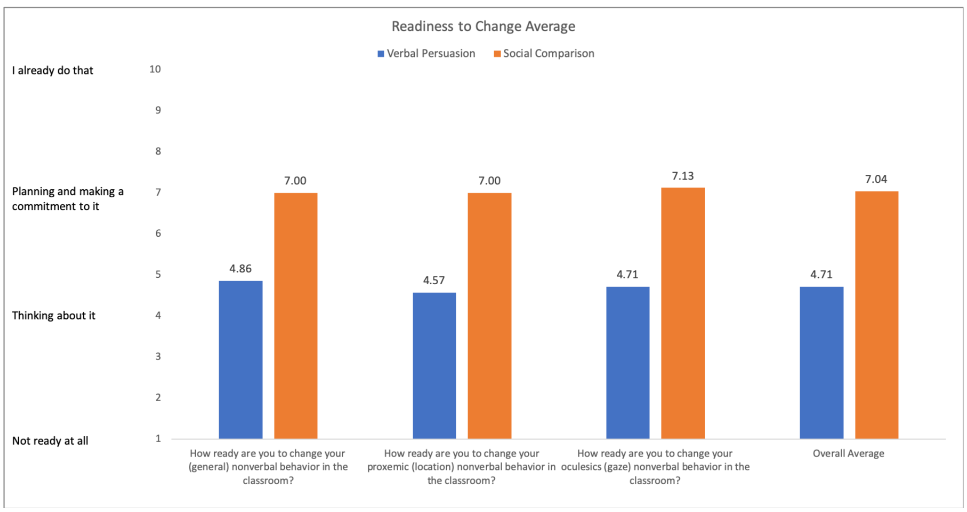
In Figures 8-32(a) and 8-32(b) I show the average scores per question and overall on the willingness and readiness to change questionnaires, based on the condition the instructors were assigned to. As a reminder, the conditions were randomly assigned and I ran a paired t-test to confirm the random assignment (as described in the previous section). The Verbal Persuasion condition is consistently scoring lower on both willingness and readiness to change, per question as well as overall, while the social comparison group is consistently scoring much higher. In their willingness to change, the average for the verbal persuasion group (3.64 out of 7) falls between the "Disagree" and "Neutral" in the scale. While the average for the social comparison condition (5.22 out of 7) falls under "Agree" and "Agree Strongly" in their willingness to change. Similarly, looking at the readiness to change chart, the average of the verbal persuasion group is 4.71 out of 10 and falls closer to the "Thinking about it" in the commitment scale. On the other hand, the social comparison group again scores much higher, with an average of 7.04 out of 10, closer to "Planning and making a commitment to it".

Taking a look at the box plots of the readiness and willingness to change per condition (Figure 8-33(a)), the verbal persuasion and social comparison conditions are quite distinct from each other and non overlapping. This is positive and together with these discussed results, it shows that the social comparison condition was more willing and ready than the verbal persuasion group to change their nonverbal behaviors in the classroom, with respect to general behaviors as well as location and gaze more specifically. These results hint in the direction that seeing their own data perform better compared to other instructors, helps instructors have a higher willingness and readiness to change their general and specific nonverbal behaviors in the classroom. Similarly, receiving a paragraph of text with persuasive and encouraging words does not seem to help increase teachers' willingness and readiness to change.

I also looked at the differences in instructors' willingness and readiness to change based on the their pre-questionnaire SE bucketing. As shown in Table 8.15, the medium SE group scores higher on average than the high SE group both on readiness and willingness to change. Seeing



(a) Willingness to change per condition.

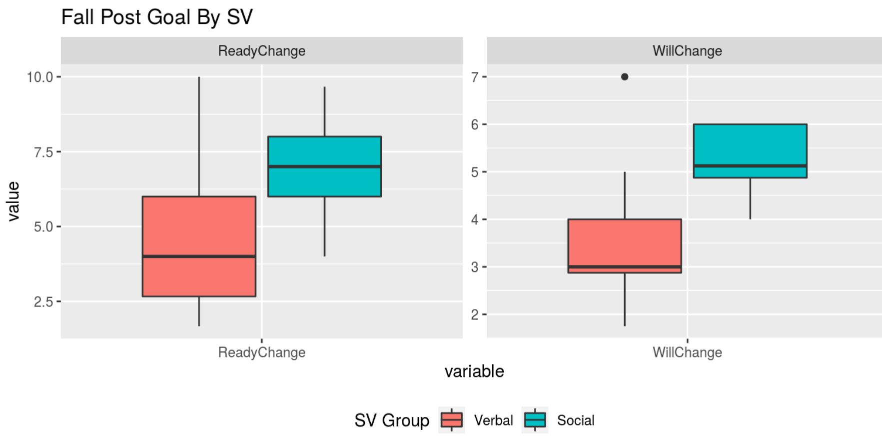


(b) Readiness to change per condition.

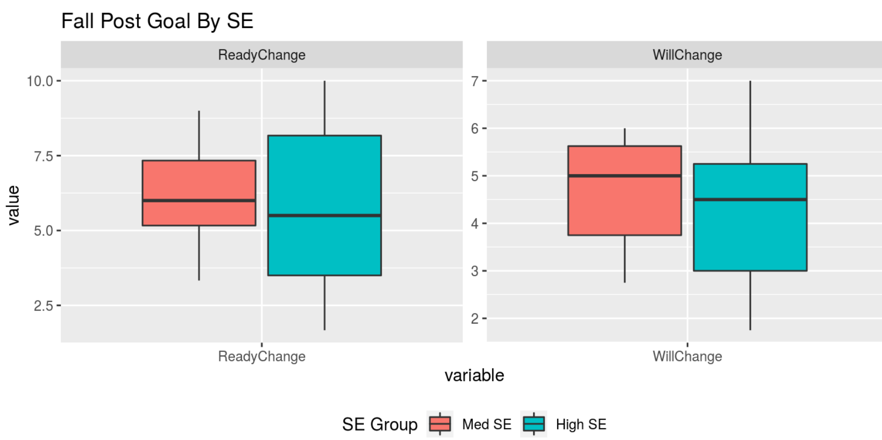
Figure 8-32: Teachers' willingness and readiness to change per condition.

the box plots of those two populations (Figure 8-33(b)) they are not distinct, rather quite overlapping. A reason for this could be that there are more participants of the social comparison group that fell in the mid SE bucket (5 social comparison and 2 verbal persuasion) than the high SE bucket (3 social comparison and 5 verbal persuasion). As a result of this, the medium SE group might be scoring higher than the high-SE group. An alternative explanation could be that the medium SE group, provided the lower self-efficacy, is aware of their perceived shortcomings and is willing and ready to change their behavior in order to perform better and improve on their skills.

Lastly, I decided to investigate if there were any correlations between teachers' willingness and readiness to change and their learning and attitudes in the post-questionnaire. In Figure 8-34(a) I share a correlation matrix where color represents the direction of the correlation (orange is positive and blue negative), the strength of the color represents the strength of the correlation, and the lack of `X` on each of the boxes represents statistical significance. Looking at this cor-



(a) Box plots of readiness and willingness to change per condition.



(b) Box plots of readiness and willingness to change per SE bucket.

Figure 8-33: Teachers' willingness and readiness to change box plots.

relation matrix, there are strong and positive correlations between willingness and readiness to change and teachers' learning and attitudes. Looking at more details at some values, in Figure 8-34(b) I share for each pairwise comparison the strength of the correlation (`r`) as well as the direction (`+` for positive and `-` for negative) and the significance (the number in `[ ]`). First of all, the willingness and readiness to change are very strongly correlated and moreover, significantly correlated (`r=0.94, p-value=0**`). Willingness and readiness to change are very strongly correlated with self-perceived learning, and moreover those are significant statistically (`r=0.82, p-value=2e-04** and r=0.78, p-value=62e-04** respectively.`) Lastly, both willingness and readiness to change are correlated with teachers' attitudes, strongly and moderately respectively (`r=0.73, p-value=0.0021** and r=0.67, p-value=0.0065** respectively.`) It is also worth mentioning that attitudes and learning are positively, strongly and significantly correlated as well (`r=0.79, p-value=4e-04**`). Doing a Bonferroni adjustment for 6 comparisons, the new p-value used for determining significance would be `p-value=0.0083`. Even provided the adjustments, all correlations in this sample remain significant. This means that a self-perceived learning and a positive attitude towards the PD materials and the dashboard and data teachers saw in the study were positively, strongly and significantly correlated with

Table 8.15: Differences of willingness and readiness to change based on SE bucket.

	Mid SE	**High SE**
Count	7 (5S - 2V)	8 (3S - 5V)
Readiness to Change	6.19 (4.4 7.98)	5.75 (3.01 8.5)
Willingness to Change	4.64 (3.42 5.87)	4.34 (2.89 5.8)

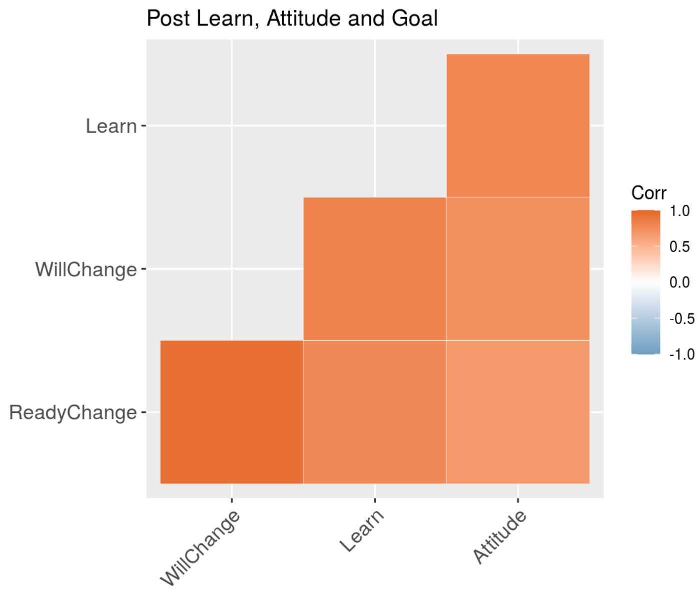
teachers' willingness and readiness to change their behaviors in the classroom.

Lastly, the post-questionnaire asked teachers if they wanted to change their nonverbal behaviors in the classroom (genera, proxemics/location, oculesics/gaze). If so, instructors were asked to list 2-3 ways they would change and if not they were asked to elaborate on why. Below I summarize teachers' answers to this question:

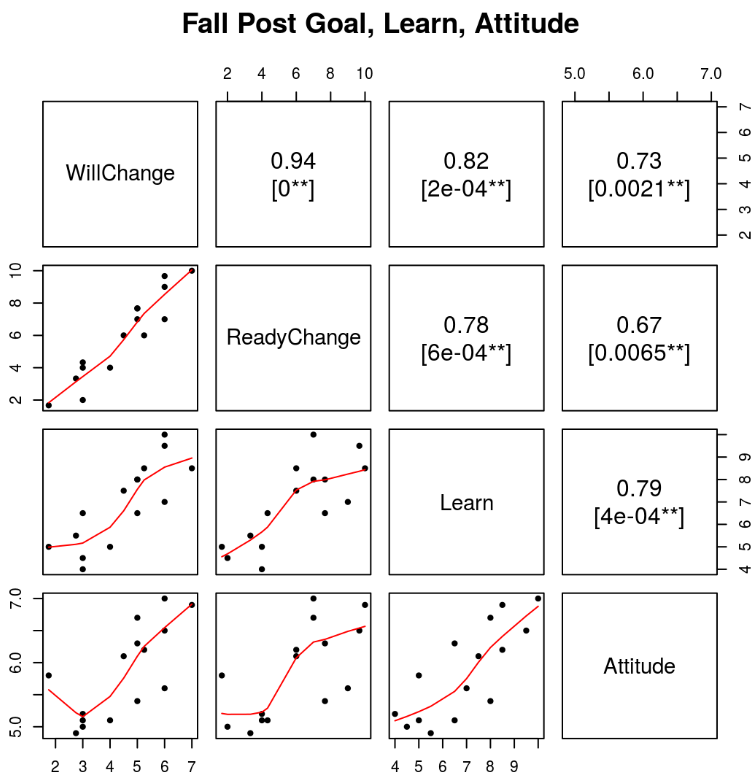
- 6 out of 15 teachers said that they were going to change something in their behaviors
- 1 teacher said they already changed some behaviors after the study while 1 teacher expressed they already do certain behaviors but they made an effort after the study to make some small changes (*ID 92: "I also made a smaller effort to stand and make eye contact with the left side of my classroom, though these were not high priorities and from my perspective only replicated behaviors I was largely already doing (just somewhat more exaggerated)."*
- 3 teachers said they were going to change some things but not others: 2 of them said that the reason they could not make certain changes was due to external constraints (such as physical constraints on having to use the board or other constraints such as their teaching load and subsequent prep time) and 1 teacher said that the reason they could not change some things was due to them not knowing a better approach (for example spend less time looking at slides and more time looking at students)
- 2 teachers sad that they were not going to change because they already do such behaviors and achieve those goals. 1 teacher in particular expressed that student learning data would motivate them to change, *ID 15: "My impression of the data is that I am doing things as I intend. In other words, no surprises. If I were to see some data that correlates my classroom behavior with student learning, that would motivate me to change."*
- 2 teachers gave responses that did not answer the question or were empty.

In terms of what behaviors specifically they wanted to change, teachers mentioned the following behaviors in relation to their gaze and movement:

- look more at students and make more eye contact (3)
- look more at specific locations and proportionally spread gaze/attention to all students (5) and pull questions from different sides of room (1)
- prepare more for class to spend less time thinking and looking at slides (1), spend less time looking at board (1)
- move around the classroom more (4) and maximize position and mobility relative to students (1)
- use a clicker (3) or other wireless technology (1) to not be stuck at computer/podium; get out from behind the podium and closer to students (2)



(a) Box plots of readiness and willingness to change per condition.



(b) Box plots of readiness and willingness to change per SE bucket.

Figure 8-34: Teachers' willingness and readiness to change box plots.

- lean forward while teaching (1)

Lastly, teachers also mentioned other behaviors they would try to do that would affect student engagement, but would not directly involve nonverbal behaviors necessarily.

- use technology (i.e., piazza) to engage students (1), have more discussions (1), or involve more group work (1)
- configure the room to sit in circle (1) or move students to different clusters from where they usually sit (1)
- write more on board (1)

Last but not least, there was another subquestionnaire in the post-questionnaire that measures yet another proxy for behavior change. In the section "Teachers' attitudes from the PD materials and data presented in the dashboard" discussed above, within the attitudes subquestionnaire, I measured teachers' (1) likelihood of enrolling in another PD of related content as well as their (2) likelihood of actually attempting to engage in the behaviors recommended in the PD (Figure 8-23). Both those questionnaires while measuring attitudes, serve as proxies for the likelihood of teachers attempting behavior change. There is more detail in the section above regarding how teachers scored in the likelihood questions, but as a summary teachers scored high in their likelihood to attempt and engage in the behaviors recommended in the PD module. This is positive and shows that teachers see such behaviors as important and valuable to engage in.

To summarize, in this study I measured several proxies that indicate intentionality for behavior change such as willingness and readiness to change, teachers' goals (if any) for what they wanted to change in the classroom as well as their likelihood to engage in certain behaviors or attempt further PD of similar content. The results showed that teachers overall are willing and ready to change their behaviors after the study, they set goals on what they want to change in relation to their oculesics, proxemics as well as other nonverbal behaviors they learned about in the PD materials. In addition, their likelihood to attempt such behaviors is high.

8.4.5 Analysis of video interviews

There were 16 teachers who took part in these interviews and the following analysis is based on these 16 data points.

Teachers' interest around data

Teachers' data interest was one of the major themes that emerged from the data, which was either prompted by the interview questions or unprompted and came up as teachers were working with ClassInSight. Teachers mentioned interest about the data that we showed them, and other data about themselves or their students, verbal or nonverbal, etc.

Teachers mentioned that they were generally aware of their own behaviors and actively tried to monitor students' behavior showing confusion, boredom or students being lost or falling asleep. However, they mentioned that they still were unaware of certain behaviors of their own or their students' behaviors. As one teacher said *ID-24:"I can't distinguish between bored and like totally lost. It's just like a blank stare in either case. I don't know how to distinguish those two things."* This is particularly true in bigger classes where it is harder for teachers to monitor everything going on at the same time and where teachers mentioned ClassInSight like data would be very helpful. As one teacher said *ID-20:"Oh my God, can you give me student information? Because* *there's just a cognitive limit beyond that. Beyond some point you're, it's hard to summarize as accurately. It's hard to even have that many eyes to realize, so that's of course very, very, very strong bias towards that. Right. In terms of expected usefulness."*

To begin with teachers showed interest in their own data. Teachers thought the data the dashboard shared with them was interesting and useful as it helped them reason and think about their performance. Specifically, they liked and found useful data in relation to physical movement, location, and gaze in class (i.e., how much they are looking at students, what is their breakdown of gaze and location at students on the left, center and right). Further, teachers expressed interest in knowing how the method of delivery of their lectures (i.e., board vs slides) would affect their location, gaze and other behaviors in the classroom.

Further, teachers expressed interest in other nonverbal data such as their posture, or more detailed information on gaze such as gaze to individual students and percentage of time teachers' back was to the students. Teachers were also interested in information such as gesturing and moving around the classroom, in particular if that is distracting to students. Facial expression data was also of interest to teachers including smiling, and if their facial expressions are showing enthusiasm, astonishment or confusion. Overall, teachers were interested in having information that showed that they were approachable or immediate, that they were engaging with the students and that this was effective.

Interestingly, teachers also showed interest in verbal and para language behaviors including were they going too fast or too slow or were they using filler/unnecessary words. Voice and intonation was also a very requested data category. One teacher said this is important especially for women because if the tone is too high is perceived as yelling and that can be undermining, *ID-88:"I think the voice intonation and things like that because, I wonder, particularly for women when I get excited about something, I will often start to yell, well what I would call yelling. ... And I particularly as a woman, that can undermine what I'm saying. So, to learn more about that."* Other teachers were interested in data such as audibility from the back of the classroom and their volume.

Secondly, teachers showed extreme interest in student data. Part of the reason teachers wanted this data had to do with limited monitoring abilities in class or with not being able to tell just from student nonverbals if they are engaged. Similarly, teachers want their students to learn and be successful and they want to have ways to measure that, i.e, through understanding, engagement, attention and participation in class.

To begin with, attention, engagement and participation was a broad category of data teachers mentioned they were interested in. In terms of positive measures, teachers were interested in data that could help them gauge if students were engaged and paying attention, if they were participating and if they were following the material presented in class. In terms of negative measures, they were interested in the percentage of time students were inattentive and disengaged, bored, confused or totally lost. Some teachers mentioned they were interested in knowing when students are using their phones as a way to measure disengagement and not paying attention. A minority of teachers were also interested in other measures that showed whether students were learning or understanding the material, if they found the class helpful and what did they take away from the class. Interestingly, some teachers requested direct student feedback or what their perceptions were about their instructors and their teaching. As one instructor mentioned *ID-75: "... I think it might be good to, yeah. Some way to assess their, like the customer satisfactions of each lectures."*

Many teachers also expressed interest in some student nonverbal behaviors as a proxy for measuring student engagement, interest or understanding and following of the material. Teachers found gaze information particularly helpful including gazing back at the instructor, where are students looking (down, away or are they sleeping), and the percentage of time they are looking at the board or slides. Teachers did not find location info on students helpful as students do not move a lot unless it is important. Other nonverbal behaviors on students teachers were interested in included gestures and motions, posture, distribution of raised hands, attendance, and facial expressions.

Another interesting theme that emerged from the interviews was teachers' interest in data that went beyond student only or teacher only data. Teachers were particularly interested in the relationships between student engagement and paying attention with teacher actions, behaviors and activities in class. For example, teachers wanted to know if being behind the podium, or their location and distance from students mattered to student engagement. Similarly teachers were interested in data that showed if teacher gesturing is engaging or distracting, or whether students are more likely to look at them if they are moving or making eye contact with the students. Teachers also wanted to know what activities or behaviors they do lead to student participation and what activity is causing a fall in engagement. Lastly, teachers were interested in how students react to teachers' nonverbal behaviors, or to changes in teacher behaviors in class, both in their perceptions and how it affects them.

A final category teachers were interested in was the reverse correlations (how teachers react to student behaviors) such as how does students' equally/uniformly spread out affect where the teacher is looking or when students are disengaged does the instructor withdraw and become less engaged with those students.

This action-reaction data was important to instructors to determine which behaviors caused student engagement or disengagement, which behaviors would have most impact on the students, and how would changes in instructor behavior affect student attention and engagement. This would allow teachers to better set goals for changing their behaviors and improving their practice. Teachers mentioned they would want information that is actionable with specific recommendations of what was good or bad for students and what they should be doing more or less of. They would want to know which of those behaviors they should most care about, which would be most valuable to teaching an student learning. They also wanted suggestions with concrete ideas how to balance these behaviors in the classroom based on their subjects, lectures styles and methods of delivery of the materials. For example, one teacher asked that if they used slides to present their materials, what should be the goal for their location and movement or the goal for their distribution of attention to students vs slides.

Some teachers in both conditions also mentioned were interested in comparison data, such as where they are compared to their peers, especially when in the same field and area and do they share similar biases with their colleagues. This would be helpful both to assess their performance, where they are compared to other teachers, but also to determine where their performance should be and what goals they should be reaching for. On the other hand, few teachers mentioned they would not find this information helpful because it might not be productive and because whether they can improve does not depend on other peoples' performance.

Lastly, very few teachers mentioned not being interested in certain aspects of nonverbal data because it does not apply to them, or it does not matter. For example, some teachers did not find location data helpful, as their location is constrained by the teaching method or the room.

We discuss more about this in the subsection on challenges teachers face in the classroom below.

Teachers' assessment of their performance

Before seeing their data and after interacting with the ClassInSight PD Module, instructors had the opportunity to share their perceptions of their nonverbal behaviors in class and how they think they were doing in relations to those behaviors. Teachers were generally aware of their performance in terms of their gaze mostly, but also location and other nonverbals in class. Instructors assessed their performance as generally doing well for the type of lecture and class that they taught. However, they acknowledged that there was room for improvement in their behaviors. As one instructor said *ID-75:"I gave myself seven or eight or something like that. I mean, nobody's perfect."* In particular, some instructors acknowledged that they did not think they do well in some aspect of their nonverbal behaviors, primarily in terms of proxemic locations (i.e., they would spend all the time behind the podium or they would not move a lot). A minority of instructors were also aware of issues with their gaze, for example their bias towards certain students or not making eye contact with everyone. As one instructor shared *ID-21:"I think when I did recitation, I definitely spent too much time looking at the board"*. Lastly, some instructors did not know how they were doing and were looking forward to the data. As ID-19 responded to the question of how they would assess their gaze performance, *ID-19:"...Um, I don't, I can't remember. I've never really been observed with the eyes specifically. So I don't know. I'd be curious to know."*

The teachers were then shown their data without any feedback first, and then with the effective teacher model comparison as described in the Methods section above. The following findings pertain to that part of the interview, before the teachers saw the third data part, which split them into the two conditions of the study. Almost all teachers found some aspect of their data not surprising. For example, teachers said their data made sense, they were aware of it and it was what they were expecting. Some of these teachers have been teaching for a long time in the classroom and they are aware of their general behaviors, know their teaching style and where they spend their attention at the high level. Despite their general awareness and experience, teachers found some aspect of the data very surprising and this brought some new value to them. For example, many teachers were surprised that their gaze was not equally and proportionally distributed to all the classroom, but rather they gave more or less gaze attention to one side of the classroom. Similarly, teachers were surprised by the high percentage of time they looked at their slides, board or their notes. In terms of location, teachers were surprised they spend more or less time than needed in one side of the classroom, making them more skewed to one location.

In their assessment of the data, teachers thought they were doing well in some aspect of the data, they were in good shape, they were happy about their performance, and they thought it was not too bad or as bad as they expected it to be. Some even said that everything looks reasonable and justified provided the materials they need to deliver and the way they choose to do so. Despite that, teaches recognized some areas where they were not doing well (i.e. skewed gaze or location, looking away from students). Teachers said they were not thrilled with their performance in these behaviors, and there were major problems they should resolve. Some teachers recognized that there was potential room for improvement in their performance, things they could do better and they could change such as being closer to students, or spending more effort to proportionally distribute gaze and location to all students. Very few teachers said that they did not care about assessing their own performance, whether they were doing well or not well, as they did not think the data ClassInSight was showing matters. These teachers mentioned they connected with students in other ways, and data showing a skewed gaze or location did not concern them as much. Similarly, few teachers were not sure how to asses their performance, they were not sure what behavior is right or wrong, and what would be a good balance to aim for in the nonverbal behaviors based on their teaching style, materials and delivery.

After seeing the third part of their data, which shared with teachers verbal persuasion or social comparison motivational feedback, instructors once again had the opportunity to share their thoughts on their performance. Overall, instructors in the social comparison condition were very happy to see they were doing better than other instructors on some aspects of their data. They said seeing this comparison made them feel better about their performance. They assessed their performance as better and further along than where they thought they were. It was reassuring to them that other instructors had issues similar to them, and that they were not terrible in their performance. They assessed their performance as very high and patted themselves on the back. For example, ID-63 in their assessment of their performance before seeing the motivational feedback mentioned: *ID-63:"I had some serious issues. You know, not being in front of the podium.... I was located on the right students were mostly on the left and I was located behind the podium and this was because I was tied to the podium and not use a clicker."* Once the instructor saw their performance compared to other instructors, they commented *ID-63:"Oh, cause it said high. I felt good about that. That's it. At least I wasn't terrible."* Regardless, they still agreed that there were things they could do better to improve their behaviors. As one instructor mentioned *ID-88:"I mean, I'm pleased. I still, it's hard to get over the idea, that, you know you can do better, you know. And so I still, I mean I'm happy and I'm not going to overly beat myself up about this semester. Things are what they are, but I sort of want us all to do better."*

On the other hand, teachers in the verbal persuasion condition had a very different reaction to the motivational feedback shared to them by ClassInSight. They were primarily confused as the data they had seen up to that point hinted that they were not doing well, however the text they received was encouraging and this caused some confusion. One teacher suspected that the text was subtly saying their performance was negative, *ID56:"I don't know what I'm getting out of here. It is a kind way of telling me that I'm not performing well. If I would read this... like I would read any texts that I'm reading. And I'm like, you know, I'm judging a text from whether or not it is honest to me or not. I would believe that this is kind of not 100% honest. It's trying to tell me that I'm under performing but in a very kind way."* Another instructors mentioned *ID-40:"I'm feeling a little, uh, patronized, you know."* Overall, the verbal persuasion feedback did not bring any new information to the instructors and did not change their assessment of their performance.

Challenges and barriers to using nonverbal behaviors in the classroom

A very interesting theme that came up during the interviews was challenges and barriers teachers face in the classroom that affect their nonverbal behaviors such as where they are located, why they spend a lot of time in one location, why they spend little time facing students, why their gaze distribution is skewed to one side of the classroom, etc. Such challenges and barriers also limit the changes in behaviors and practice teacher can make to improve, which I discuss in more detail in the goal setting subsection below.

One of the biggest themes that caused challenges for teachers was the physical layout of the room and the classroom set up. Many teachers mentioned physical constraints that make it difficult to teach due to the design of the classroom and the weird and small shapes of the room, where the furniture is located, etc. This affects many of the teachers' behaviors in class. For example, some rooms are small, with little space in front of the podium. This creates no opportunities for the teachers to be close to students without being on top of them. It also restricts teachers' gaze and makes it so that they can only look at the people sitting in the front. In addition, in such small environments, moving something such as a table or podium, would be in the way of another furniture or of where the teachers would be walking, not allowing them to get to a certain part of the classroom. Similarly, teachers cannot stand in certain locations due to the podium or projector slides being there. Often furniture such as podiums and desks are heavy to move and make it hard for teachers to create more space at the front. These restrictions constrain and dictate teacher proxemic behavior in class making teachers stand too much in one location and not enough in another. Further, teachers mentioned that the classrooms they teach are different every time (i.e. location of podium, board projector or the size of the classroom), and that affects their performance and behaviors in each case.

Another major theme that caused barriers for teachers' nonverbal behaviors was the nature of the course, the types of activities instructors included in their teaching and the way these materials get presented. For example, in relation to the ratio of looking at students vs other locations, some instructors said that in technical courses, they have to look at their notes often as they need to be super precise and make sure that what they are writing is correct. Similarly, another instructor said that when they play videos in class, they cannot look at students. One instructor even argued that STEM courses are different and that *ID-14:"I don't think STEM works with a lot of where you're out circulating in the room very much because there are things that we have to, we absolutely have to, you know, write on the board or present somehow. Um, and it's, it doesn't really work. I mean, in a recitation situation it works great. To have students work in small groups and then you can walk around and check on how things are going. ... I think the model that you're going to probably find that the model is people mostly standing behind a podium writing on document cam or writing on a pad that projects or something like that."* Others mentioned they need to write on the board or work on the doc camera as part of their lecture activities, which would not allow them to face the students all the time and would make them glued to the podium or at the board.

A third major category that caused barriers for instructors' nonverbal behaviors was the technology they had to use to deliver their course materials. Teachers felt that they were too chained to these tools making it hard to have diverse location and gaze, and to change their practices. One of the biggest barriers for teachers was the use of the board. Many technical courses use the board which teachers expressed makes them immobile; they had to write on it and stay close to it, and as a result they would not be in areas of the classroom where there is no board. Similarly, facing the board to write made it harder for teachers to face the students. Further, the laptop with slides and notes and the doc camera were major "culprits" of teachers staying behind the podium for the majority of class time. Even though they are facing the students in this scenario, teachers mentioned that they could not look at the students all the time as they often had to pay attention to their notes or divert their gaze to the slides to point at.

When suggested to substitute such tools with different technologies (i.e. tablets or clickers to help teachers be more mobile), teachers mentioned that any technology would bring some sort of new challenge. For example, clickers could not help with the doc camera and tablets would introduce other issues such as dangling cables, lagging connections, etc. Further, instructors feared that if they were to optimize certain behaviors, other behaviors could potentially suffer. For example, if they teachers wrote quickly on the board to create the opportunity to turn and look at students, then students who benefited from the slow writing and absorbing the material slowly would have trouble keeping up. Similarly, an instructor said that they could use power point slides instead of the doc camera to improve their gaze, but they steered away from that because with power point students do not take notes and get passive.

Another interesting barrier for teachers' nonverbal behaviors is teacher time and familiarity with the course material. Teachers mentioned that when they are less familiar with the material or the material is new to them, they have too look more often at their slides or notes, and there is a limit on how much they can gaze students. As one instructor mentioned *ID-24:"Cause I can't remember 90 minutes of lecture material, so I have to like look at the slide and what I'm supposed to talk about."* Some teachers said they have a lot of material to cover in class in a short amount of time so they cannot necessarily focus on the nonverbal behaviors if they take time from that or if they require significant planning. They mentioned they have limited time and energy in their work, and have other commitments in addition to teaching that need their time.

A final and very interesting theme that emerged as a barrier for teachers using certain nonverbal behaviors in class were students themselves. Some teachers mentioned that when they are trying to engage with certain students, but they are not getting a response from them, teachers feel as if they have hit a wall and that these students are signaling that they want to be left alone. When students make no effort to participate and keep avoiding teachers' gaze, teachers stop engaging verbally or non verbally with these students. Instead, teachers prefer to engage with students who are more responsive and active. Further, some students sit in the back or farther away areas in class that are hard for teachers to reach with their gaze. Due to such barriers, teachers' location and gaze is often directed away from those students in class. However one teacher challenged such barriers and said this might just be an excuse rather than a real barrier. *ID-63: "I mean I think at some point it becomes an excuse, right? Like I just either don't want to engage or I don't know how to engage or I don't feel comfortable taking questions. And taking questions is hard, you know, if they can ask anything, especially if it's a very technical area. I noticed that in myself, just like, I really don't want a question on this, so I'm just going to sort of look at it, and then go to the next slide, you know? Um, whereas if you stop, look at students and invite questions, then you might get something that, you know, you feel like you might not have a very good answer to."*

Lastly, sometimes we forget that teachers are also humans and health issues and other physical limitations could also be barriers and pose challenges to their nonverbal behaviors in the classroom. For example, one teacher said they had trouble with gaze because of health issues in their eyes that made them droop or gaze away. Other teachers had trouble with hearing, and thought that would make students repeat themselves ad get disengaged. Lastly, another teacher had difficulty with smiling due to health issues.

Teachers' reaction to PD and their beliefs on nonverbals' importance

A very interesting and unexpected theme that emerged from the data was teachers' reaction to the PD materials ClassInSight shared with them as well as their opinions and beliefs around the importance and impact of teacher immediacy and nonverbals. To begin with, after reading the

PD materials, some teachers expressed that they were aware or had heard of immediacy and nonverbal behaviors before in broader terms but did not necessarily know the importance of it. As one teacher mentioned *ID-89:"So same with the closeness. I mean I, for me it's natural. I will see from my data sets. But for me it always felt kind of like natural to move towards the students when I explain something. But I never knew if it was good to do that or it would be intimidating for the students if I got closer. But it's just as good"*. Others mentioned they had never thought about this or do not often think about it in their teaching, but they should. Some teachers agreed with the PD materials that teacher immediacy and nonverbal behaviors are important to teaching and found it reasonable and not surprising that those behaviors correlate with student learning. One teacher suggested that this should be talked more about in pedagogy training and another one wished they had taken part in the study several years prior.

However, others expressed their scepticism or did not agree that this topic matters at all and questioned whether the importance of such behaviors was just an assumption. As one instructor mentioned, *ID-15:"... but the issue of approaching students physically that has never sort of dawned on me as being particularly important to teaching at least the kinds of things that I'm teaching typically."* Despite ClassInSight having cited every claim made in the PD materials on the importance of teacher immediacy and nonverbal behaviors, teachers questioned those citations and the literature; they wanted to see the actual studies run in the papers, what kind of research was conducted and in what context, what was the statistical significance, how it was measured and whether it was a first order effect. Instructors made claims such as *ID-24:"I guess I'd want to see the studies that say that standing behind the podium matters... There were citations, but I didn't actually look at the citations, right? I mean I'm not completely convinced that this is a first order effect... Proxemics. So I mean how, how big is the effect? "* or *ID-20:"Modest relationships sounds modestly important... Uh, I think it's convincing case why, um, immediacy and eye contact could be useful concepts for teaching, although as I think you saw from my moderate correlation comment there's lots of questions about it, which are not there"*, as well as *ID-14:"The data or the literature that you review, is it, do you know what kinds of coursework is involved in that?"*.

Further, teachers wanted to know how much teacher immediacy and nonverbal behaviors affect students, what effect do they have on them and and what is the magnitude of this effect. They mentioned they have limited energy and time and they wanted to know how much they should care about this or if they should focus on it at all. As one teacher expressed *ID-24:"I just don't know how much I should care about this versus other things. I am energy and time limited in terms of the teaching I can, and where I can improve. So is this what I should focus on really or not? I don't know."* as well as *ID-43:"Do you know, so, so when you have statements like, uh, when teachers display more immediacy, students evaluate more positively the class, how much more positively do they, so are there quantitative?"*

Finally, when presented with the effective teacher model and the accompanying PD material, some teachers gravitated towards not agreeing with the effective teacher model or agreeing only with parts of it. Teachers mentioned that some of those suggestions did not matter, or did not apply to their course provided the material they cover, *ID-40:"Ah. Okay. Um, "spend less time behind the podium and more in front of it or among students". Well, I don't agree with that."*

Goal-setting, intentionality, desire and interest for behavior change

Throughout the interview, prompted by the interview questions, or by their performance based on the data the dashboard shared with them (i.e. seeing that there were areas they could improve on), teachers mentioned their interest and desire in changing their behaviors and set goals for how they aimed to improve their practice in the classroom. These goals involved change of some aspect or overall of their location and gaze behaviors. For example improving their proxemics through rearranging the layout of the desks and chairs in the room or using a technology such as a clicker to help them move more around more. As one instructor mentioned *ID-56:"I would just say that the two most important things is the pointer. Like I'll put like an Amazon order for a pointer right now"*. Instructors also mentioned they wanted to work on their gaze and attention in the classroom, through covering the material in better ways (i.e. including worksheets in class or using polls) or preparing more and better ahead of lecture. This would allow them to look more at students and at various parts of the room the data showed they neglect. As one instructor mentioned *ID-21:"Well, yeah, I think I could spend more time looking at the students, I think could be better. There's areas for improvement. Yeah I'm a little sad, I didn't look at all of the areas of the room."*

Some teachers also mentioned they were interested in changing their behaviors, but there was a barrier that did not allow them to do so, or they were not sure how to change and improve. Barriers and challenges are described in more detail in the subsection above. Teachers mentioned that often there was no way to get around these barriers. As one teacher express *ID-75:"I think for these peculiar room, I'm not sure there's a better way to do this."* Similarly, they also expressed that they were not sure how they could implement a change or whether they had any opportunities to do so. As one teacher expressed in relation to their gaze *ID-63:"... it's unclear to me whether I could fix that because I don't know, maybe some people could think always by looking at people, but sometimes it requires me to look away, just because when you're looking at people and sort of processing what's going on in their face, I feel like that can interrupt my sort of cognitive processing of what I'm trying to think about. Um, so that's important. I'm not sure. I'd have to think about how I could fix that..."* Further, instructors mentioned that they had some uncertainty around how incorporating a new tool, activity or more in general an altered version of any aspect of their nonverbal behavior would affect students in the classroom.

Lastly, a minority of teachers mentioned they were not interested in setting goals and changing their behaviors for some aspect of their data. Their reasoning was that a change would not make sense for the particular class they were teaching or because they thought their performance was not concerning. As one teacher expressed *ID-35:"Uh, from this class, I can't, I don't think I can change anything."* Further, some professors emphasized that they were not sure if teacher immediacy and nonverbals mattered and how big was their impact (as discussed in the subsection below). As a result, they would not be willing to set a goal and change their behaviors. As one instructor mentioned *ID-15:"So, you know, maybe I could spend more time looking at the students, but I'm not sure that that would, I don't feel that that would necessarily improve anything."* Further, another instructor expressed that they would be willing to change their behaviors only if these constructs mattered; *ID-24:"If we assume that this matters, then I could improve by, uh, not spending so much time behind the podium."*

In terms of their goal setting and desirability for behavior change after seeing the verbal persuasion or social comparison feedback, the findings did not show any major differences with the exception of how the participants felt towards each feedback type (as also discussed above).

The verbal persuasion condition did not affect teachers' goal setting. In fact, some teachers expressed that it might even be discouraging or condescending making people think that they are not doing well or that they are doing well and do not need to improve. On the other hand, the teacher in the social comparison condition felt more positive and were encouraged to see that they were not doing as bad as they thought and their performance was better than others. This did not affect their goal setting, they expressed interest in changing their behaviors similar to before seeing this feedback and would continue doing some of the things they were already doing in the classroom. Few instructors mentioned that seeing themselves compared to others does not affect what they decide to do about their own behaviors.

8.5 IRB incidents

As described in the previous chapter and this chapter, the IRB put extra requirements to the studies described in this chapter, including having RAs (research assistants) present in class during data collection, as well as stopping the automatic data collection from the sensors and substituting it with a manual one. Despite these changes, partway through running the study described in this chapter, my team and I ran into some other issues with unconsented third parties. Again, those issues could not be foreseen or predicted before they happened, and in particular, being pioneers in the field of instrumented classrooms, my team and I, together with the IRB, had to figure out ways to deal with the new issues.

More specifically, we ran into cases when a student from a previous class would come back to class to retrieve an item they had left behind (i.e., an umbrella). We also had a case where a student walking by the hallways, opened the door to a class in session, peeked in quickly, and then shut the door. Even though RAs had been trained to stop the data collection as soon as they notice a third party present in class, those are cases that happen so quickly, that before the RA can send the command to stop the data collection, the third party is not in class anymore and the data collection with their face and/or voice is already captured. Similarly, in a last case, a couple of students from the previous class stayed over until after the beginning of the class we were doing data collection on. The RA who was responsible for that class session was not able to tell those students were third parties until they left the class a few minutes after class had started. In this case again, it was challenging to determine these students were unconsented third parties, until it was too late.

Provided these new cases, I retrained the RAs on how to deal with those cases. In addition, my team and I had long discussions with the IRB for potential solutions moving forward. For the remaining part of the studies (these studies), the IRB required us to put big signs, as the ones shown in Figure D-1 outside and in class, next to each sensor. The signs mentioned the course number, name and date when we were doing data collection for research. As for moving forward on solving issues with having RAs in the classroom, re-automating the data collection process, and avoiding any third parties being captured by mistake, the IRB, my team and I have been continuing those discussions, without a final solution yet.

8.6 Conclusions

In this chapter I describe a study I ran during Fall 2019 with 16 instructors at a R1 institution. Through this study, I aimed to investigate how sharing with teachers their own data affects their reflection-for-action and their behavior change intentionality. Further, I investigated how motivational feedback aimed at increasing SE affects teachers' values, efficacies, motivations, goal-setting and their intentionality for behavior change. Lastly, I aimed to test for consistency, generalizability and statistical significance of the findings, compared to my prior studies. To conduct this investigation I created ClassInSight, a high fidelity professional development training and dashboard prototype designed based on findings from my prior work.

8.6.1 RQ1: How does ClassInSight affect teacher reflection-for-action and their intentionality for behavior change?

Reflection and Goal setting during the Interviews

After working with ClassInSight, instructors expressed they found some of the data from the dashboard surprising, despite their experience with teaching for many years. ClassInSight helped instructors assess their performance, where some of them saw they were not doing well and there was room for improvement. They set goals for changing their behaviors on some aspects of their data and express how they would try to do better in the classroom. These findings show that the data from the ClassInSight dashboard together with the PD materials was helpful for teachers to reflect on their performance and recognize areas for improvement, and set goals to to change their behaviors.

Despite their performance, teachers expressed they often found it difficult to set goals and change their behaviors due to challenges and barriers in the classroom, that restrict their performance and dictate their behaviors. This included variables such as the classroom set up, the nature of the course, the materials, the technology used to facilitate lectures, students themselves, etc. These barriers made teachers unwilling to set goals, or unsure what goals to set and get around such barriers. These findings suggest that instructors in this study, potentially have an external Locus of Control (as Discussed in Chapter 6) which affects motivation, goal-setting and behavior change negatively. ClassInSight was not designed to support or affect Locus of Control, rather it focused on measuring or affecting teachers' SE. Further research is needed to properly measure instructors' locus of control and how to best support and affect it.

Further, even though most instructors expressed interest in nonverbal behavior data, and found their own data helpful to assess their performance, some instructors did not want to set goals to change their behaviors. They showed scepticism on the importance of teacher immediacy and nonverbals on student learning, questioned prior work and literature in this area and wanted to know if and how much these constructs have an effect on students. Some instructors even mentioned that they would be willing to change their behaviors only if ClassInSight could show them the relationship between their data and their students' data, or the type and magnitude of impact their behaviors have on students. As discussed in Chapter 6, the value teachers see in the task is important to motivation and it will affect goal-setting and behavior change. ClassInSight did have PD materials to show the value of such constructs to instructors, however it was not designed to affect value explicitly. Further research is needed to determine the best way to show or highlight the value of such constructs to instructors.

Proxies for Behavior Change in the Post-Questionnaire

Teachers reported that they learned from taking part in the study. In particular, they found both PD and data helpful to increase their knowledge and learning, but they believe they learn more from seeing their own data and the dashboard module. Similarly, teachers have an overall positive attitude towards the PD materials and the data they saw in the study, however their attitude towards their data and the dashboard is higher on average. Findings also showed that teachers have a generally more positive attitude towards gaze and eye contact data than towards location and position data. Further, the attitudes and learning are positively, strongly and significantly correlated with each other.

Further, teachers score high in their likelihood to engage in the behaviors recommended in the PD, showing that the PD module in the study incentivised teachers to attempt and engage in the recommended behaviors. Despite that, their likelihood to enroll in another PD module of related content provided they had the choice and their schedule permitted it, was much lower. This could be both an issue of value (teachers do not see the value of such behaviors) as well as an issue of locus of control (external time limitations make teachers more selective in the types of activities they can engage.)

In their willingness to change, teachers scored between "Neutral" and "Agree" which shows that they are relatively willing to change their behaviors. Teachers were more willing to change after seeing their data in the dashboard rather than after reading the information on the PD module. Looking at teachers' willingness to change specific nonverbal behaviors, teachers seem most willing to change their oculesic (gaze) behaviors than their proxemic (location) behaviors. In terms of their readiness to change teachers scored between "Thinking about it" and "Planning and making a commitment to it" on the scale. This shows that teachers in this sample are past the stage of "Not being ready at all to change their behaviors" and are "Thinking about it" towards making planning and commitment to this change. Teachers' willingness and readiness to change were strongly and positively correlated with each other and with the reported learning and attitudes discussed above.

In the post-questionnaire, almost a third of the instructors set one or more goals for changing their behaviors, while one instructor mentioned they already changed their behaviors in class after the study. Three instructors set goals for changing some behaviors, but mentioned that external factors would not allow them to set certain goals and change certain behaviors. Two teachers expressed they were not going to change their behaviors because they already do well with such behaviors in class, while one teacher said that even though they do certain behaviors, they made an effort after the study to make some small changes. The main goals teachers set to change their behaviors included looking more and more proportionally at students as well as moving around more and using technology such as clickers to allow for better mobility and not being stuck behind the podium. These findings are consistent with the interview findings discussed above.

Value in immediacy and nonverbals

In the pre-questionnaire, in terms of behavior change intentionality, half of the instructors were interested to change their behaviors, focusing on ways to better engage their students. Instructors acknowledged they had not had any training on those skills. Interestingly, one instructor mentioned that they would need to have a better understanding of the value of immediacy to be able to say if they wanted to improve their behaviors. While another instructor mentioned that there are external factors that inhibit them to do well in terms of those skills. These findings hint in the direction that the value of immediacy and nonverbal behaviors might not be enough to motivate teachers to improve on their skills. And even when they are interested in change, there are other external factors that could hinder their goal setting and improvement.

In fact, looking at how teachers scored in terms of their beliefs and values around immediacy and nonverbal behaviors, teachers in this study still scored high (between "Agree" and "Agree

Strongly"). Teachers saw more value for immediacy in teaching rather than in students' learning. Similarly, teachers saw more value in the gaze and eye contact nonverbal behaviors rather than location and position in class.

Surprisingly, the value teachers see in immediacy and nonverbal behaviors very slightly increased from pre to post, which could mean that the study materials (PD and data) need to do a better job at conveying and convincing the teachers of the value of such constructs.

In conclusion, the findings in this susbsection show that ClassInSight helped instructors assess their performance and set explicit goals for how to change their behaviors in the classroom. Through the various proxies for behavior change (learning, attitudes, likelihoods and willingness and readiness to change), teachers showed they are willing and ready to change their behaviors after the study, they set goals on what they want to change in relation to their oculesics, proxemics as well as other nonverbal behaviors they learned about in the PD materials.

To note is the finding that, even though in the study I was aiming to affect teachers' self-efficacy, value and locus of control came up in particular during the interviews as discussed above. Based on Chapter 6, these two variables have an impact in both their interest to change their behaviors and the goals they set to improve their practice in the classroom. However, the findings here suggest that their impact might be even bigger than what I hypothesized at the beginning of Part 2 of my thesis and than what prior literature suggests. The findings suggest that teachers have external locus of control, and "justify" and "blame" their performance on the barriers and challenges outside of their control. This external locus of control will make teachers less motivated to set goals and improve their behaviors in the classroom. As a result, a technology such as as ClassInSight should explicitly support teachers' locus of control for example by providing them actionable suggestions that move the locus from externally to internally. Further, some instructors expressed their scepticism on the importance of nonverbals and immediacy; it seems they see the value of such constructs to teaching but they are not convinced of the value, magnitude and type of impact on students and their learning. Once again, a technology such as ClassInSight should provide instructors with support on value, for example by showing relationships between teacher and student data, or showing causality.

Further research is needed to better understand how much locus of control and value affect goal-setting and behavior change, and how to best design tools and technologies that will support teachers in this aspect. My hypothesis is that out of these three constructs, in the higher education setting population, where instructors, in particular tenure faculty, have many other commitments often more important than teaching, the value they see in teacher immediacy and nonverbals is the most important to them wanting to change their behaviors. If the value is not there, despite their high SE, teachers will not be motivated to change and will likely blame external factors outside of their control for their performance. An exemplar of the importance of value for such instructors was expressed by one of the participants in the current study who said: *15-One of the comments that came back in FCEs was that professor X seems to care a lot more about thermodynamics than he does about the class. And I'm thinking damn straight. Yes. I know that was supposed to be an insult, but you know, I'm sorry."*

8.6.2 RQ2: How does motivational feedback affect teachers' values, efficacies, their goal setting and intentionality for behavior change

In the post-questionnaire, the social comparison group scores much higher on average than the verbal persuasion group in learning. The box plots of the two populations for overall learning are almost non-overlapping and distinct for learning from the dashboard. These results show that the social comparison group perceived they learned more in the study, in particular in relation to seeing their data and the dashboard. These results hint in the direction that seeing their own data perform better compared to other instructors, helps instructors report learning more both from the study overall and from the data specifically. Similarly, receiving a paragraph of text with persuasive and encouraging words (in the verbal persuasion condition) does not seem to help increase teachers' reported learning.

In addition, on average and overall the social comparison condition scores much higher in attitudes than the verbal persuasion condition. The box plots of the overall attitude for the two populations are distinct and non-overlapping. This could mean that seeing their data perform better when compared against other instructors (the social comparison group) leads to a more positive attitude for instructors than only seeing a paragraph of motivating text as feedback (verbal persuasion group).

Further, the Verbal Persuasion condition is consistently scoring lower on both willingness and readiness to change compared to the social comparison group. The box plots of the two populations in the readiness and willingness to change pare quite distinct from each other and non-overlapping. These findings show that the social comparison condition was more willing and ready than the verbal persuasion group to change their nonverbal behaviors in the classroom. These results hint in the direction that seeing their own data perform better compared to other instructors, helps instructors have a higher willingness and readiness to change their nonverbal behaviors.

All together, these findings hint in the direction that social comparison might be a better motivator for teachers for changing teaching practices and their behaviors in the classrooms. A potential reason for this could be that as verbal persuasion is dependent on the persuader, feedback coming from an app or us as researchers might not be as motivating to the instructors. On the other hand, in the social comparison condition, instructors saw themselves surpass their peers and this might have been most motivating for them to change their behaviors. This is also emphasized by the interview findings, where the instructors in the social comparison condition expressed much happiness and positivity after seeing their performance was better than others. While the instructors in the verbal persuasion group felt patronised or thought the text was not encouraging rather was hinting to them that they were not doing. Designers of such technologies should pay careful attention to the type of motivational feedback presented to the teachers, and should explore other types of motivational feedback that could result in even higher motivation and incentive for teachers, for changing their behaviors and practices in the classroom.

8.6.3 RQ3: What are teachers' values, data interests, assessment of their performance, motivations, etc., around teacher immediacy and nonverbal behaviors? How do such constructs change after teachers see their own nonverbal behavior data? How do these findings compare to the findings from Chapter 7?

Effect of the instructors' role

The population in the current study was majorly tenure faculty, while the population of the study in Chapter 7 was majorly teaching faculty. This is important to note as the distribution and scores teachers achieved in the various variables and measures during the current study, were different and lower in many cases compared to the Chapter 7 study. Further, issues with value and locus of control come up more frequently in the current study, as discussed above. A reason for this could be the different populations, in particular as teaching faculty and tenure faculty have different priorities, and maybe even values when it comes to teaching. This affects their motivation, time and energy they would put into teaching and as a result the goals they set and their intentionality and desire to change and improve their practices.

Only half of the instructors in this study had experience with the Eberly Center for Teaching Excellence and Educational Innovation at CMU. Similarly, outside of CMU, almost a third of the teachers did not have any prior experience with PD, while the other instructors had minimal experience with such PD. This distribution in experience is very different from that of the Chapter 7 study instructors, where the majority there had worked with Eberly at various lengths and had considerable experience with PD outside of CMU. An explanation for this difference could be that for tenure faculty, unlike for teaching faculty, teaching is not necessarily the primary focus and concern of their job as other matters related to research or administration maybe their primary responsibility. As a result, the time and effort they would put into PD and teaching is likely to be different from teaching faculty.

In terms of their familiarity with immediacy and nonverbal behaviors, most teachers had no idea what immediacy was while they were all familiar with nonverbal behaviors and could provide some examples. These results are similar to the Chapter 7 findings, where the lack of familiarity with immediacy is more due to this construct being only discussed in literature. Similarly, teachers in this study were moderately confident in their immediacy skills, but there was still room for improvement.

Self-efficacy

In terms of SE and SE for NVBs, instructors fell almost equally distributed between the mid and high SE/SE for NVB buckets. Unlike the Chapter 7 study, more instructors in this sample fell into the mid-SE/SE-NVB group, thus bringing down the averages of those constructs, compared to Chapter 7. Taking a closer look at SE for NVB, teachers scored much higher in their SE for gaze rather than location. This is consistent with the value and beliefs that teachers had about gaze versus location, as discussed above. Teachers scored high in their self-reported nonverbal behaviors, with still room for improvement. Teachers perceive they use gaze and eye contact way more often than they use location and position in class. This is also shown by the higher average score teachers get in this questionnaire in terms of oculesics than proxemics behaviors.

Motivation

When asked what things motivate them in doing the best in the classes they are teaching, the instructors in this study answered quite differently from the instructors in Chapter 7. For example, the main themes in the current answers revolved around student learning and success and the importance and beauty of the topic they were teaching. Constructs related to immediacy and nonverbal behaviors were far less common answers and less motivating to instructors in the current sample, unlike the Chapter 7 instructors. Again, the differences in the distribution of the population could be a reason for this, hinting at the differences in value or the importance teachers see in nonverbal immediacy. On the other hand, similar to Chapter 7, most instructors were intrinsically motivated in terms of teaching and almost half of the instructors were also extrinsically motivated. Looking at more detail into the teaching faculty versus the other faculty in this study, I found that the former score the highest in terms of intrinsic motivation and the lowest in terms of external regulation. This supports the reasoning that for teaching faculty, unlike for other faculty, teaching is the primary interest and focus of their jobs. This results in teaching faculty to be more intrinsically motivated in relation to teaching, while tenure and other faculty, for whom teaching is not their primary focus, might be less intrinsically motivated and more extrinsically motivated when it comes to teaching. Similarly, in terms of PD aspirations and Planned Efforts for teaching, the instructors in this study score lower from the Chapter 7 study instructors, in particular in terms of undertaking further PD.

Based on those observations and findings, I wanted to investigate if there were any statistical differences between the teaching faculty and the other faculty who took part in this study. The teaching faculty consistently scored higher than the other faculty on all the variables, except for external regulation. I found that the teaching faculty scored lower in their external regulation and higher in their efforts and aspirations. This would hint in the direction that teaching faculty are more motivated to put effort to improve their teaching, and their teaching is not extrinsically motivated, compared to other faculty. The box plots of the two populations shows distinct and almost distinct and non-overlapping patterns in terms of general self-efficacy, confidence, intrinsic motivation, external regulation and efforts and aspirations. These findings hint in the direction of teaching faculty scoring higher in many of the variables, in particular those related to general teaching and motivation. As described in Chapter 6, this is important as such constructs affect goal setting and ultimately lead to performance and behavior change. This again is understandable as for teaching faculty, unlike for other faculty, teaching is their specialty and profession, and the primary focus of their job.

To summarize, instructors in this study scored quite high in terms of the various variables measured in the pre-questionnaire. However, those scores were often lower than the respective scores of the Chapter 7 study. This might be an effect of the population distribution in Chapter 7 (a majority of teaching faculty) and the fall (a majority of tenure faculty), leading to different motivations, priorities and goals when it comes to teaching. Looking at differences between teaching faculty and other faculty in this study, I found that the former consistently scores higher than the latter on variables of interest such as self-efficacy and motivation. This could potentially mean that teaching faculty will be more motivated to set goals and work on changing their behaviors, compared to other faculty.

Pre-questionnaire statistics

In a statistical analysis of the pre-questionnaire data I found that there exist strong and positive correlations among many of the variables in the pre-questionnaire, with the exception of external regulation that is negatively correlated with all the variables. In particular, the SE variable was positively correlated with all the other variables including SE for NVBs, intrinsic motivation, Effort and Aspirations, value and confidence and negative correlated with external regulation. Those were strong and moderate correlations and they were all statistically significant! These correlations (together with the other correlations discussed in more detail in the findings section above) show the connection between the more general teaching constructs (such as SE and motivation constructs) to the specific constructs relative to this study that measure various aspects of teachers' immediacy and nonverbal behaviors (value, confidence, SE for NVB and self-reported nonverbal behaviors). As described in Chapter 6, expectancy and value constructs have an effect on learning and performance, by affecting motivation, which then directly leads to goal-directed behaviors that support learning and performance and ultimately lead to behavior change. Thus, the correlations and significant findings in this section show promise towards a path that leads to motivation, goals setting and ultimately behavior change for teachers' practices in the classroom in relation to their immediacy and nonverbal behaviors.

In addition, provided the importance of SE and the positive and strong correlations with the various variables in the study, I investigated differences between the mid and high-SE groups. I found that the high-SE group consistently scores higher compared to the mid-SE group, with the exception of external regulation where the medium SE group scores higher. Looking at the box plots of the populations, the mid-SE and high-SE groups are distinct from each other and non-overlapping. These findings again support the prior findings of the correlations that a high SE translates into higher scores on all other variables.

To summarize, in the pre-questionnaire, I found that many of the variables general to teaching and specific to immediacy and nonverbal behaviors, were strongly, positively and significantly correlated. In particular, general teaching SE was highly correlated with many variables. Bucketing the instructors based on this variable into mid and high-SE, I found that the two groups were different, with the latter scoring higher in most cases, compared to the former. Again, these findings are important especially when considering that constructs such as efficacy and motivation affect goal setting and ultimately lead to behavior change.

Post-questionnaire

I discuss in detail proxies for behavior change above and here I would like to emphasize how these findings were different from the Chapter 7 findings. To begin with, learning in this study is consistent with the Chapter 7 findings. However, in this study, the learning scores were higher than the respective scores from Chapter 7. This could be explained due to the population, where in the current study the majority of the participants were tenure faculty and had fewer experiences with PD and training, thus learned much more from this study than the Chapter 7 study counterpart. Further, teachers in this study scored lower in their attitudes, willingness and readiness to change compared to Chapter 7. Teachers in this sample were less willing and less ready to change their general and specific nonverbal behaviors in the classroom. Similarly, the value they found in immediacy and nonverbal behaviors on average in this study was lower than the Chapter 7 study.

Pre Post changes and differences

In terms of changes from pre to post questionnaire, there were no statistical changes per variable with the exception of SE for NVB which was significantly different (and almost significant after a Bonferroni adjustment). Some of the other variables slightly increased and some slightly decreased. These results are understandable as constructs such as SE and motivation are too large and broad constructs related to teaching, and as a result difficult to change significantly based on a single study. In particular, as the intervention in this study was not focused on teaching generally rather on a sub-aspect of it, namely immediacy and nonverbal behaviors. By the same argument, the construct of SENVB, which is related directly to the study intervention, increased significantly from pre to post. This hints in the direction that showing teachers PD together with their own data in relation to immediacy and nonverbal behaviors could help increase instructors' self-efficacy in relation to those behaviors.

To summarize, the only significant difference from pre to post was the SE for NVB score. This is positive and shows that the study intervention affected teachers' self-efficacy for immediacy and nonverbal behaviors. Again, based on the discussion in Chapter 6, a higher SE can lead to more motivation for setting goals and changing behaviors, thus this finding is very important in terms of how the intervention can help support teachers' behavior change.

Interview Findings: Discussion and Conclusions

The findings showed that overall teachers are interested in data about themselves. However, they expressed strong interest in data about their students, in particular engagement and attention in class. Interestingly, teachers had various definitions of what attention and engagement is to them. Further, teachers were interested in data that showed the relationship between teacher and student data such as what teacher behaviors correlate with student engagement and what teacher behaviors cause engagement or disengagement. Further research is needed to investigate how to best integrate these two data, teachers and students, while highlighting the relationships, correlations or causal between these data. Teachers also found comparisons of their data against their peers very helpful, as a way to assess where their performance is and what goals they should set and strive for.

Final remarks

To summarize, findings in this Chapter showed that ClassInSight helped teachers assess their performance and set goals to change in certain aspects of their nonverbal immediacy performance. Proxies for behavior change in addition to the interviews showed that instructors were willing and ready to change some of their behaviors. Further, instructors expressed interest in their own data and in student data such as engagement. Instructors were particularly interested in data that showed how teacher behaviors affect students in the classroom.

However, some instructors said they would not change their behaviors in class or they could not set goals to change. Issues around the value and locus of control came up as barriers to interest and possibility for behavior change. On the other hand, findings hinted in the direction that social comparison as a way to support SE might be a better motivator for teachers for changing teaching practices and their behaviors in the classroom. In addition SE for NVB significantly increased before and after teachers worked with ClassInSight, hinting at the importance of SE. Further exploration is needed to understand how value, locus of control and SE interact with each other, affect instructors, at what levels and magnitude, and how technology can best support motivation and behavior change by supporting and affecting such constructs.

Part3: Towards a teacher dashboard with teacher and student data to support teachers' reflection-for-action and behavior change

Chapter 9

Motivation for Part 3

9.1 Introduction

The investigations and studies in Part 1 and Part 2 resulted in very interesting findings, which answered some questions and raised even more questions worth exploring in Part 3. There were many interesting directions I was considering taking this work: from better understanding the dilution observed in Part 1, to measuring actual behavior change in Part 2, to focusing on detangling the relationship and importance between SE, value and locus of control, to creating a pipeline for generating specific nonverbal measures from raw sensor data, etc. Provided it was not possible for me to do everything, I decided to pick the most interesting of those directions and what seemed most important to investigate first, based on what I learned from Part 1 and Part 2. Below I summarize what Part 3 of my thesis work is going entail.

1. First, I decided to investigate the issue with the value of teacher nonverbal immediacy that came up in the findings in Chapter 7 and Chapter 8. On one hand, instructors questioned the value and magnitude of such behaviors on their students. On the other hand, literature has shown such value, but primarily focusing on self-report measures. Little work has focused on working with and drawing conclusions from actual teacher and student data from the classroom. Motivated by this, in Chapter 10 I decided to focus on exploring patterns of behaviors, in particular with potential for improvement on both teacher and student data. Further, I also aimed to explore any relationships (i.e., correlations) among such data. My goal was to take the first step towards showing value of such behaviors using patterns and relationships from the data.

2. Second, I decided to further investigate how to integrate teacher and student data while also supporting teachers' reflection-for-action. Findings from Part 1 and Part 2 showed that teachers were interested in student and teacher data respectively. In particular, in Part 2 they expressed interest in having both teacher and student data. Further, no prior work has focused on combining both teacher and student data, with the aim to support teacher behavior change. Motivated by this, in Chapter 11 I focus on investigating how to integrate and combine teacher and student data, and support teachers' reflection-for-action through supporting SE and Value. To the best of my knowledge, this is the first work that takes a step in this direction, getting closer to creating a technology that can be tested in the classroom and teachers can use to work on their practice and improve their behaviors.

Chapter 10

Investigating Patterns of Behavior with Potential for Improvement and Relationships Among Teacher and Student Data

Abstract Prior work has shown that teacher nonverbal immediacy is one of the most valuable tools instructors have available to them. However, much of prior work relies on self-reports to measure the effects and value of nonverbal immediacy in the classroom. Little work has focused on investigating patterns and relationships from actual teacher and student nonverbal behaviors in the classroom. New technologies such as instrumented classrooms create multiple opportunities to collect large amounts of data for such investigations. In this work, I explore and analyze data collected from 45 courses with the EduSense instrumented classroom, and generated through human coding (17) or machine learning models (28). The aim of this work is to explore patterns of behaviors, in particular with potential for improvement, and relationships among teacher and student data. Overall, I found very interesting patterns in teacher behaviors such as them spending the majority of class time immobile, in one location, or looking at their students on average less than half of class time. Further, I found some weak to moderate correlations among teacher and student behaviors, which hint towards the value and importance of nonverbal immediacy. In this chapter, I discuss the contribution of this work and provide design guidelines for technologies that share with teachers data from the classroom.

10.1 Introduction

Teacher immediacy is conceptualized as those nonverbal behaviors (i.e., location and movement in the classroom, eye gaze, body posture, gestures, etc.) that reduce physical and/or psychological distance between teachers and students and increase their interpersonal closeness, with the goal of enhancing student learning [22, 23, 102, 201]. Nonverbal immediacy behaviors are some of the most valuable communication tools instructors have available to them [201]. Nonverbal immediacy behaviors have been shown they are important to teachers, to student learning and students' attitudes towards learning [22, 63, 173, 253]. More in general, teacher immediacy has been shown to positively associate with a range of classroom variables [251, 253] such as perceived instructor credibility and fairness, student intent to persist in college, etc.

Prior work has majorly focused on measuring the effect of teacher immediacy through variables such as students' self-reported learning and their perceptions of their understanding and learning, students' attitudes towards learning, the course and the instructors, students' perceptions of teacher immediacy, instructors' own self-reporting or observations from a third party (i.e., [25, 199, 253]). However, this limits the scalability of the amount of data that can be collected and is also subjective based on the reporter. Little prior work has looked at exploring patterns of behavior of teacher and student nonverbal data in the classroom, what areas for improvement are there and what relationships exist among and between teacher and student data. Part of the reason for this is that prior to instrumented classrooms, it was very challenging to collect such data at scale from the classroom, which is also why much of the prior work cited here relies on self-reports. Recent work from Martinez-Maldonado et al. (i.e. [160, 162, 164]) uses a combinations of multiple sensors and human coders to look at the classroom proxemics (teacher and student location) in a lab setting, as students are working in a collaborative environment. My work in this chapter goes beyond this work as it focuses on classrooms in-the-wild, and in multiple types of nonverbal behaviors (not only proxemics) with the aim to explore patterns and relationships in the data.

In addition, my prior work and findings from Chapter 7 and Chapter 8 showed that teachers, despite the being shown the prior work on the importance of nonverbal immediacy behaviors, were sceptical of the value or magnitude of the value on students. They expressed that they wanted to see the actual relationship and magnitude of the effect between teacher and student data, and how their actions and behaviors would affect their students. Further, teachers expressed interest in social comparison as a way to assess how they are doing and to see how their performance compares to others. Lastly, while looking at their data, some instructors assessed their performance as not doing well and identified various areas of improvement for their behaviors. This shows that potentially, across instructors, there might be similar or other major areas for improvement.

My work in this chapter is motivated by the gap in literature and findings from Part 2 as discussed above. In this chapter, I aim to investigate various patterns of behavior in the classroom both on teachers and students, identify any potential areas with room for improvement on teacher behaviors, and explore relationships among teacher data, student data and between teacher and student data. I use the EduSense [11] instrumented classroom that creates the opportunity to collect a massive amount of data from multiple courses and class sessions. Specifically, I collected data from 45 courses over 3 semesters, where data from 17 courses was hand coded by human coders, and data from 28 courses was automatically coded by the EduSense machine learning models. The research questions of this chapter are the following:

1. RQ1: What common patterns of teacher and student behaviors are there in the classroom and what areas for improvement can we identify?
2. RQ2: What relationships can we determine between teacher and student data?

Findings showed some very interesting patterns of teacher behaviors in the classroom. For example, teachers are very immobile; they spend the majority of class time on one side of the classroom, typically close to the podium. They do not move a lot and their location is not equally distributed to across their students. Further, teachers also spend less than half of class time on average looking at their students and are not balanced in how they distribute their gaze in different sides of the classroom. Lastly, I found some weak to moderate relationships among teachers' own data and teacher and student data. This is a first step towards exploring and identifying the relationship of teacher actions with student engagement, and even student learning, in the future.

The findings aim to create new knowledge around patterns of behaviors in the classroom, and fill in the above mentioned gap in the literate. Further, findings from this chapter provide solid design guidelines for designers of technologies that share with teachers data from the classroom and fill in the gaps of teachers' needs as discussed in my prior work in Chapter 7 and Chapter 8. In particular, these results will help in providing to teachers evidence of the value of such behaviors in the classroom (i.e. through showing the areas for improvement in their behaviors, the relationships among teachers and student data and the social comparison of their data with other instructors). The findings from this chapter also support the design of the dashboard prototypes for Chapter 11, of integrating teacher and student data in one interface to support teachers' reflection-for-action. My work in this chapter is a pioneer in using big data from multiple courses and class sessions over multiple semesters, while focusing on a variety of teacher and student nonverbal data, to determine the value of nonverbal immediacy behaviors.

10.2 Related Work

Immediacy is the perceived closeness between people that is achieved through language and communication [247]. Teacher immediacy is conceptualized as those nonverbal behaviors that enhance closeness to and interaction as they reduce physical and/or psychological distance between teachers and students and increase their interpersonal closeness, with the goal of enhancing student learning [22, 23, 102, 172, 201]. Nonverbal behaviors that teachers can use in their teaching include location and movement in the classroom, eye gaze, smiles, nods, relaxed body posture, gestures, etc [25].

Nonverbal immediacy behaviors are some of the most valuable communication tools instructors have available to them [201]. For example, nonverbal immediacy behaviors are important to teachers to better understand student nonverbal messages and to gain the ability to send students positive signals that reinforce learning and at the same time avoid negative signals that hinder learning [173]. Further, prior work has shown that teacher immediacy is meaningfully correlated with student learning in the course, positively affects students' perceptions of their understanding and learning, and has a modest relationship with students' actual learning performance in the course [22, 63, 253]. When teachers display more immediacy in the classroom, students evaluate more positively the class, the instructor, the subject matter and course content [22]. Teacher immediacy has a positive relationship with students' attitudes towards learning. More immediate teachers are more motivating to students and students are more likely to develop positive attitudes and interest toward the class, attend class more and approach rather than avoid the subject [22, 64]. More in general, teacher immediacy has been shown to positively associate with a range of classroom variables such as perceived instructor credibility, fairness and clarity, instructor-student out-of-class communication, student compliance, students' perceptions of being mentored, student intent to persist in college, etc. [251, 253].

Nonverbal immediacy is communicated by a set of nonverbal behaviors including proxemics (the decreased physical distance, location and position) and oculesics (the gaze and eye contact). There exists a large body of research that has studied the effects of the instructors' use of proxemics and oculesics while teaching on their students and the classroom environment.

To begin with, research has shown that immediate teachers communicate at physically closer distances and they choose direct unimpeded angles when interacting with their students. They spend time among their students rather than behind their desk or a podium [24]. In contrast, a teacher who stands behind their desk or podium and rarely approaches their students or allows them to approach her/him is perceived by students as unfriendly, unperceptive, unapproachable, and non-immediate and non-caring. The teacher who withdraws from students is perceived as non immediate and non-caring [201]. Similarly, teachers who sat at, on, beside, or behind their desks were rated by students as low in both affection and inclusion. Teachers who moved in front of their desks or among their students were perceived as warm, friendly, and effective [[119]. A significant positive relationship was found between the teachers' spending time in front of the desk and the students' feeling that they were part of a class unit.

Further, research has shown that direct eye contact and gaze can provide psychological closeness between teachers and students and has been shown to be an important component of the teacher's immediacy. Good eye contact increases rapport [23, 25]. Eye contact permits teachers to more easily monitor and regulate their classes while simultaneously signaling warmth, attentiveness and immediacy [24]. High levels of gaze make students more attentive to the teacher [50]. For example, students in high eye contact availability are more likely to participate than those in low eye contact availability. The teacher who rarely looks at the student when talking is communicating that he or she is not very interested in that student and that the teacher is not approachable [50, 201]. Teachers who look at their students are perceived as more animated, more interested and more immediable [201]. Eye contact is such a basic immediacy cue that its absence makes the warmest teachers seem cold and distant [24]. For example, [50] found that the absence of eye contact between teachers and university students usually produces negative feelings in students.

Although the study of nonverbal behaviors is not new, the majority of the work in prior literature has relied on self-reports or observations from third parties, in a small number of classes or instructors and not actual, measured or manipulated immediacy cues [251, 253]. For example, measures for teachers self-reporting their behaviors or third parties observing teacher behaviors are commonly used in the literature (i.e., [23, 25, 200]). Further, measures for students to share their perceptions of teachers' immediacy (i.e., [23, 25]), or their self-reported learning, their perceptions of their understanding and learning, and their attitudes towards learning, the course and the instructors, are also commonly used in the literature (i.e., [63, 102, 199, 252]). These measures however introduce bias due to the subjectivity of the party who is reporting this information. In addition, they make scaling up (i.e., collecting data in multiple class sessions and courses at the same time) very challenging to impossible.

Little prior work has focused on actual measures of teacher and student nonverbal behaviors in the classroom. For example, more recent work from Martinez-Maldonado has started looking at classroom proxemics and how teacher and students use classroom space [160, 161, 162, 164]. Specifically, this work focuses on collaborative learning environments such as laboratory settings of team simulations in healthcare, or physics laboratories. The work uses a multitude of indoor sensing technologies in addition to human coding to better contextualize the data in the classroom. The aim of the work is to collect data on students as a way to provide them feedback and reflect on their performance, as well as provide data to teachers to help them gain insights into their classroom. The overall purpose of the work is to create designs that share meaningful and explanatory data and understand how this data can be helpful to instructors.

My work in this chapter is different from this work in multiple dimensions. To begin with, I look at a variety of nonverbal behaviors, besides proxemics, in the classroom. For proxemics specifically, the behaviors I focus on are also different from the work above, as I do not restrict the type of course to a collaborative learning environment only. Further, I work with teacher and student data, both combined and separately. The data for this chapter was collected in a "in-the-wild" setting, which is very different from a laboratory setting as described above, and focuses on multiple classrooms and instructors of different subjects and courses over multiple class sessions and semesters. Lastly, the aim of this work is to better understand patterns of behaviors, potential for improvement and relationships between and among teacher and student data. This work is a pioneer in advancing the state of the art and knowledge on teacher and student behaviors in the classroom, as a way to determine the value of nonverbal immediacy behaviors.

10.3 Methods

In this chapter, I will focus my investigation and analysis on two sets of classroom data. Both sets include video recordings of classroom sessions at an R1 institution (CMU) collected with the EduSense instrumented classroom system. The first set, which I call the *Hand Coded Data*, was entirely generated by human-codings of video recordings of classroom sessions. The second set, which I call the *Automatically Generated Data*, was generated by the EduSense system automatically, through its machine learning models, and then processed manually as described below.

10.3.1 Hand Coded Teacher Data

The hand coded teacher data was collected and generated during the study I conducted in Chapter 8, in Fall 2019. The video data was initially manually collected by 16 RAs, who then used a coding protocol to do behavior coding on each of the videos. The coders used the Boris software to code when each behavior would happen. I then created a Python script to process the codings and generate the data used in this chapter. This process is described in more detail in Chapter 8, Methods section.

The behaviors included in the data set are as follows: (1) percentage of class time the teachers' gaze is directed towards the students (including percentage of time the gaze is directed at the left, center and right sides of the classrooms), (2) percentage of time the teachers' gaze is directed in other locations in the classroom (including percentage of time the gaze is directed at laptop/notes, board, projector slides, and transition/thinking gaze), (3) percentage of time that teachers are sitting or standing, (4) percentage of time that the teacher is location at the front of the classroom (left, center or right) and among students (other), (5) percentage of time the teachers' location is behind the podium, in front of the podium or in another location not near the podium. The behaviors coded did not include any student data except for (6) percentage of students sitting on the left, right and center side of the classroom. The reason for not including student behaviors is because human-coding such behaviors would be too tedious, and almost impossible to track. Lastly, I collected (7) class time in hours and class sessions per instructor. An example of the classroom split into left-center-right is shown in Figure 10-1.

The percentage data was aggregated per instructor (all class sessions per instructor were averaged into one value for each of the teacher behaviors mentioned above). In total, there were 17 instructors (17 courses), each ranging with 2-6 class sessions per course, with a total of 67 class sessions of varying lengths (50 mins to 80 mins, with a few class sessions being more or less

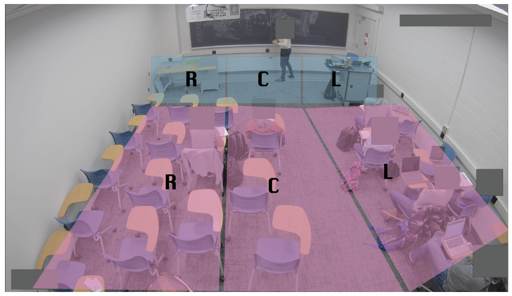


Figure 10-1: Classrooms were manually separated into left-center-right at the front and among students.

depending on how much recording time I was able to get from the classroom). The total video data time across instructors was 64.7 with and average of 3.8 hours of data per instructor.

To determine if I should report the data in aggregate form (per instructor, thus 17 data points) or per class session (in total 67 class sessions) I ran a variance component analysis which aims to measure the variance of within and between groups of subjects [4]. I ran the analysis on a couple of variables, including teacher gaze, teacher location left, center, right, etc. The intraclass correlation coefficients were closer to 1 (i.e. teacher gaze to students coefficient = 0.86 and teacher location left coefficient = 0.80), which by definition means that the between group variance (across 17 data points) is more important than the within group variance (within each instructor, across the 67 data points). Thus, in the analysis I will focus on reporting the aggregate data per instructor for each of the behaviors discussed above.

Further, to help the analysis I calculated some intermediate variables. First, I calculated teachers expected gaze and location if they were to take in consideration where students are sitting. Namely, if students are sitting 50% on the left, 20 on the center and 30 % on the right, that should be teachers' expected location percentage distribution (out of 100%) and gaze percentage distribution (out of their current % of teacher gaze to students).

Further, I created what I call "collapsed measures" of teacher behavior; projecting three or more dimensions into one dimension. I did this with the aim to compare among different teachers and different dimensions by normalizing their behaviors on a scale from 0 to 1. First, I collapsed teachers' location left-center-right and teachers' gaze left-center-right into a teacher location collapsed variable and a teacher gaze collapsed variable. To calculate these variables I used a simple entropy formula, *(SUM(ABS(1/3-D1), ABS(1/3-D2), ABS(1/3-D3)))/(4/3)* where D1, D2 and D3 represent the 3 original dimensions. For example, if a teacher has a percentage distribution of gaze to students into the left-center-right sides of the classroom 14%-10%-5% then the collapsed measure of these 3 dimensions into one would be 0.53. The closer the collapsed value is to 1, the more the instructor is spending time in and favoring one of the sides of the classroom, and the closer they are to 0, the more balanced their behavior is in relation to the left-center-right sides of the classroom. Second, I created a collapsed teachers' location that takes into consideration 4 dimensions: teachers location at the left-center-right-other, where other includes when instructors are located among students and left-center-right when they are at the front of the classroom only. The entropy formula for this calculation is *(SUM(ABS(1/4 - D1), ABS(1/4-D2), ABS(1/4-D3), ABS(1/4-D4)))/(1.5)*.

Finally, I created two collapsed variables to encompass: 1). teachers' current location behavior in the left-center-right vs the expected one based on where students are sitting on the left-center-right, and 2). teachers' current gaze behavior towards the left-center-right vs the expected one based on where students are sitting on the left-center-right. The entropy formula for this calculation is *=(ABS(C1-E1)+ABS(C2-E2)+ABS(C3-E3))/2* where C1,C2,C3 are the current teacher behaviors and E1,E2,E3 are the expected teacher behaviors.

In the findings section, I make use of various analysis and charting methods including correlations and correlation matrix calculations, regression models, various forms of chartings and box plots.

Even though this hand coded data set only includes teachers data, I decided to analyze it to investigate patterns of behaviors only among teacher data and relationships between those behaviors. The hand-coded teacher data is much more granular and includes more variability and detail than the teacher data the EduSense system can automatically provide as discussed below. Further, the hand-coded data is potentially more accurate than the EduSense system data as to measure EduSense's accuracy and to train its machine learning model, the standard is to hand-code classroom behaviors and use that data as ground truth [11]. Despite that, there is potentially a small margin of error between the absolute, real data and the hand coded data by the human coders. This margin of error could be due to coder-error and could potentially be emphasized by the camera angle in the classroom. For example, when the camera is on the far left back wall of a wide classroom, and the instructor is standing behind the podium on the far right of the front wall, even for human coders there is going to be some difficulty in determining if the instructors' gaze is directed at the students right in front of them or at their laptop, right in front of them. Similarly, when the instructor is standing at the right side of the classroom at the front and is looking to their left, depending on the camera angle, it might be challenging to determine 100% accurately if the instructor is looking towards the center or left, especially in wider classrooms. Lastly, there might be a small margin of error in counting where students are sitting (left, center, right) as sometimes they might be sitting between two areas (i.e. left and right) and sometimes, depending on the camera view, they might not be captured on the video.

10.3.2 Automatically Generated Teacher and Student Data

In addition to the hand coded data, I decided to also analyze a set of data that had been automatically collected and generated by the EduSense instrumented classroom system. I was interested in this data set in particular as it includes teacher and student data across multiple class sessions and courses. For the analysis I used data generated from video recordings of 28 courses that ran in the Spring, Summer or Fall 2019. There were a total of 380 class sessions in this set after filtering data that was empty or was erroneous (i.e., data that showed 0 students in class). The minimum number of sessions per course was 2 and the maximum was 34, with the median being 11 and the average being 13.5 class sessions per course. Based on this description, it can be seen how easy and feasible it is for an instrumented classroom such as EduSense to collect large amounts of data, almost 5.6 times more class sessions than the hand coded data.

Once EduSense had generated the data, my team and I worked on processing it to bring it to a form that had meaning in the classroom environment. An example of this process is described in Chapter 7. In a nutshell, my team and I created Python scripts that would take the raw data, and using manually inputted information about the classroom (such as size of class or location of the podium) split the classroom into two regions: left and right. Then using these regions and the raw data, the scripts (using machine learning and methods such as principal component analysis) would generate the following higher level data: (1) percentage of time the teacher is located at the left-right side of the classroom at the front, (2) percentage of time the teacher is at the podium (in close proximity to the podium), (3) percentage of time the teacher is looking left-right at the students, (4) teacher movement as a variance of their location in the classroom, (5) student density in percentage form at the left-right sides of the classroom, (6) percentage of time students' gaze is directed at the left-right sides of the classroom at the front. For example, x-coordinates of teacher location do not make much sense on their own. We mapped them into the front of the classroom (Figure 10-2) and then grouped them into left and right sides of the classroom.

Here I will share how each of those variables is measured and calculated. The definition of a frame is a snapshot of the classroom taken every few seconds (i.e. 1-2 seconds) and is used as a unit of time in the following definitions and calculations.

1. To calculate teacher gaze and location percentage to the left and right, we calculate the respective individual percentages per frame, sum the values up and divide by the number of frames per class session. This gives us a percentage of frames, or a percentage of time the teacher is located or gazes to the left and right.

2. The podium proximity is calculated using the location of the podium, location of the instructor's head, and a proximity metric. The proximity metric is determined on a room-by-room basis (what, from the camera's point of view, is a reasonable radius to consider "at the podium"). If the instructor is within the defined radius of the podium for a given frame, it is added to the "at podium" bucket. This is divided by the total number of frames. In summary, the podium proximity metric is the percentage of frames/time the instructor is "at" the podium, and thus is on a 0%-100% scale.

3. Teacher movement is a variance of the location coordinates of the instructor across all frames for a class sessions calculated as a statistical variance. The minimum value is 0, but there is no maximum as the variance can theoretically be as high as possible (within reason). The variance scale will not only depend on the instructor, but also the distance of the camera and its angle per room.

4. To calculate student gaze percentage to the left and right, we count the number of students who are looking left and the number of students who are looking right per frame. We sum up all those values and divide by the total number of frames for that class session.

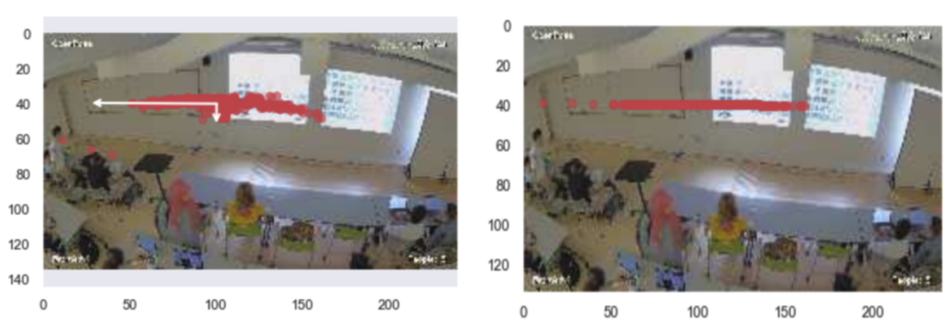


Figure 10-2: Teacher x-location scatter plotted at the front of the classroom then normalized in a line using principle component analysis. This information is then used to group the instructors' location into the left-right region of the front of the class

Further, similar to the hand coded data, I created collapsed variables including collapsed teacher location, collapsed teacher gaze and collapsed student gaze. To calculate how to collapse 2 dimensions into one I used the simple entropy formula $ABS(0.5 - D1) + abs(0.5 - D2)$, where D1 and D2 would be the left and right percentages for the variables mentioned here. Similarly, I created a collapsed variable for teacher current location vs teacher expected location based on where student are sitting and teacher current gaze vs teacher expected gaze based on where the student are sitting. To calculate this collapsed variable I used the following entropy formula, similar to the one described above in the hand-coded data but instead of 3 it has 2 dimension comparisons $(ABS(C1 - E1) + abs(C2 - E2))/2$. Further, provided that the teacher movement is a metric of teachers' location variance, I decided to standardize the values [5] in order to be able to compare across the different variance scales across classrooms. Through this standardization, the movement variance distribution would roughly be the same range as a normal distribution.

Similar to the hand coded data, in this analysis I will report general statistics and patterns of teacher and student behaviors, as well as relationships such as correlations and regressions among the variables. To determine if I should report the results on the 28 aggregate data points per instructor and course, or per class session (380) data points, I ran a similar variance component analysis as described in the hand coded data section. Again I found that the intraclass coefficient was closer to 1 for many of the variables (student gaze right coefficient = 0.93, teacher location left coefficient = 0.59, instructor gaze left coefficient = 0.80). This shows that the between variance is the most important, thus I will report only on the 28 aggregated data points in this analysis.

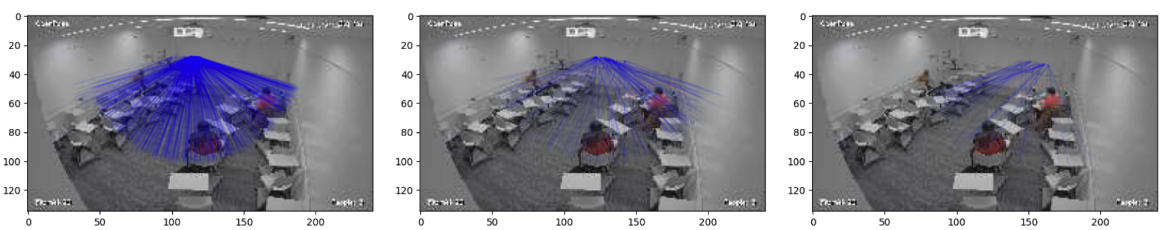


Figure 10-3: Teachers gaze vectors can be extended to determine if they belong on the left-right side of the classroom. However, as seen in this image, many vectors cross through both the left and the right.

Despite the huge amount of data in this data set, as well as the opportunity to work with both teacher and student behaviors, there is less granularity in this data set (i.e., only left and right separation, and no detailed teacher gaze data for other locations in the classroom) and there are some potential limitations to the accuracy of the generated data. For example provided the camera angles, the automatic split of the classroom into left-right might not have been accurate in all classrooms. Further, for teacher and student gaze, there is potentially a higher inaccuracy in the data given the version of the EduSense gaze model I was using for this study. Specifically, the gaze module converts the teacher gaze in 3D space into a 2D gaze vector coordinate. This causes loss of a lot of information such as when the teacher is looking at their laptop, it is challenging to impossible for the model to determine if they are looking at the laptop or across their laptop, at their students. Often it is challenging to automatically detect who the instructor is as EduSense does not do face recognition. As a result, we have to relay on other methods to infer the instructor standing at the front, which brings in other inaccuracies such as not being able to detect the instructor or mistaking another party for the instructor. Lastly, again for teacher and student gaze, it is impossible for the system to determine 100% accurately if the teacher is looking left or right if the teacher is not looking directly in front of them, but rather at an angle (Figure 10-3).

10.4 Findings

10.4.1 Hand Coded Teacher Data

General Info

In this section, I will discuss the findings of analyzing data collected from 17 courses and 67 class sessions of different lengths. The total number of hours included in the data is 64.7 hours with an average of 3.8 hours per class and a minimum of 1.6 hs and maximum of 6.0 hs per class.

Location

Findings show that teachers spend a lot of class time in one location (Figure 10-4). For example, the majority of the teachers in this data (14 out of 17) spent on average more than 50% of class time in one location (left, center or right at the front of the classroom). Further, almost a third of the instructors (6 out of 17) spent 70% or more time in one location while 2 of them spent more than 90% of their time in one location. In addition, the majority of the teachers spend their time in front of the classroom, with only 6 out of 17 spending some time (more than 5%) among their students (in the "Other" location). Out of those 6, only 2 spend more than 50% of the time with students, with the rest spending less than 20% of the time among their students (Figure 10-4). On average teachers spend most of their time on the right (33.1%), followed by center (30.4%), left (26.5%) and other time among students (10.1%). However the standard deviations per each measure are quite high as shown in Table 10.1. Box plots of teachers location at the left, center, right and other locations are shown in Figure 10-9.

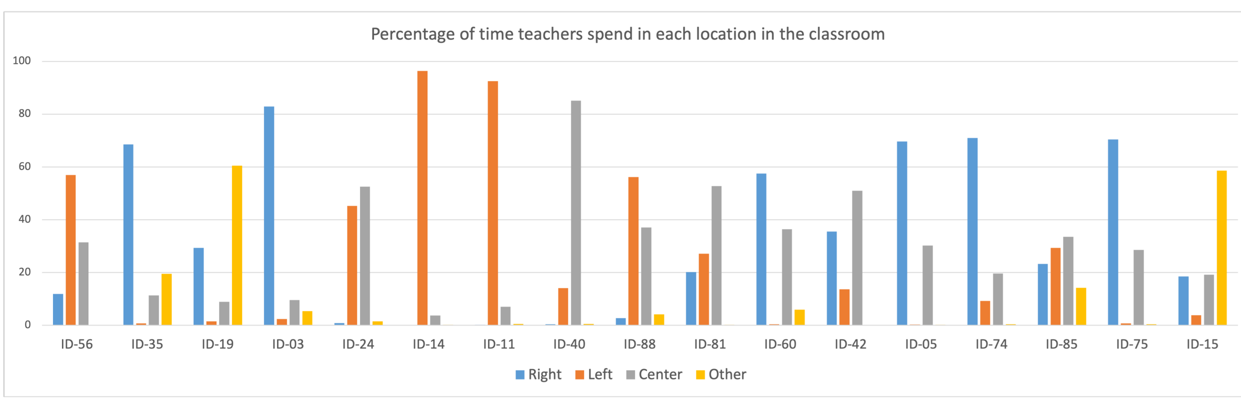
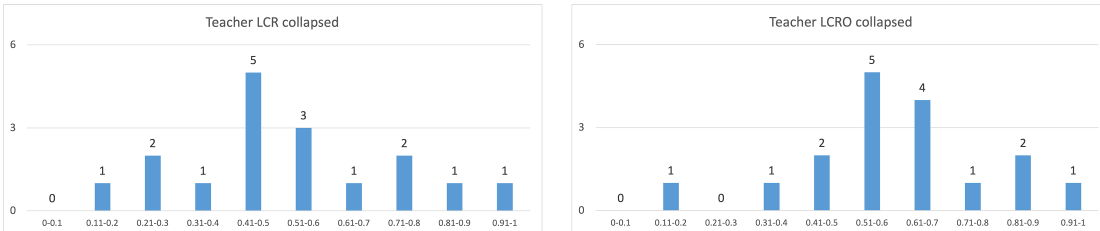


Figure 10-4: Percentage of time each instructor spends at the front of the classroom (left, center, right) or among the students (other)

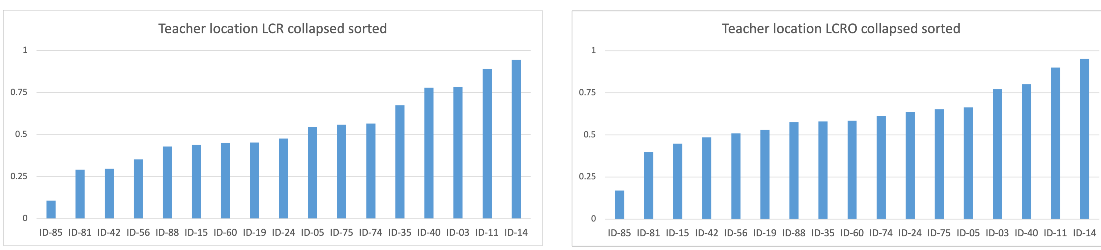
In Figure 10-5 I show the collapsed measures of teachers' location in the left-center-right at the front of the classroom (left image) and the collapsed measure of teachers location in left-center-right-other in the classroom (right image) distribute between 0 and 1. The instructors with a measure closer to 0 have a more balanced location position, namely, they tend to spend a roughly equal amount of time on all sides of the classroom. Instructors with a measure closer to 1 have a less balanced, more skewed location, favoring one side of the classroom over the others. The figures show an overall normal distribution of instructors' collapsed location measure. With fewer teachers being balanced (close to 0) and the majority being unbalanced, with a score in-between 0 and 1 or closer to 1 (Figure 10-5).



(a) Percentage left-center-right collapsed. (b) Percentage left-center-right-other collapsed.

Figure 10-5: Teacher percentage of time per location collapsed in one dimension.

Further, to show how teachers compare against each other in terms of their location (i.e., in a social comparison condition), I have created Figures 10-6 where I sort instructors from most to least balanced in the percentage of time they spend in various locations. In this chart, one can see where each instructor stands compared to the others, and how the majority of instructors tend to be skewed in their location in the classroom. Very few instructors score closer to 0 in their collapsed location measure.



(a) Collapsed left-center-right location sorted. (b) Collapsed left-center-right-other location sorted.

Figure 10-6: Teacher collapsed location sorted from most to least balanced.

However, teachers' balance could depend on where the students are sitting in the classroom. For example, if their students sit on the left and center, it makes no sense for the instructors to be located at the right side of the classroom. For this reason, I calculate the teachers' expected location in location left-center-right based on the student density on the left-center right sides of the classroom, and I collapse in one variable the expected location and the current location (as described in the methods section). In Figure 10-7 I share the sorted collapsed variable, where again, a minority of instructors are balanced in their location, while the majority are closer to being skewed or unbalanced. However, in this chart where I take into consideration students location density, teachers are less unbalanced than in the prior charts when student location was not taken into consideration, as shown in Figure 10-6.

Except for one teacher who sat 75% of the time, all the other teachers stood for at least 90% of the time. In relation to their location relative to the podium, teachers stood on average stand 37% of the time behind the podium, with a minimum time of 8% and a maximum time of 89% (Table 10.1). In Figure 10-8 I show the distribution of teachers' percentage of the time behind

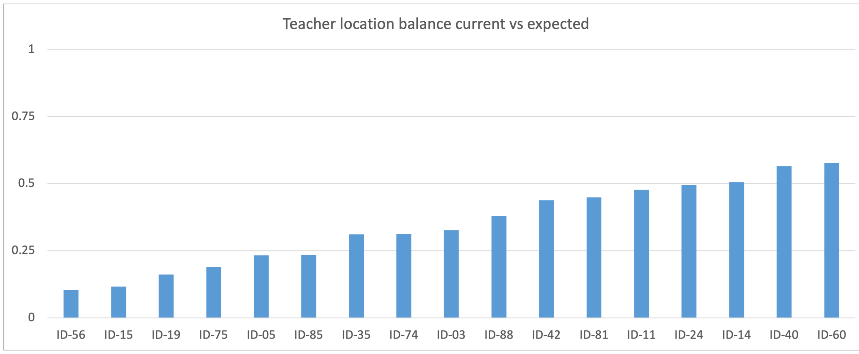


Figure 10-7: Teachers location vs expected location based on student density collapsed in one measure.

the podium. The majority of teachers spend less than 40% of class time behind the podium.

On the other hand, most teachers spend very little time in front of the podium (less than 4%) with only one teacher spending 17% of the time in front of the podium. A box plot of instructors' location at the front or behind the podium, or not at the podium is shown in Figure 10-9.

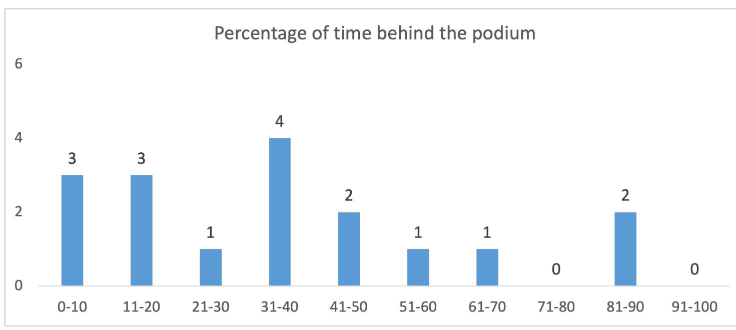


Figure 10-8: Instructors' percentage of time behind the podium

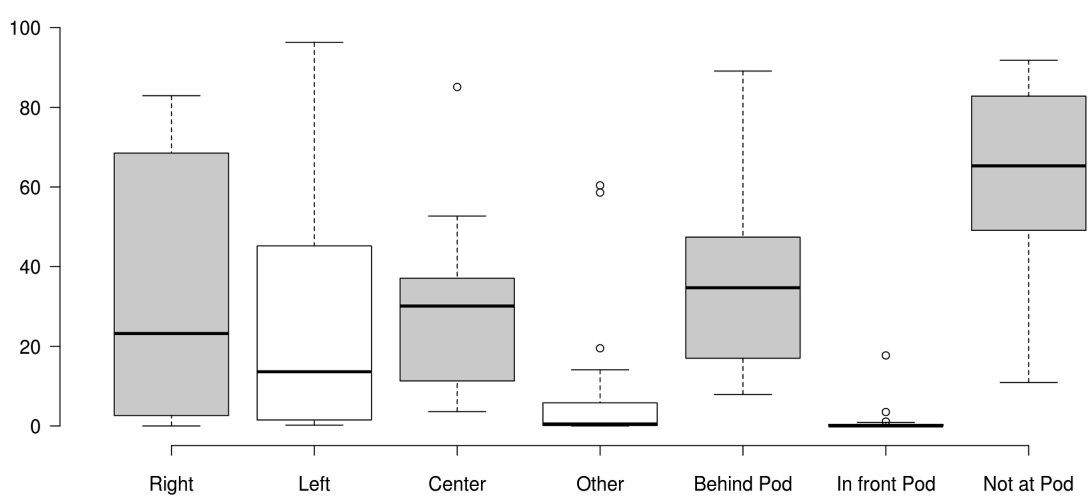


Figure 10-9: Box plots of teacher location related variables.

	Teacher Location				Podium				
	Right	Left	Center	Other	Behind	In front	Not at	Sit	Stand
AVG	33.1	26.5	30.4	10.1	37.0	1.4	61.6	5.3	94.7
STDEV	30.3	32.1	21.3	19.4	25.0	4.3	25.3	18.1	18.1
MIN	0.0	0.2	3.6	0.0	7.9	0.0	10.9	0.0	24.7
MAX	82.9	96.3	85.1	60.4	89.1	17.7	91.8	75.3	100.0
Median	23.2	13.6	30.1	0.5	34.7	0.0	65.3	0.0	100.0

Table 10.1: Teacher location related variables, in percentage of time unit

	Left	Right	Center	Students Overall	Laptop/ Notes	Board	Slides	Think/ Transit	Other Overall
AVG	11.1	17.9	13.5	42.5	17.6	17.9	14.9	7.1	57.5
STDEV	11.7	11.5	7.5	18.4	15.0	20.6	13.4	5.8	18.4
MIN	0.1	2.7	2.5	9.5	1.9	0.0	0.0	0.5	25.2
MAX	36.8	42.5	28.2	74.8	59.6	60.5	35.8	20.0	90.5
Median	5.7	15.7	12.8	44.2	13.7	9.1	13.1	5.4	55.8

Table 10.2: Teacher gaze towards students and other locations, in percentage of time unit

Gaze

Teachers look at their students on average 43% of the time which is less than half of class time. The maximum amount a teacher looked at their students in this data set is 75% of class time and the minimum is 9.55% of the time (Table 10.2). In total, 12 out of 17 teachers looked at their students less than 50% of the time during class, while a majority (16 out of 17) look at their students less than 70% of the time. There were no instructors who looked at their students 75% of the time or more. In Figure 10-10 I show the distribution of instructors' gaze towards students overall.

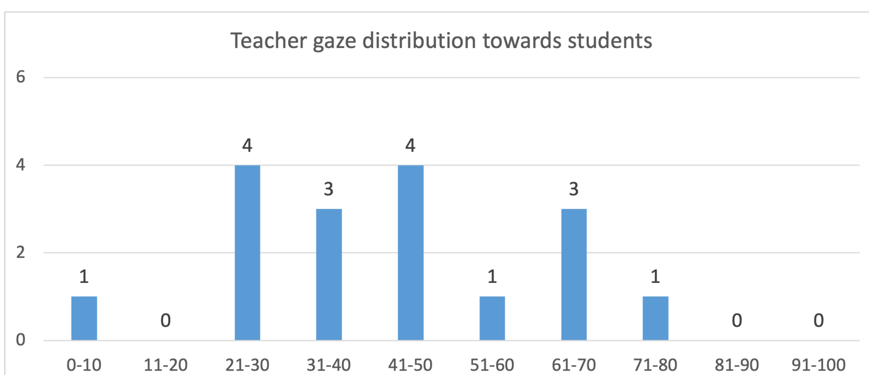


Figure 10-10: Teacher gaze distribution towards students as percentage of time.

On average, teacher have a slight preference to looking on average towards their students on the right (17.94%) followed by center and left (13.51% and 11.05% respectively). The standard deviation for teacher gaze, similar to location, is quite high. The box plots of teacher gaze in Figure 10-12 best show this variance.

When they were not looking at their students, teachers direct their gaze in other locations in the classroom including their laptop or notes, the slides or the board. Regarding teacher gaze that does not fit into any of those categories, I created a final category called thinking/transitory gaze (Table 10.2). The majority of the teachers spend less than 20% of the time on these individual other locations. Overall, almost a third of the teachers (5 out of 17) spend more than 20% of time looking at their laptop/notes. Similarly 5 teachers look at the board more than 20% of the time while 6 teachers look at their slides more than 20% of the class time. In Figure 10-11 I show per instructor, the balance of gaze towards these other locations. As shown in the figure, there is a range of distributions in terms of whether the instructors are using the board or the slides, better seen in the box plot distributions in Figure 10-12.

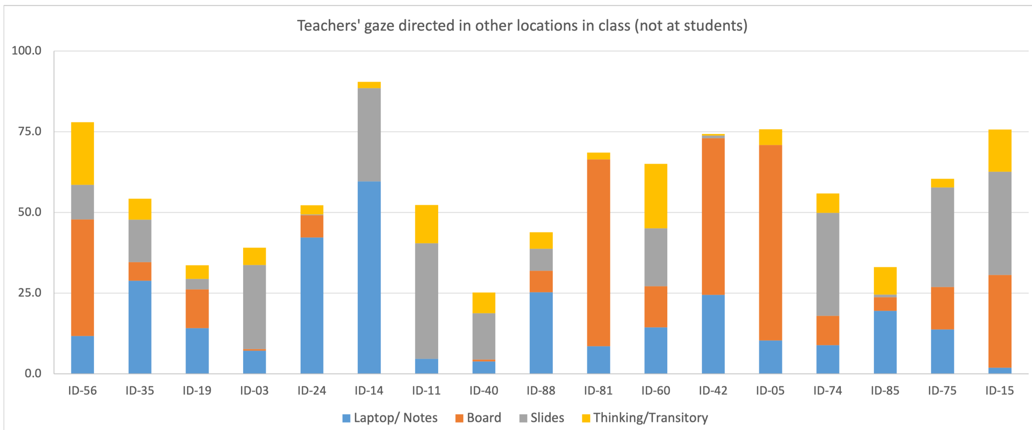


Figure 10-11: Teachers' gaze to other locations, per instructors.

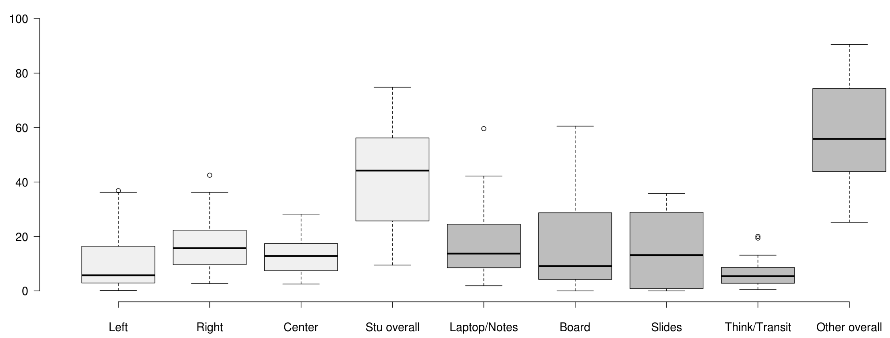


Figure 10-12: Teachers' gaze towards students and other locations in the classroom

Similar to location, I calculate how much teachers are balanced based on where students sit in the classroom. Specifically, I measure the collapsed value of teachers' current gaze towards students on the left-center-right versus their expected gaze in each of those locations, based on the student density per location in class. I show the teachers' measures in this collapsed variable in Figure 10-13, sorted from teachers who are currently most balanced based on where students are sitting (closer to 0) to teachers who are least balanced based on student density (closer to 1). As can be seen from the figure, teachers are overall closer to 0 (below 0.2) rather than closer to 1, thus instructors' gaze is generally balanced based in were students are sitting. Thus, teachers are close to where they should be balance wise, but with some room for improvement. This might be an effect of instructors looking very little towards their students.

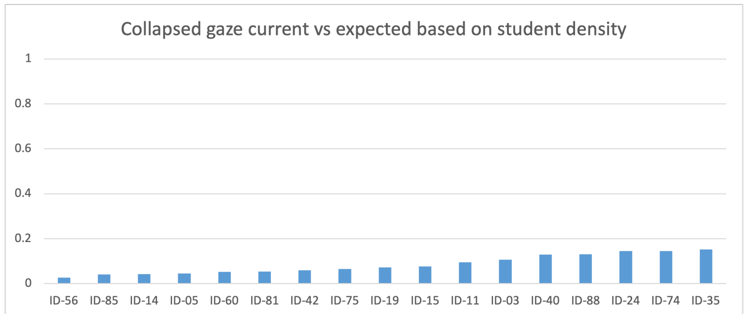


Figure 10-13: Current vs expected gaze collapsed measure

Relationships

In this section, I will share the analysis and findings of the relationship among some of the data in this data set.

Teacher Location and Teacher Gaze

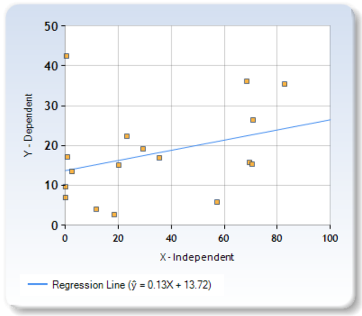
In Figure 10-14 on the left I show the correlations between the percentage of time the teacher is located on the left, center and right and the percentage of time the teacher looks towards the left, center and right sides of the classroom. Overall, the location to the left is positively correlated with the gaze to the left, the location to the right is positively correlated with gaze to the right. Interestingly, the location at the center is positively correlated with the gaze at the center and right. All the correlations are weak to moderate however they point in the direction that teachers' general location is correlated positively with teachers' gaze towards those locations in the classroom. For example, this means that when the teacher is located a lot of the time on the right, their gaze towards the right side of the classroom will also be higher. This finding is reinforced by the correlation of teacher location overall (left, center right) towards their gaze overall (left, center, right) as shown in the correlation matrix in Figure 10-14 on the right. As shown, the overall location is positively, but weakly, correlated with the overall gaze with a correlation coefficient of 0.262.

	Loc L	*Loc C*	*Loc R*	*Gaze L*	*Gaze C*	*Gaze R*
Loc L	1					
Loc C	-0.166	1				
Loc R	-0.722	-0.305	1			
Gaze L	0.073	-0.190	-0.199	1		
Gaze C	-0.045	0.461	-0.240	-0.049	1	
Gaze R	-0.415	0.247	0.334	-0.099	0.292	1

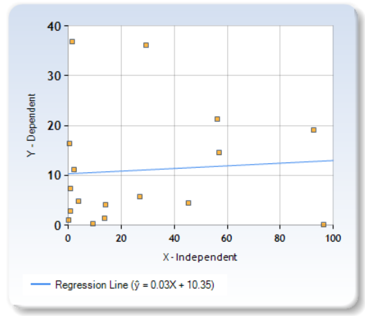
	Loc (LCR)	*Gaze (LCR)*
Loc (LCR)	1	
Gaze (LCR)	0.262	1

Figure 10-14: Matrix correlation of Location vs Gaze per class section (on the left) and all class sections together (on the right)

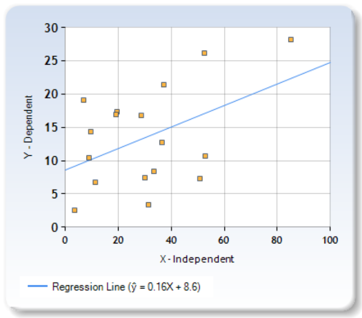
I wanted to investigate these relationships between teacher location and gaze data a bit more using linear regression. In Figure 10-15 I show the linear regression models for the left, right, center and overall location and gaze. For all charts, the x-axis represents location and the y-axis represents gaze. Again, here there are some positive relationships through the positive and upwards slopes of the teachers' location and gaze in the classroom showing that those two variables are correlated.



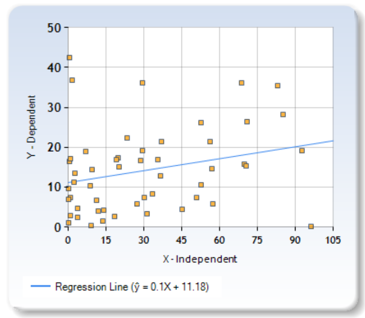
(a) Loc Right (x-axis) to Gaze Right (y-axis)



(b) Loc Left (x-axis) to Gaze Left (y-axis)



(c) Loc Center (x-axis) to Gaze Center (y-axis)



(d) Loc LCR (x-axis) to Gaze LCR (y-axis)

Figure 10-15: Regression of location and gaze per side (L,C,R) and overall.

Teacher Location and Gaze versus Student Location

Even though I did not have student data in this data set, I looked for any relationships between student location density in the classroom (left, center, right) and teacher location and gaze in each of these sides of the classroom. In relation to location, there are positive weak correlations of teacher location on the left and right, with student density location in those parts of the classroom (Figure 10-16(a)). Further, teacher location in the center is weakly correlated with student density location both in the center and right sides of the classroom. In relation to gaze, there are some weak to moderate correlations between teacher gaze and student locations, as shown in Figure 10-16(b). For example, the teacher gaze to the left and right is moderately and positively correlated with student location density to the left and right respectively. I notice this interesting pattern where teacher gaze to the center is positively correlated with students sitting at the center side of the classroom, and more weakly correlated with students sitting on the right side of the classroom. Overall, there seems to be a positive relationship between teacher location and gaze, with student density location, more so a moderate correlation between teacher gaze and student density in the classroom.

10.4.2 Automatically generated teacher and student data

General Info

In this section I will discuss the findings of analyzing the data collected from 28 courses and 380 class sessions. The data was collected during Spring, Summer and Fall 2019 at an R1 institution

	Loc L	Loc C	Loc R	Stu L	Stu C	Stu R
Loc L	1					
Loc C	-0.166	1				
Loc R	-0.722	-0.305	1			
Stu L	0.284	-0.458	-0.118	1		
Stu C	-0.210	0.218	-0.097	-0.119	1	
Stu R	-0.139	0.292	0.161	-0.835	-0.447	1

(a) Teacher location vs Student density location

	Gaze L	Gaze C	Gaze R	Stu L	Stu C	Stu R
Gaze L	1					
Gaze C	-0.049	1				
Gaze R	-0.099	0.292	1			
Stu L	0.539	-0.343	-0.360	1		
Stu C	-0.196	0.473	-0.254	-0.119	1	
Stu R	-0.377	0.048	0.465	-0.835	-0.447	1

(b) Teacher gaze vs Student density location

Figure 10-16: Relationships of teacher location and gaze with student location density in the classroom.

(CMU). The minimum amount of class sessions per course was 2 and the maximum was 34, with a median of 11. The average class sessions per course is 13.6, with a standard deviation of 7.17.

Location

In the data collected and generated automatically through the EduSense instrumented classroom, I could only measure information in terms of location such as the percentage of time the teacher is staying on the left or right sides of the classroom. Unfortunately, due to the nature of the data as described in the methods section, it was not possible to have a more detailed location information or to have information when the teacher was spending time among students.

In this data set, I found that the majority of instructors (21 out of 28) spend 70% or more of the time in one area. Similarly, a bit more than a third of instructors, (10 out of 28) spend more than 90% of the time in one area in the classroom (either left or right), as shown in Figure 10-17. A box plot of teachers' percentage of time left and right can be seen in Figure 10-20. On average, across all instructors in the data set, I found they spend most of their time on the right side of the classroom (average=68%) (Figure 10.3). This might be an effect of the podium, as the podium was located on the right side of the classroom in 19 out of 28 courses (270 out of 380 class sessions) and instructors on average were at the podium 47% of class time, so almost half of the time.

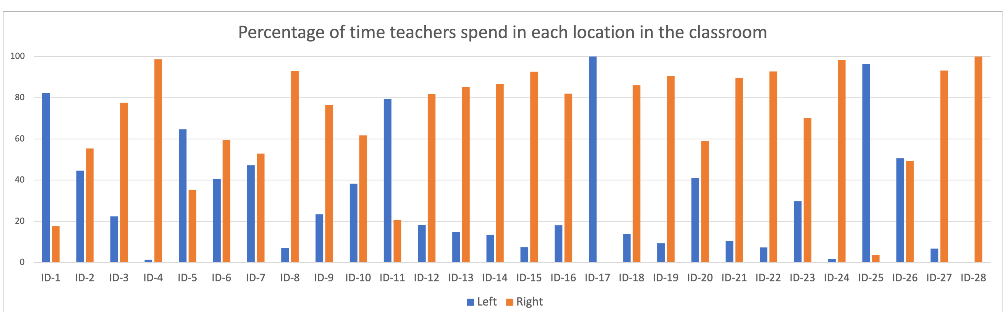


Figure 10-17: Percent of the time teachers are spending on the left and right sides of the classroom, at the front of the classroom.

I further collapsed teachers' left and right location percentages into one dimension as shown in Figure 10-18. I sort the collapsed measure location from most balanced (close to 0) to least balanced. As it can be seen in the figure, the majority of instructors are not balanced in their location between left and right and spend most of class time in one location. To consider balance based on where the students sit, I have created the chart in Figure 10-19 which shows a collapsed measure between teacher location left and right and where students sit left and right. As the figure shows, when taking into consideration student density, instructors are more balanced, however the majority of instructors are still far from being perfectly balanced and have room for improvement (closer to 1).

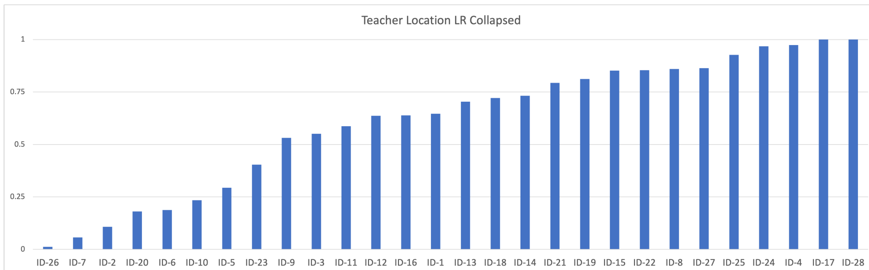


Figure 10-18: Teachers' location left and right collapsed into one measure and sorted from most to least balanced in location.

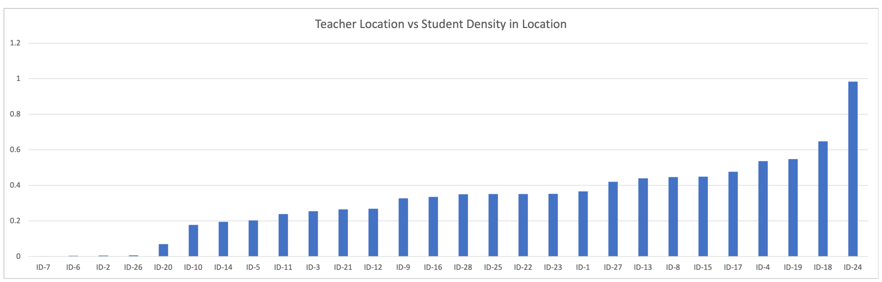


Figure 10-19: Teachers' location left and right vs student density location collapsed into one measure and sorted from most to least balanced in location.

In relation to the podium, in this data set I could measure only the time the instructor is spending at the podium location, without being able to determine if they are at the front, back or on the sides of the podium. Overall, almost half (13 out of 28) of the teachers are almost 50% of the time or more at the podium while 6 of them are there 70% of the time or longer. Only 2 instructors spend 90% or more of the time at the podium. As you see, when instructors are spending the majority of the time on one side, they are likely close to the podium most of the time. Below I show the distribution of instructor proximity to the podium (Figure 10-20).

In Figure 10-21(b) I show the distribution of the standardized movement variance (measure described in the Methods section). If the teacher did not move at all, the minimum would be -1.02. The average is 0, and there is no upper limit to movement. As shown here, the teachers tend to be below average, with very few moving a lot in class.

Teacher Gaze

In the automatically connected data set, I was more limited in the type of data I could collect and generate on gaze. Specifically, I could only determine the percentage of time the instructor is looking towards the let or right sides of the classroom. Almost half of the teachers (11 out of 28) are not balanced in their gaze and they spend more than 70% of their time looking more at one side of the classroom than the other (Figure 10-22). Out of those, 4 spend more than 90% of the time looking at one side of the classroom more than the other. On average teachers

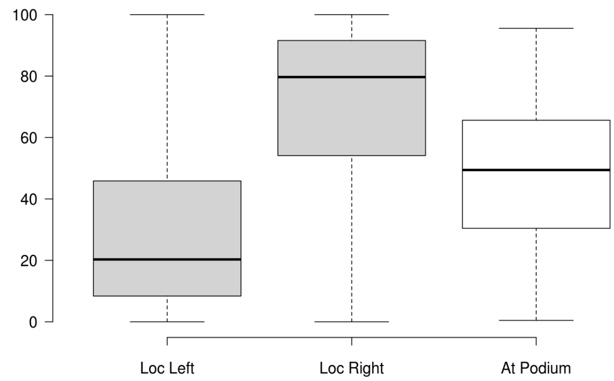
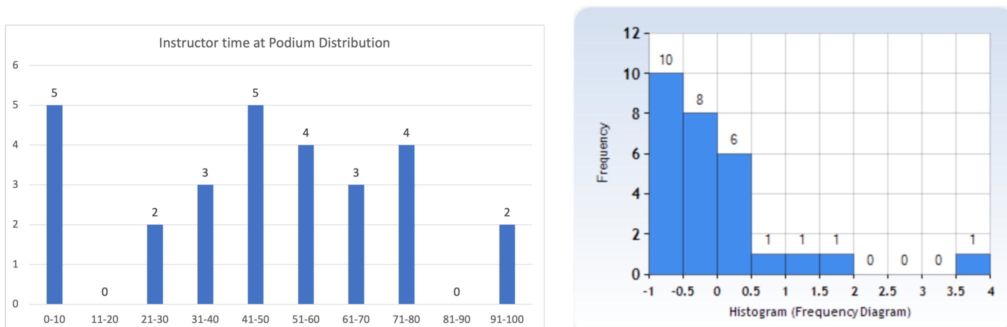


Figure 10-20: Distribution of teacher location at the podium



(a) Distribution of At Podium time

(b) Standardized movement distribution, minimum -1 and average 0.

Figure 10-21: Teacher time at podium and movement distribution.

look 53% at the left side of the classroom and 47% at the right side of the classroom (Figure 10.3). One thing to mention is that for some instructors, they are spending almost and equal amount of time looking at the left and right sides of the classroom. An example of this is also the averages between the left and right sides of the classroom being quite close to 50-50. This can also be seen in the collapsed gaze measure as shown in Figure 10-23 where some instructors are close to being balanced (0 value) while others are further away from 0 and closer to 1 (being less balanced). Taking into considerations where students sit, instructors are more balanced overall, but some of them closer to 1 still have major room for improvement (Figure 10-24)

Student gaze

In this data set, I had information on students' gaze overall towards the left or right side of the front of the classroom. I found that students look on the right on average 32% of the time and on the left 68% of the time (while they sit on average on the right 48% of the time and on the left 52% of the time, so almost 50-50, Figure 10.3). In 16 out of 28 courses, students spend 70% or more of the time looking at one side of the classroom (either left or right). In 4 of those classrooms they spend 90% of their time looking only at one side of the classroom (Figure 10-25).

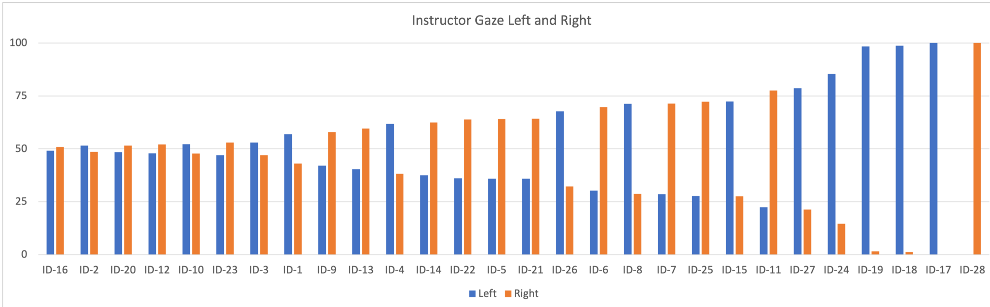


Figure 10-22: Instructors' gaze left and right

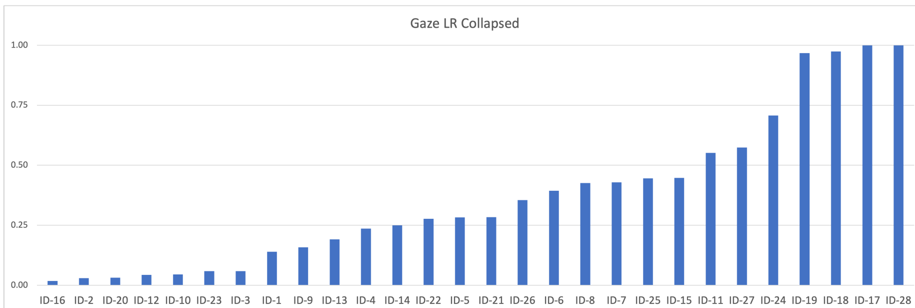


Figure 10-23: Teachers' gaze left and right collapsed.

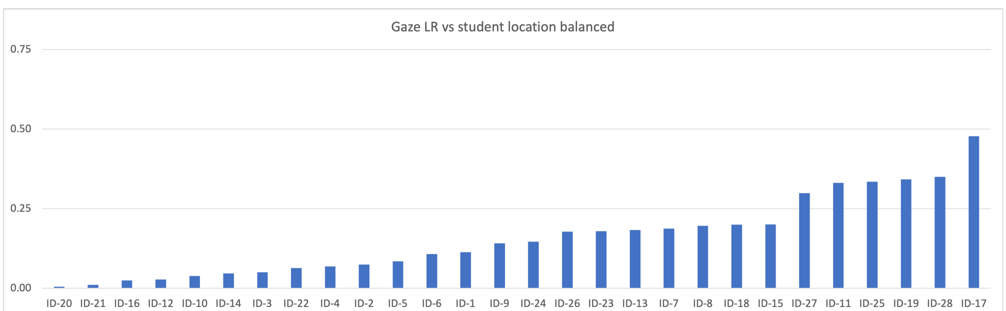


Figure 10-24: Teachers' gaze left and right versus student density location collapsed.

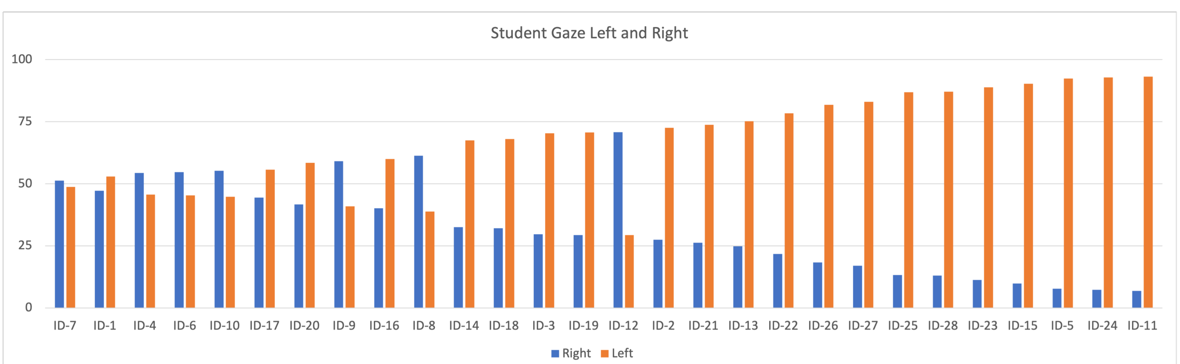


Figure 10-25: Student gaze LR

	Teach Gaze L	Teach Gaze R	Teach Loc L	Teach Loc R	Teach move. standard.	Teach At Podium	Stu Gaze R	Stu Gaze L	Stu Loc R	Stu Loc L
AVG	0.528	0.472	0.318	0.682	0.000	0.471	0.324	0.676	0.476	0.524
STDEV	0.244	0.244	0.294	0.294	1.000	0.264	0.189	0.189	0.135	0.135
Min	0.000	0.000	0.000	0.000	-0.870	0.005	0.068	0.293	0.000	0.329
Max	1.000	1.000	1.000	1.000	3.930	0.956	0.707	0.932	0.671	1.000
Median	0.488	0.512	0.203	0.797	-0.270	0.494	0.295	0.705	0.492	0.508

Table 10.3: Statistics for each variable in this data set

Relationships

In this section, I will analyze the relationships among teacher data, student data as well as between teacher and student data. I show a correlation matrix with the interesting and important results in Figure 10-26.

To begin with, I found very weak correlations between teacher location and teacher gaze. Specifically, teacher location on the left is weakly and negatively correlated with teacher gaze on the left and teacher location on the left is weakly positively correlated with teacher gaze on the right. Further, there is a moderate correlation between the teacher at the podium and the teacher location. Time at podium is positively correlated with teacher location on the right (r=*0.34*) and negatively correlated with teacher location on the left (r=*-0.34*). Similarly, teacher movement is moderately and negatively correlated (r=*-0.34*) with teacher location at the podium (Figure 10-26).

In terms of teacher and student data relationships, student gaze has a very weak correlation with teacher gaze and with teacher location. However, student location and teacher gaze are strongly and positively correlated. Specifically, students' location on the right is positively correlated with teachers' gaze on the right (r=*0.55*), and students' location on the left is positively correlated with teachers' gaze on the left (r=*0.55*). In terms of students' location and teachers' location, there are some positive but weak correlations.

Lastly, in terms of student only data, students' location is also correlated with students' gaze to the front of the classroom (Figure 10-26). More specifically, students' location to the right is positively correlated with students gaze to the right (r=*0.22*) and similarly, students' location to the left is positively correlated with students' gaze to the left.

10.5 Discussion and Conclusions

In this chapter I aimed to investigate patterns of behavior in teacher and student data, and identify any potential areas with room for improvement. Further, I aimed to explore relationships among teacher data, student data and between teacher and student data in the classroom. I discuss here the findings from analyzing data from 17 courses hand coded by human coders, and 28 courses automatically coded by machine learning models in the EduSense instrumented classroom system. All data was collected with EduSense, regardless of the mode it was generated.

	Teacher Gaze Left	Teacher Gaze Right	Teacher Location Left	Teacher Location Right	Teacher movement standardized	Teacher At Podium	Students Gaze Right	Students Gaze Left	Students Location Right	Students Location Left
Teacher Gaze Left	1									
Teacher Gaze Right	-1	1								
Teacher Location Left	-0.11	0.11	1							
Teacher Location Right	0.11	-0.11	-1	1						
Teacher movement standardized	-0.04	0.04	0.14	-0.14	1					
Teacher At Podium	0.19	-0.19	-0.34	0.34	-0.34	1				
Students Gaze Right	0.08	-0.08	-0.04	0.04	0.06	-0.10	1			
Students Gaze Left	-0.08	0.08	0.04	-0.04	-0.06	0.10	-1	1		
Students Location Right	-0.55	0.55	0.08	-0.08	0.21	-0.16	0.22	-0.22	1	
Students Location Left	0.55	-0.55	-0.08	0.08	-0.21	0.16	-0.22	0.22	-1	1

Figure 10-26: Various correlations of the variables in this dataset

10.5.1 What common patterns of teacher and student behaviors are there in the classroom and what areas for improvement can we identify?

Findings from both data sets showed that teachers are very immobile in the classroom and they spend a lot of time in one place. The movement measure in the automatic data set also emphasizes this finding, showing that the majority of the teachers do not move a lot in the classroom, and very few move more than the average. Further, the hand coded data set showed that only a minority of teachers spend some time among their students, with everyone else spending the majority or all their time at the front of the classroom. When at the front, teachers spend most of their time in one location, on average on the right side of the classroom. This seems to correlated with the location of the podium being on the right for most classrooms and teachers spending time in proximity to the podium. From the classrooms in both data sets, it seems that the podium is generally on the opposite side of the main door entrance for a class, and that tends to be on the right. Further, in both data sets I found instructors spend a significant portion of time on average at the podium (in the 40-50% range). From the hand coded data set, findings showed that teachers spend at least a third (37%) time on average behind the podium. In addition, in both data sets I found that when taking into consideration student density, teachers are not balanced, namely they are not spending more time located where there are more students and vice versa. This finding is also one of the insights instructors learned and were surprised from in the findings from the interviews in Chapter 8 and shows there is room for improvement in this aspect.

Based on these findings, and prior literature discussed in the Related Work section, there is a lot of room for improvement in teachers' proxemic behavior in the classroom. For example, teachers should be spending more time closer to students, among their students. One strategy instructors should consider is incorporating active-learning activities where students can work individually or in small groups, creating the opportunity for the teacher to walk among students. Further, teachers should consider moving the podium at different areas of the classroom each class, or keeping it in the center, to allow for a more equal distribution of their physical location in the classroom. Teachers should also consider getting rid of the podium altogether, and using technology such as a tablet or clicker to allow them to move more freely at the front of the classroom and make a conscious effort to spend more time and move in areas that there are more students sitting. Teachers should also move more around the classroom; for example, every time they change the topic they can consider moving to a different side of class. Certainly, more movement does not mean running around or pacing infinitely, but creating more opportunities to be less glued to one side of the classroom. Lastly, as literature suggests, teachers should consider having less barriers such as the podium or table among them and their students, and instead make a more conscious effort to stand in front of the podium or table. Overall, findings from this chapter showed that there are areas with room for improvement in teachers' proxemics and location starting with creating opportunities to be closer to students, moving more around the classroom and being more balanced in the time they are spending in each side of the classroom.

In terms of gaze, I will discuss the findings from the hand coded and automatic data separately, due to the major differences in the kind of data collected by each set and due to the different types of limitations in collecting and generation each data set. To begin with, findings from the hand coded data show that teachers look at their students less than half of the time on average, with some teachers barely looking at their students (less than 10% of class time). The time they are not looking at students, teachers spend looking at their laptop/notes, board or their slides. Interestingly, findings showed that teachers have a slight preference for looking more often on the right side of the classroom. This might be an effect of their location (they are majorly standing on the right), an effect of where the students are located or an effect of the instructors being right-handed (though I did not collect this kind of information and I am basing this hypothesis on the general population statistics of right vs left handed people). In terms of their balance towards where the student density is concentrated, teachers are generally balanced on how they split their gaze among students. This is an interesting finding that contrasts the location balance as discussed above. However, a reason the findings showed a relative balanced gaze could be because teachers are spending very little gaze to students, and the amount of gaze students are receiving is not enough to really measure balance in gaze. Thus, this analysis would be most appropriate in a scenario when teachers have improved their gaze and are looking at their students the majority of the time, and determine how this gaze is balanced among the students.

Secondly, findings from the automatic collected data set showed that the majority of teachers spend most of their time looking at one side of the classroom more than the other. However, for a quarter of the instructors, I found that their gaze is split almost 50-50 between the left and right sides of the classroom and the average time across all instructors that they look left and right is almost 50-50. This might be due to the limitations of gaze data in this data set, where due to the camera angle it is challenging to detect if the teacher gaze vector when extended is aiming the right or left sides of the classroom (as described in the Methods section). More in general, the gaze data in this data set could be less accurate than the ground truth, due to the various limitations also described in the Methods section. Further, findings showed that the teacher gaze balance based on where students are sitting is worse than in the hand coded data. Some teachers in this set score similarly in this balance compared to the hand coded data set, however almost a quarter of the teachers have some room for improvement.

Overall, from both data sets I found that teachers have major room for improvement in terms of their gaze. To begin with, teachers should make an effort to spend less time looking at other locations and spend more time (at least more than half of class time) looking at and building immediacy with their students. There are various ways and active-learning strategies teachers could use to accomplish this goal. For example, teachers could incorporate more questions in their slides or board work, that will allow them to turn towards students and have a discussion, thus allowing them to spend more time looking at students. Teachers could also try to be less reliant on their notes, for example by sharing with students beforehand print-outs of the notes or by memorizing more parts of their notes. Once they reach an improvement in their overall gaze to students, teachers should then work towards balancing their gaze among different parts of the classroom, and again, there are various strategies they could try to accomplish that. For example, for each class, teachers could pinpoint various students on different parts of the classroom to call on, which will lead to them looking more towards that side of the classroom. They could also try to be more conscious during class time as to where they are looking at any point in time.

In terms of student gaze, findings from the automatic data showed that students tend to look more on average towards the right side of the classroom. This might be an effect of the instructor being located more on that side of the classroom. In some classes, I found that students spend an equal amount of time looking at the left and right sides of the classroom. Without the ground truth, it is challenging to determine if this is what is really happening, or due to the limitations of the automatic data set, it is an inaccurate or partially accurate result that is caused by the camera angles in the classroom.

10.5.2 What relationships can we determine between teacher and student data?

I investigated various relationships among teacher data, student data and teacher and student data. Overall, I found that there are some weak to moderate correlations, in both data sets. From a data analysis perspective, even though I did not find strong correlations, the results hint into some interesting directions that I discuss below. Further, to some extent it was expected that due to the limitations described in detail in the Methods section (such as the camera angle with the data collection, generation and accuracy) there would be some challenges in determining a strong relationship among the data, both in the hand coded data set but more so on the automatic data set. In addition, as the literature suggests, there *should* exist strong correlations in the data, however due to the instructors not exhibiting such behaviors in the classroom and due to them having areas and much room for improvement, I instead found *weak to moderate* correlations in the data. A better approach to measure relationships among the data is to determine causality through experimentation. For example, the instructor could try to intentionally move their location throughout class to see how much that affects their gaze or their students' gaze. A final reason for not finding strong correlations could be due to the variety of course types or the variety in types of activities within each course. The data and findings in this chapter showed a lot of variability in behavior and many outliers, which could be an effect of the different types of courses, activities or teaching styles. For example, rather than comparing teacher and student behaviors against courses, it would make more sense to compare against the same type of course (i.e. discussion based or lecture based courses) or the same types of activities (i.e., group work, writing on the board, active-learning, live programming, etc.) This would allow for a stronger, more accurate and fairer measure of relationships among teacher and student data.

Specifically in terms of relationships, the results from the hand coded data showed that teacher location and gaze are moderately correlated. This means that these variables move in the same direction; when one increases the other increases and vice versa and where teachers stand the most is where they look the most. It is not possible to determine causality based only on this information, or the direction of causality. However the findings hint in the direction that those behaviors are related to each other and have implications for teachers' goal setting and behavior change in class. For example, instructors should be more conscious of how their location and gaze in the classroom affect each other and should set goals to spend time in different locations in the classroom. With a technology such as ClassInSight, they could then determine if this change in location results in change in gaze and if so how and how much. Teacher should further consider moving their podiums to somewhere like the center at the front of the classroom and determine if that change in location results in a more balanced gaze. In contrast, in the automatic data set, I found weak and negative correlations between teacher gaze and location. The negative correlation could be a result of the accuracy and other limitations in this data set, and the weak correlations suggest that this finding does not accurately depict the relationship between teacher location and gaze and thus should not be considered as a result. Rather, the finding from the hand coded data is the more accurate and reliable one, as described here.

Further, I found a positive and moderate correlation between the location of the podium and teacher location and a negative and moderate correlation between the location of the podium and teacher movement. Again, even though not showing causality, these results hint in the direction that teachers should spend less time at the podium, which would allow them both to move more and be located in different areas in the classroom. Again, one way to determine causality, is through a technology such as ClassInSight that allows the teacher to track their behaviors and experiment by changing one and seeing how the other behaviors follow the change.

In terms of teacher and student data in the hand coded data set, I found that teacher location and teacher gaze are positively and moderately correlated with student location in the classroom. In the automatic data set, the correlations are very weak for teacher location and student location, but strong for teacher gaze and student location. This means that where the majority of the students sit, is where the teachers are located the most and where their gaze is directed at the most. It is not clear if teacher location and gaze are causing students to sit in certain areas of the classroom, or where students sit affects teacher location and gaze. However, the findings hint in the direction that there is some relationship among this data. Teachers should make an effort to spend an equal amount of time located and looking at their students, or they should ask students to sit in different locations (i.e. more balances left, center right, or closer to the front) to have more opportunities for building immediacy through gaze and location.

In terms of relationships with student gaze, I found weak correlations among teachers' location and teachers' gaze with student gaze. This result might be due to the limitations and accuracy in the automatic data set or due to students maybe not looking directly at the teacher, rather the board or the slides. Further research is needed to investigate the relationships among these data types. Further, student location and student gaze were moderately correlated, showing that students on one side of the classroom tend to look more towards the front of that side of the classroom. This should be another incentive for instructors to re-organize where students sit in the classroom and how they direct their gaze and attention at the front, through different materials and mediums (i.e., board, slides, etc.).

In conclusion, findings in this chapter showed some very interesting patterns of behaviors with room for improvement on teachers and students as well as the relationships among this data. These findings fill in the gap in the literature and bring new knowledge about nonverbal behaviors in the classroom. Further, findings suggest that teachers have much room for improvement in their behaviors in the classroom. The correlations among the data hint in the direction that there exists a relationship among and between teacher and student data. To the best of my knowledge, this is the first study aimed at determining the value of nonverbal immediacy behaviors by analyzing actual classroom data on teachers and students.

Researchers can use these findings as an opportunity to design better Professional Development and design dashboards that share with instructors data on their own and their students' behaviors. For example, to emphasize the value of nonverbals, which came up as an issue in the Chapter 7 and Chapter 8 interviews, designs of technologies could include findings from this chapter, showing that teacher location, gaze or their balance has room to be improved, or that teacher location and gaze are correlated with student location. Further, data from this chapter could be used to design social comparison charts for dashboards, that would allow the teacher to compare their performance with their peers, determine where they stand in their behaviors compared to others, and what goals they can set to reach and improve their practice.

Overall the findings in this chapter contribute both to new knowledge as well as guidelines for designing technologies that can help instructors in the classroom. Further research is needed to better determine the causal relationship and direction of the causality for the measures discussed in this data set. Lastly, more research is needed to determine relationships between and among other data such as teacher gesturing, student facial expressions, etc.

Chapter 11

Investigating how to integrate teacher and student data and how to support reflection-for-action

Abstract In my prior work, I found that instructors were interested in both teacher and student data. A large body of work has focused on sharing with teachers student data and very little work has looked at sharing with them their own data. To the best of my knowledge, no prior work has looked at sharing both teacher and student data, with the aim of supporting teachers' behavior change. In this chapter, I design for and investigate multiple dimensions on how to integrate teacher and student data and how to support teachers' reflection-for-action as a first step towards behavior change. Findings from a co-design study with 22 instructors showed that instructors value relationships between teacher and student data, want to see the data integrated in a spatial and temporal form, and are interested in activity information in particular combined with student engagement. Further, SE support such as mastery experience and social comparison, together with support for value helped instructors assess performance, set concrete goals and provide actionable suggestions on what to change in the classroom. This chapter provides a solid foundation and recommendations for researchers and designers who create technologies for teachers. To the best of my knowledge, this is the first study that thoroughly investigates integrating teacher and student data to support reflection-for-action.

11.1 Introduction and Motivation

In Part 1 and Part 2 of this thesis work, I explored and aimed to better understand teachers' interest and data needs in terms of student data (Part 1) and in terms of teachers' own data (Part 2). Findings showed that teachers were very interested in this information. Based on their wants and needs, I designed tools that shared with them student data (the Luna dashboard prototype) and teacher data (the ClassInSight dashboard prototype). Further, I ran classroom studies to investigate the effects of such data tools on teachers' and their practice. I found that student data affected teachers' knowledge, lesson planning, and actions they take in the classroom (Part 1) and teacher data affect their goal-setting and intentionality for behavior change (Part 2). Further, in Part 2 teachers expressed strong interest in having their own data together with their students' data.

In addition, much prior work and literature has focused on sharing with teachers student data. Very little and more recent work has started to focus on sharing with teachers their own data (i.e., [99, 164, 194]). I have covered this literature in more detail in Chapter 2, Background work. Despite this, to the best of my knowledge, there exists no prior work that focuses on supporting teachers' reflection-for-action with teacher and student data, in particular, in the teacher immediacy and nonverbal behaviors domain.

Based on and motivated from my findings from Part 1 and Part 2 of this thesis as discussed here, teachers' interest in teacher and student data as well as based on the gap in the literature as described here, in this chapter I focus on designing for and investigating how to integrate teacher and student data while aiming to support teachers' reflection-for-action as the first step towards behavior change. The central question driving the work in this chapter is the following:

- RQ: How can we integrate teacher and student data while considering teachers' needs in multiple dimensions and also aiming to support their reflection-for-action?

Integrating teacher and student data is challenging primarily as there are multiple dimensions to be considered for these data individually and even more so when they are combined together. Further, a layer of complexity is added when aiming to also support teachers' reflection-for-action, which brings even more dimensions that need to be accounted for. In this chapter I outline and describe each of these dimensions including integrating teacher and student data while showing a relationship between this data, taking into consideration how to present the data in a spatial or in a temporal form, the types of data to include for teacher and student data, etc. For reflection-for-action I focus again on self-efficacy (SE) but this time adding more ways to support SE, and also focusing on value and ways to support it. I ran a co-design study with 22 instructors in a university setting at an R1 institution. During the co-design interviews, I share with teachers multiple prototypes that combine various dimensions for integrating teacher and student data and for supporting reflection-for-action. I focus again on teacher immediacy and nonverbal behavior data.

Findings showed that teachers valued the relationship between teacher and student data, in particular if this was a causal relationship and showed how teacher behaviors affected their students in their engagement and learning. Further, instructors expressed interest in combined spatial and temporal information, with various levels of granularity for temporal data which aligned with the type of behavior change they were interested in. Finally, student engagement was an important metric for determining room for improvement in behaviors and instructors shared various ways how they gauge engagement in their classrooms. They also mentioned that engagement depends on the classroom activity. Despite that, some instructors expressed skepticism on the importance of engagement to learning.

In terms of the support for reflection-for-action, instructors reflected on the performance shown in the prototypes, determined areas for improvement and set goals and gave actionable suggestions on what they could change in their behaviors in the classroom. In particular, teachers' today's performance and trendlines over time (a form of mastery experience that supports SE) as well as comparisons with other instructors (a form of social comparison that support SE) helped teachers in their reflection, assessment and goal-setting. Further, the value of the the relationship between teacher and student data, and the value of student engagement were two other dimensions that supported teachers' reflection-for-action. Finally, interesting new dimensions came up, in particular in relation to goal-setting. In this chapter, I discuss in detail the findings for each dimension discussed here.

To the best of my knowledge, this is the first study that aims to design for and investigate integrating teacher and student data with the aim to support reflection-for-action. The study is unique as it uses co-design sessions to investigate various dimensions for integration and for supporting reflection-for-action through SE and value. The study does not measure actual behavior change, however it explores teachers' intentionality for behavior change through their reflection, assessment and goals they set to change their behaviors. Findings provide a solid foundation and strong recommendations for researchers and designers who aim to create technologies that support teachers in the improvement of their practices.

11.2 Designing the Dashboard Prototypes

11.2.1 Design Considerations and Dimensions

Based on the findings from Chapter 7, 8 and 10 on teachers' data needs and wants as well as prior work on the importance of nonverbal immediacy in the classroom, there were two major aspects I was focusing on for the design of the new dashboard prototypes: integration of teacher and student data and the support of reflection-for-action. Before starting the design process, I first outlined a set of design considerations based on what I learned from prior studies on teachers' wants and needs, and based on the question I am aiming to answer through this work.

To begin with, regarding the integration, teachers expressed strong interest in having both teacher and student data. However, designing for this integration is particularly challenging due to the multiple dimensions that need to be take into consideration. Below, I list and define such dimensions.

#1 Dimensions to consider while designing for integrating teacher and student data.

1. DATA: Types of data to present: teacher only, student only, combined. Types of teacher data: gaze, location, etc. Types of student data: engagement, gaze, etc.
2. TEMPORAL: Time scales for presenting data: class session/today, weekly, last/next week
3. SPATIAL: Spatial information in presenting the data

Second, in relation to reflection-for-action, through the design process I aimed to support other variables that affect teachers' motivation as discussed in Chapter 6. Based also on the findings from Chapter 8, in this work I decided to continue supporting teachers' self-efficacy by designing for multiple types of support (i.e., through mastery experience, social comparison and verbal persuasion [34, 35, 38]). In Chapter 7 I define verbal persuasion and social comparison. On the other hand, mastery experience can be defined as indicators of capability or performance accomplishments. In the theory of self-efficacy, mastery experience produces the highest and strongest increases in self-efficacy (i.e., [34, 35]).

Further, I decided not to focus on locus of control in this work, rather try to better design for emphasizing the value of nonverbal behaviors (i.e., by showing the relationship of teacher and student data or focusing on investigating and designing for better measures for student engagement as other ways to express value). Lastly, I created designs that explicitly supported instructors in assessing their performance and in setting goals for behavior change. Below I list and define these dimensions.

#2 Dimensions to consider while designing for supporting reflection-for-action.

Designing for Value

1. RELATIONSHIPS: Explicit vs implicit relationships between teacher and student data. Kinds of relationships: statistical correlations
2. STUDENT ENGAGEMENT: Operationalizing student engagement: hand raises, gaze, facial expressions, etc.

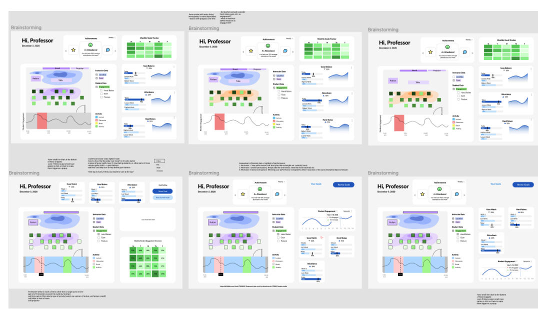
Designing for Self-efficacy

1. MASTERY EXPERIENCE: Instructors' own performance or their students' performance: today/this week, compared to set goals, trends over time, etc.
2. SOCIAL COMPARISON: Instructors' own performance or their students' performance compared to other instructors
3. VERBAL PERSUASION: Encouraging text on performance

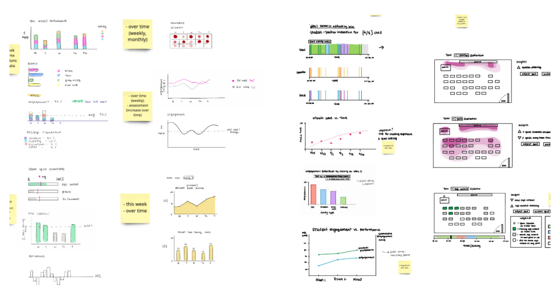
Designing for Assessment and Goal-setting

1. ASSESSMENT: Explicit (through text, visual cues, goal-setting, etc.) vs more implicit (performance today/this week, trends over time, comparison with others, relationships of teacher and student data, etc.)
2. GOAL-SETTING: Explicit goal-setting vs not explicit

(a) –



(b) –



(c) –

Figure 11-1: Various iterations of the designs of the data-sharing tool.

11.2.2 Creating the Prototypes

Based on these design considerations, findings from Part 2 of this thesis as well as prior literature, my team and I started creating low and medium fidelity prototypes of a dashboard that shares with teachers teacher and student nonverbal data with the aim to support reflection-for-action. My team consisted of 4 RAs (Research Assistants), 3 of which had participated in the thematic analyses of Chapter 7 and Chapter 8. In the early iterations, my team and I independently created designs as shown in Figure 11-1. We met on a weekly basis, discussed and worked together on iterating the designs. After multiple iterations, we then had weekly co-design sessions where we worked together on the designs until we reached three prototypes that satisfied all the design consideration discussed above. These prototypes were not final dashboard designs. Rather they were meant to be a starting point to support a discussion with instructors during co-design sessions, as I will describe below. Here I describe each prototype, together with its design considerations.

Prototype 1

In Figure 11-2 I share the first prototype used in the co-design sessions with instructors. This design encompasses many of the dimensions discussed above. To begin with, at the top chart, the design shows a 2D view of the classroom (spatial information) overlaid with teacher data (gaze and location) and student data (student engagement). The color intensity represents a low or high value of this data. Further, the teacher and student data is designed in such a way that it shows, not explicitly, a relationship between where teacher stand and where teachers look to student engagement. On the left of the chart, the design shares options for teachers to pick the data they want to see about themselves. Further, the design provides teachers with the option to select the ways they prefer to measure their student engagement in the classroom. Lastly, at the bottom, the design shows a chart over the current class time (temporal) of student engagement performance. The chart allows the teacher to select and see the activity that was happening at any particular time. This represents yet another not explicit relationship between student engagement and the activity happening in class at that point

This design aims to support value by showing (not explicitly) the relationships of teachers and student data in the 2D view of the classroom. Specifically, teachers standing close to their students and looking more at their students have students in those areas more engaged. Further, the design aims to support value by showing student engagement measures, as one of the important variables in teachers' interest in behavior change. Lastly, the design supports self-efficacy as well, through mastery experience, by showing teacher and their students' performance during that particular class session. The design has no explicit assessment or indicators of performance except for the relationships between teacher and student data. Further, there is no explicit goal-setting requirements in the design.

Overall, through this design I aimed to further investigate how to design for the teacher and student data integration. Specifically, I aimed to understand what relationships would teachers be able to identify from the various data the design is showing, and is that something that would be helpful to their reflection-for-action. Further, I aimed to understand the importance of student engagement to teachers and how they operationalize or quantify student engagement in the classroom. To investigate teachers' interest in goal-setting and behavior change I accompanied the co-design sessions with a semi-structured interview protocol which I will discuss in more detail below.

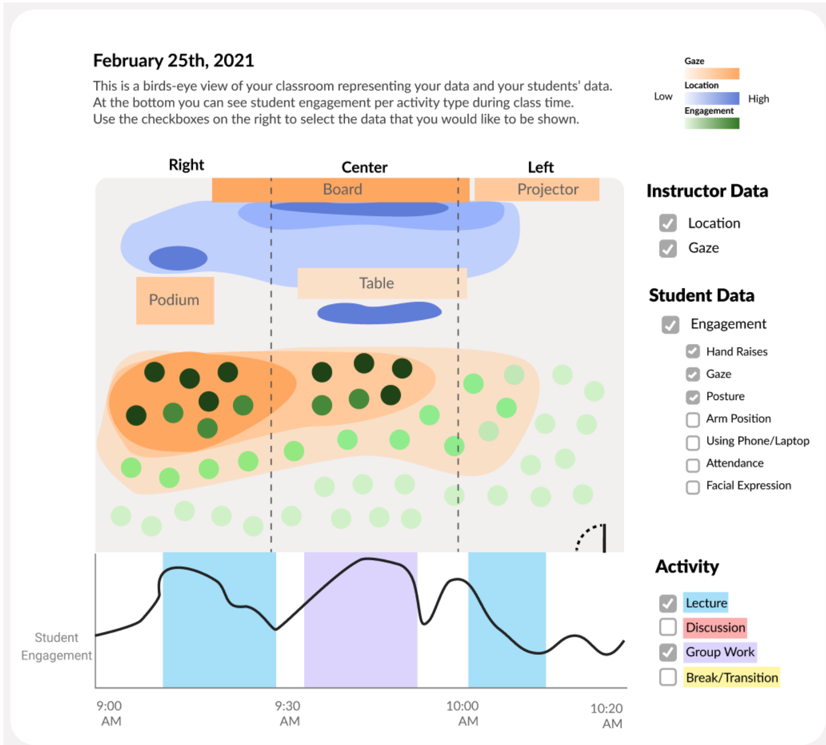


Figure 11-2: High-fidelity prototype of the first design.

Prototype 2

In Figure 11-3 I share the second prototype used in the co-design sessions with instructors. The prototype was shown to teachers in three different parts: first, the teacher only design (top left), second, the student only design (bottom left) and third, the teacher and student designs together (right). This design encompasses many of the dimensions discussed above.

The teacher only design shares with teachers their performance on three nonverbal types of data; two related to gaze (teachers facing forward and gaze balance) and one related to location (location diversity). For each data point, the design shows teachers' performance this week (mastery experience) and the goal they set last week to achieve for this week. The performance is accompanied by a neutral text description (when the teacher has not achieved their goal) or an encouraging description (verbal persuasion) when the teacher has achieved or exceeded the goal. The performance is also accompanied by a visual cue: a red circle when the teacher has not achieved the goal and a medal when they have achieved the goal. Lastly, the design shares teachers' progress in the form of a trendline over the weeks (mastery experience) and also compares that with other instructors' performance (social comparison). In this design, the teacher has not achieved their goal in the first two data types, but has achieved their goal in the last data type. Similarly, the instructor is doing better than others in the first data type, but worse than others in the second and third data type. Below today's performance, the design directs teachers' attention to set a goal for next week. All of the above elements of the design were aimed to investigate how to help instructors' reflection-for-action, particularly to help them assess their performance and set goals to change their behaviors. In summary, this design introduces teachers only to their own data. There is no student data, no relationships among data and no spatial information.

Figure 11-3: High-fidelity prototype of the second design.

The student only design is very similar to the teacher only design (Figure 11-3) with the exception that instead of teacher data, the design shares student data. More specifically, the design shares student engagement, student gaze and students on the phone data. The instructor has not achieved their goal in the first and third data type, but has achieved their goal in the second one. The instructors is doing better than other colleagues in the first and second data type, but is doing worse than others in the third data type. Except for these differences, all the other design elements are the same.

From these two prototypes individually, I aimed to better understand the teachers' reflection-for-action process including what do they notice about and how do they assess their performance/their students performance, which elements in the design do they use to assess their performance, are they motivated, and if so, what goals do they set to change their behaviors.

Finally, in the teacher and student design (Figure 11-3), the two previous designs, teacher only and student only, are shown together. All the other elements of the design are the same as discussed above with the exception that teacher and student data shown together, not explicitly, hints at a relationship between the two. Note that no specific relationship was aimed to be shown by the values of each of the data points and charts in the designs.

By showing the two prototypes together, in one that combines teacher and student data, I aimed to investigate what relationships, if any, teachers try to identify between teacher and student data. Further, I aimed to investigate if their intentionality for behavior change and goal setting would change now that they see the two data types together.

Prototype 3

In Figure 11-4 I share the third and final prototype used in the co-design sessions with instructors. The design presents to teachers a chart with the teacher data (on the left y-axis), the student data (on the right y-axis) and weeks in the semester (temporal information in the x-axis). For this design, the teacher data is teachers' percentage of time facing forward (gaze related information) and percentage of students who were engaged for that class session (engagement information). The trendiness represent a form of mastery experience. Unlike prototypes 1 and 2, this design aims to show an explicit positive correlation relationship between teacher data and student data. The chart shows no spatial information, as well as no explicit assessment or goal-setting elements in the design.

Through this design, I aimed to explore what relationships teachers would identify between teacher and student data. Further, I aimed to investigate if such relationship would motivate them to set goals in changing their behaviors.

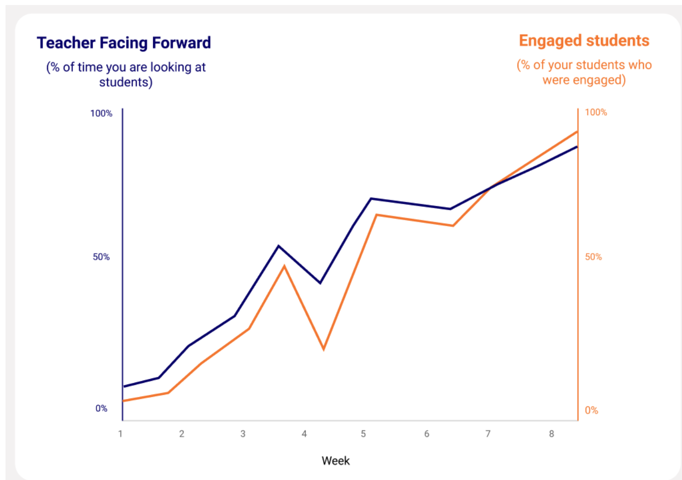


Figure 11-4: High-fidelity prototype of the third design.

11.3 Methods

Study Design and Participants

Based on the prototypes described above and what I aimed to learn from each prototype, my team and I created a protocol for a semi-structured co-design interview with instructors. The interview was aimed to facilitate the discussion and the co-design activity with instructors. To help with this process, I made two choices in relation to how the interview was conducted. First, when I introduced instructors with each prototype I asked them to imagine that this was data from one of their colleagues and to assume that they were trying to give this colleague feedback or advice based on the data. This was meant for instructors to more comfortably critique the performance shown in the charts and brainstorm for possible actions to take, with the process being less personal and threatening to them (compared to if this was framed as their own data). Second, during the co-design session I included a "sketch artist"; one of of the RAs in my team or myself, who would translate instructors' ideas and design suggestions into the prototypes. One reason to include the sketch artist was to facilitate the co-design session for instructors and simulate an in-person co-design session experience, provided that the interviews were all remote due to the pandemic. In an in-person session, the participant could easily use pen and paper to express their ideas or draw on the prototypes, however, this was more challenging to do online. Further, the sketch-artist would make it easier for the instructor to express their ideas freely, while they took care of converting these ideas into sketches in the prototype. In Figure 11-5 I share an example of a sketch created during the co-design sessions with instructors

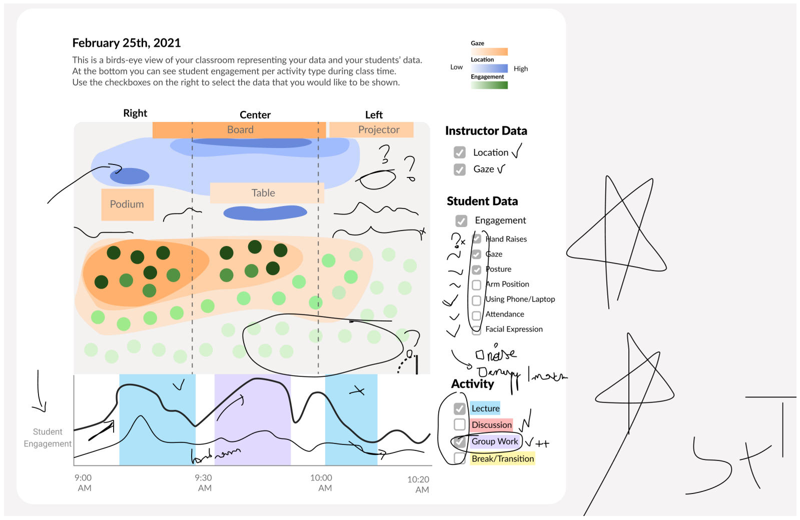


Figure 11-5: Sketch from co-design sessions with instructors.

In Appendix I share the protocol used for the semi-structured interviews in the co-design study. The interview starts with asking the instructor two questions about the courses they teach and the years they have been teaching, as a way to built rapport. The instructors then are provided with a description of the study and what we aim to get out of the co-design session. Then, a definition of immediacy and nonverbal behaviors is presented to the instructors. I answer any preliminary questions instructors have and then I share with them each prototype design. As the interviews progressed, I added some questions to better understand interesting points that previous participants had brought up during the interviews (i.e., asking about the difference in the teacher's opinion of engagement and paying attention, and their importance to student learning).

I emailed around 100 instructors to recruit them for the study; teaching and tenure track faculty who taught in the School of Computer Science at CMU. I aimed to get an equal number of teaching and tenure track faculty to get the perspective of both sets of instructors. I share the email template I used in Appendix E.1. Instructors were offered $30 in an Amazon Gift Card for 1h of their time. Only 22 instructors (10 teaching and 12 tenure faculty) expressed interest in the study, potentially due to the difficult Spring 2021 semester and due to the pandemic. I scheduled and ran 1h Zoom interviews with these instructors. I audio and video recorded the interviews.

Data analysis

There were on average 22hs of video interviews recorded from the teacher co-design sessions (on average 40 minutes to 1h interviews per instructor). Research assistants in our team transcribed the interviews first automatically, using the Temi service. Then they manually double checked the transcriptions for accuracy. While the interviews were still in progress, my team and I started the analysis process. For 2 rounds, each team member watched 2 interviews, kept notes of interesting findings based on our design goals and study aims. We then came together, discussed the notes, and built high level themes based on the discussion.

My team and I then then used Atlas.ti to conduct a thematic analysis on the transcriptions based on these high level themes. We independently tagged each interview with themes. We came together weekly and discussed discrepancies and uncertainties in the tagging. We repeated this process multiple times until each interview was tagged by one team member, and was re-checked by a secondary team member. Once the interviews were fully tagged with the major themes, we came together to discuss potential patterns within each major theme which created sub themes. We reviewed and organized these sub themes in a second word document, by splitting or merging the initial themes. Before writing the findings section, I re-read the thematic analysis findings and taggings on the interviews, adding any taggings and necessary and summarizing the themes. Based on this process I then wrote the following findings section.

11.4 Findings and Discussion

Below, I will discuss the major themes that emerged from the thematic analysis of the co-design sessions with instructors. Overall there were 22 participants in this study: 10 teaching track faculty at all levels (average of 8.3 years of experience teaching at the university level) and 12 tenure track faculty (average of 18.9 years of teaching). The average years in teaching across all instructors was 14.

11.4.1 Relationships in data

Findings from Chapter 7 and Chapter 8 showed that instructors were interested in both teacher and student data, in particular in the action-reaction between their data and their students' data in the classroom. In this study, I found that the relationships between teacher and student data are extremely important for instructors, even more important that what my previous findings showed, both to reflect and assess their performance and to set goals on what behaviors they wanted to change in the classroom. Relationships in the data, whether implicit or explicit, represent an aspect of the value that instructors see in the data.

All instructors expressed interest in the relationship between teacher and student data. More specifically, instructors were able to identify such relationships even when they were not explicit in the designs and agreed that such relationships made sense and were expected to some extent. For example, a participant recognized the following relationship, even though it was not explicit, from Prototype 1, Figure 11-2: *"ID-27: So clearly there's a relationship between instructor gaze, now that I know what that is, and student engagement."* More in general, in the Prototype 1 design, instructors were able to identify and recognize the relationship and correlation between teacher location and teacher gaze to student engagement, and the relationship of where students are sitting in relation to the teacher, to student engagement.

In addition, when the relationship between the data was explicit, instructors valued seeing that data and agreed it was an important piece of information. For example, instructors identified the strong and positive correlation in the Prototype 3 design (Figure 11-4). They were positively surprised by this information and expressed it was valuable and helpful. As one instructor said, *"ID-44: We can see here that, if I'm interpreting this correctly, that there's a very strong correlation between these two things [pointing at the trendlines in Prototype 3]. So that's good now actually that's very valuable information."*

Interestingly, teachers looked for and tried to infer relationships among teacher and student data, even when the design shown to them did not have any such relationships. This happened in particular with Prototype 2 (right, Figure 11-3) which showed teachers teacher and student data in one interface, but contained no relationships designed in it. For example, as they were discussing the design, one instructor said, *"ID-99: I'm trying to determine, like, what makes sense or how can I, like, what is the correlation between these behaviors, right. The instructor's behavior and the students' behaviors."* Even though there was no correlation in the data, instructors tried to analyze and figure out what they could connect together, what data showed similar trends such as where teachers were not doing well and where students were not doing well. They also paid close attention to the design elements, for example how data were grouped together or what row/columns the data was presented, in hopes of making sense and findings hints of correlations between teacher and student data. Often, they would draw conclusions for such potential relationships. As one instructor mentioned, *"ID-79: Like the thing that you're struggling the most at is gaze balance. The thing that you're struggling the most at is student engagement. Aha, it must be that if you drove a gaze balance, you'd have more student engagement."*

Furthermore, throughout the co-design session, many instructors mentioned they needed to see relationships between teacher and student data, in particular correlations and how what they do affects students. For example, one instructor expressed their interest for correlations by creating a design of a chart that would show teacher and student data in a plot form, *"ID-81: But as I think what you really want is a dashboard correlating like basically X versus Y, right. Like teacher on X and the student on Y. Teacher metric on X and student metric on Y. I guess the other way around, student metric is the Y and teacher should be X."*

Overall, the majority of instructors expressed interest in correlations as a statistic. Even though they recognized correlations do not mean causation, they mentioned that a correlation or a high enough correlation would be good enough for them to try and change something in their behaviors. As one instructor expressed *"ID-79: For what's captured here that the results are definitive, that movement and gaze are related to student engagement. I think we could even go so far as to say they cause student engagement. Although obviously that's not captured here because this doesn't capture causality. But nonetheless, I think it's pretty obvious that that's true."*

However, other instructors questioned if representing correlations between teacher and student data was good enough, or even appropriate. They suggested strongly that correlation does not mean causation. In particular, they mentioned that they were not sure of the direction of the causal relationship. For example, they didn't know if more engaged students would naturally sit closer to them, in the front row or if the teachers' location and proximity to students would make them more engaged. A causal relationship in this case would solve the directionality issue, something that correlations cannot do. For example, one instructor discussed the following while working with Prototype 3 and the correlation of teacher facing forward with student engagement *"ID-13: There is a correlation not a causation and moreover it's about one specific aspect about facing forward. Maybe it's not facing forward, but maybe implicitly, I'm asking more questions implicitly or explicitly. And that's why the engagement is increasing. I can't really say from the plot."* Further, some instructors expressed that they would use the data provided to do some experimentation or some research in the classroom. For example, they would try to keep constant one variable, say gaze, and change their location. They would then monitor how their students' engagement would change based on their location change, thus determine causality that way. As one instructor expressed, *"ID-23: This is useful if you're trying to discover something and make changes. So, the discovery part, if I give it to you, you won't have a strong hypothesis* *initially, otherwise you would have already acted on it. Right. So you want to, you want to do matching, what matters, like be able to separate both curves. And then, you do that, you do an intervention and you see how that affects engagement in this case."*

In addition to the relationships between teacher and student data, instructors expressed interest in two other types of relationships. First, the relationship between teachers own data (i.e. how does movement affect gaze) and second, the relationship of the classroom activity with student engagement. In particular, teachers were interested to know how the activities they choose to do affect their students and their engagement during class time.

Overall, knowing the relationships between teacher and student data supported teachers' reflection and assessment of their performance, interest in experimentation and behavior change and as a result, their goal-setting. I discuss these findings in more detail in the assessment and goal setting section below.

11.4.2 Spatial and Temporal Information

Findings showed that spatial information was very important to instructors, as a way to reflect and assess performance, determine areas for improvement and set goals to change behaviors. Out of the three prototypes shown to teachers, only Prototype 1 (Figure 11-2) had spatial information, which drew a lot of interest and comments from instructors. In the other prototypes, instructors noted the design was missing spatial information and they would like to have it, or they would want to go back to Prototype 1 to see this information there. In particular, instructors expressed strong interest in spatial and temporal information shown together which was not included in any of the designs. They acknowledged it could be challenging to represent both dimensions in one view, but they thought a design like that would be extremely useful. As one instructor mentioned, *"ID-81: You have a spatial view... and then there's a temporal view. But I think what you really need is a spatial-temporal view ... So basically saying, oh, every time you go here, something happens. Every time you go here, something happens ... So, one thing I wanted to know is like the top left is engaged. Is that through across time or is it only, is it biased because of my podium presence? So having some kind of like a spatial temporal view of this would be helpful. Like I need snapshots of this [classroom map] over time."*

Instructors discussed that having this extra spatial dimension with the time dimension would help them identify relationships among teacher and student data, in particular causalities and the direction of causality. For example instructors wanted information about their location over time, their gaze over time as well as their students' engagement over time. They would use this snapshots over time information to identify how engagement changes as location of instructor or gaze of instructor change and recognize where they need to make improvements. During the co-design session of Prototype 1, instructors suggested design ideas that could help integrate spatial and temporal information. For example, they proposed having a slider in the interface that could help them swipe through or select different moments in time, and see how their behaviors and their students' engagement was mapped in the classroom at a particular point in time. As one instructor said *"ID-79: Now, what you could do is have a way to play. Like you move along a line. And while you're doing that, the spatial heat map changes ... Now, that could be really interesting!"* I discuss in more detail the effect of spatial and temporal information on teachers' assessment and goal-setting in the sections below.

11.4.3 Granularity of Temporal Information

Findings from the co-design study showed not only that temporal information was a very important dimension for showing teachers their own and their students' data, but also that the granularity of the temporal data had different implications for teachers' reflection-for-action. Depending on the timescale, instructors would be able to determine how they are doing, what areas they need to improve on and set goals on how they can improve in their practice in the short term and long term.

To begin with, instructors showed interest in having individual class session data or "today's" information. In particular, instructors were interested in class session level data as their lectures and classes can vary and are different from day to day. As one instructor mentioned, *"ID-99: So these are the average data, right? But my class is not average. Like every day is different. The one day I'm doing like, okay, let's do the paper reading and presentation. One day I have a guest speaker, one day I have group activity. So I think I would like to, learn in terms of like these different types of classes. Because if you try to average all these in one chart, probably I will end up with a confusing data."* Further, instructors expressed that they could use this kind of information at the end of the day, to review their performance, what happened during the lecture, and what worked or did not work well. Lastly, instructors mentioned that their unit of preparation is the individual class session, and they generally set goals and plan how to achieve those goals and keep students engaged. Thus having data shown at the class session level would be helpful to support their lesson-planning. In fact, some instructors expressed that with a data tool, they wanted to be able to annotate what happened during any individual class session or note what kind of lecture it was. As one instructor mentioned, *"ID-23: It's something I would like to have a way to make annotations for each week. Things like, it was like, a fire alarm or something."* This would help them determine in the future if a drastic behavior in the data was because of something they did or because of the type of class session they had on a particular day.

More interestingly, instructors mentioned that they wanted to have the ability to narrow down into different portions of the lecture, and be able to see what activity or topic they were covering during that part, what was the content and how it was being delivered. Instructors mentioned that the type of activity or topic determines their behaviors (i.e., are they standing next to the board or behind the podium using the laptop) and their students' engagement. In order for them to identify areas for improvement or what is causing student engagement to be low, they need to be able to see what exactly is going on at any point during the lecture: is it the content, or the way it is being delivered through an activity or something else outside of teachers power, what was the teacher doing and how were the students reacting. As one instructor said "*ID-80: But a key thing is for me, like the classroom data was a specific day. And so it was better situated in that day, especially if I was able to narrow it down to different portions of the lecture, to be able to see like, okay, during this lecture, during that part of the lecture, how is engagement and my location differing?"* These findings reinforce instructors' intention to determine relationships and and what is causing what in the data, as a way to identify areas for improvement and decide what they can do to fix certain behaviors.

Lastly, teachers also expressed interest in longer periods of time data, such as over the weeks/semester or over the years. They were interested in this level of granularity to see how their performance changes or improves over time. For example, the trendlines showing weekly performance information were very helpful to instructors, in particular to assess their progress and to decide what things they needed to change in their behaviors. I discuss this in more detail in the assessment and goal setting section below. Further, instructors mentioned they could use this data at the end of the semester as a reflection and to determine how their performance was for that class and what was helpful or useful to do next time. Similarly, instructors mentioned they wanted to have yearly information, as a way to determine what changes they need to do this year, based on their performance in the previous year or years. As one instructor mentioned, *"ID-72: For me over time would be helpful both within the course, pace of a course, having some chart of progress ... Also from year to year. So I often revise the lecture and give it next year, hopefully improving it."* They mentioned that annotations per class session (discussed above) would be very helpful in this scenario, to determine what they did and how, and how that affected their behaviors and their students' reactions.

Overall, these detailed level of granularity in the timescale of the data was necessary for instructors to assess and identify areas for improvement and determine in what ways they can change or fix any issues. I discuss this aspect in more detail in the assessment and goal setting sections below.

11.4.4 Student Data: Engagement

Overall, instructors expressed that nonverbal behavior data has value or some value. In particular, they mentioned they saw behaviors such as gaze as surrogates to attentions and engagement, which on their on are surrogates for student learning. Instructors also mentioned how they missed this information from the classroom, now that they had to teach through Zoom. They mentioned that in Zoom they feel there is a lack of information and they often cannot see students' gaze or facial expressions. As a result, instructors have no idea what students are doing. As one instructor mentioned, *"ID-99: That's why zoom is different. That's why, I don't know if the student is sleeping or in another room or actually, you know, listening. I have no idea. So that's kind of a lack of information for me."*

During the co-design sessions, instructors shared ways they use to identify or gauge engagement and disengagement in the classroom. This included ways to measure engagement based on what was presented through the designs (i.e. in Prototype 1) as well as other ways instructors use in their own teaching. Student engagement is one major aspect of the value instructors see in using nonverbal data.

Instructors shared that facial expressions, gaze and hand raises were on top of their list as ways that show student engagement in the classroom. For example, facial expressions such as looks of confusion, interest or following along, often overlapped with gaze and nodding, were some of the ways instructors could tell if their students were engaged. Further instructors mentioned that attendance was important, more in the sense of if students are not in class, then there is no opportunity to engage at all. Posture and taking notes were also ways some instructors used to determine if their students were engaged. As one instructor said, *"ID-44: In terms of importance, I would say like, attendance would be important. Not using phone laptop would be important. Hand raises is kind of like for me, attendance. So I guess they all seem to overlap. Facial expressions are always good clues for the instructor in terms of like, you know, are the students looking confused or are they nodding."* On the other hand, instructors discussed strong indicators that show students are disengaged in class. This includes them being on their phones or laptops, or sleeping in class. Some teachers wanted a separation of phone and laptop, while others wanted to know if students on laptops were keeping notes and engaging with the material, or if they were on a random site or playing games. As one instructor mentioned, *"ID-48: I would differentiate between the phone and the laptop. If people are on their phone, I consider them to be disengaged. If they're on their laptop, I don't know."*

Even though instructors agreed overall on ways to measure or gauge engagement, some instructors mentioned certain behaviors that would not be helpful regarding engagement. The main concern was related to, if such nonverbal means can actually measure engagement. For example, some instructors mentioned posture could be less significant and they were not sure how to use it. In their opinion, if a student was sitting back and seemed relaxed, did not mean that they were not engaged. Similarly, in terms of arm position, teachers were not sure how important that was. For example a hand raise means engagement, but a lack of hand raise does not mean disengagement necessarily. Further, they mentioned facial expressions could depend on the person, for example, a lost facial expression does not mean the student is disengaged. Gaze was also confusing for instructors to some extent. They expressed that they were not sure how they would use it, as student gaze could vary during class time (i.e., looking at notes, then board, then notes, etc.) Further, they mentioned that certain gaze behavior, i.e. looking up, even though at first look seems like disengagement, it could mean the opposite; the student is actually thinking hard. On the other hand blankly starring ahead is a sign of disengagement despite the gaze contact being high. As one instructor mentioned *"ID-15: I think gaze is not so reliable either. I don't know what is crossing their minds really. They may be looking at the right place but they may be very like detached from what is going on."* Lastly, some instructors disagreed that phone or laptop use could show engagement or disengagement, rather exactly what they are doing within such tools is what they would need to know to determine engagement.

Finally, instructors mentioned various other ways, not including nonverbal behaviors, or including outside of class behaviors, that they use in their own teaching to gauge engagement. In class instructors would use student feedback such as polls, clickers, in-class activities or quick questions/quizzes. Some instructors proposed to have real-time feedback from students on what they find interesting or how they are feeling during class. Other instructors used audio signal, for example the level of quietness during group work to determine when students are starting to get less engaged. As one instructors said, *"ID-51: I measure that when students are working in groups or kind of, in pairs or turn your neighbor kind of thing. I use the ambient volume, the room, to measure of engagement."* More in general, vernal communication such as quality of questions asked and answered, and student responses, were one of the important ways teachers used to gauge engagement. Outside of class teachers use behaviors such as sent emails, office-hours visit, Piazza questions, scores, assignments, grades, etc. to determine student engagement and participation.

An interesting finding from the co-design sessions is instructors' suggestions that the way student engagement is defined or what counts as student engagement depends on the activity that is being conducted in class or the content being covered. For example, whether students using the laptop shows engagement or disengagement depends on the activity type. If the students are using the laptop during group work, then that shows engagement. However, if they are using the laptop during an exam, that could be showing disengagement. As one instructor said: *"ID-80: You know, a student that is on their laptop is not engaged or on their phone is not engaged unless say, okay, we're actually in a group work. And I've said, you know, 'Hey, two of you know, you're working in pairs. One of you is on the laptop.'"* Similarly, instructors mentioned that the content and method of delivery is important to determine what is engagement. For example, if the instructor is covering a very theoretical topic and the class is board heavy, then engagement in this scenario would look like students paying attention and keeping notes. However, in a class that is more discussion based, then engagement takes the form of speaking up and participating. Further, some instructors mentioned that the amount of engagement will also depend on class size. Engaging a big class in discussion as a form of engagement is definitely much harder or even impossible, compared to a small class. As one instructor said *"ID-77: It's interesting because if engagement really means like engaging meaningfully, like in like a discussion or something like that, if that's kind of like the metric for engagement. If this was [mentions course number that has 200+ students] like only 43% seems like an awful high number. Like it would be an impossibility for a giant course."* Finally, instructors also mentioned that some students could show engagement in one way but not others. For example, they would show a lot of engagement during discussion, but not so much engagement during group work. These findings suggests that engagement has more dimensions and is multi-faceted. Determining when engagement is low and why impacts teachers' assessment and goal-setting for behavior change as I will discuss below.

Finally, throughout the co-design interviews, the issue of paying attention, engagement and student learning came up. Some instructors mentioned that they thought paying attention and engagement were the same. Others saw paying attention as a more passive act (listening, nodding, following along) while they saw engagement as more active. They thought that by just paying attention students will miss information, while engagement allowed for a deeper level of understanding of the material. They saw both as necessary and important to student learning, but engagement was most important to take learning to the next level. As one instructor mentioned *"ID-13: I would say paying attention is certainly a necessary condition because if they don't pay attention, then they'll miss what's happening. But beyond that, I think engagement really takes it to the next level."*

However, other instructors expressed that paying attention or engagement were not necessary to student learning. For example, they said you could have a fun activity in class which will make students engaged, but it does not mean that they will learn. As one instructor said *"ID-81: Even engagement I think is a fraudulent metric. Right. I think that creates academics who are like "show persons" as opposed to actual teaching... I think if I'm humorous I'm going to get more engagement. But it doesn't mean I'm actually a better teacher ... I can be a standup comedian and be engaging."* Some instructors even mentioned that engagement could be harmful as it could dilute learning. As one instructor mentioned, *"ID-79: In high school, there's a lot of effort in the middle school, a ton of effort to get high engagement and sometimes the way they do that is exactly by diluting the technical quality of the curriculum. And then it's really engaging, like instead of asking people to understand how to solve a problem, ask their opinion about a problem, "How do you feel about this?'"* Other instructors mentioned that there might be some relation between paying attention, engagement and student learning, however this was not a strong relationship. They believed that students can still learn even if they are not engaged or paying attention in class. They mentioned that engagement can help to learning, but learning was the ultimate goal. As one instructor expressed, *"ID-48: Well, in fact, I don't care about student engagement at all if they're learning. Isn't that the action I think that we care about. As a measure of their potential learning, right. Is the indirect measure. If they're learning, they're engaged, not necessarily the other way around."* Finally, some instructors mentioned that they did not care about engagement and they did not think it was their responsibility to keep students engaged. In their opinion, students are adults and their engagement and learning is up to them.

Overall, regardless of their belief on the importance of paying attention or engagement, the ultimate goal of instructors is student learning.

11.4.5 Assessment

In this section I will discuss findings from how the instructors reflected on and assessed the performance of "their colleague instructor" based on the designs shown to them during the co-design sessions. Often, instructors also expressed how they would assess their own performance, if the data shown was their own data from their classrooms. Instructors used a variety of elements from the designs to assess the performance as described below including trend lines, social comparison, the goal set in the prototype from the prior week, etc. They often used one or more of those elements to identify how they were doing and what room for improvement is there, as a precursor to setting goals and deciding on behavior change. As one instructor mentioned *"ID-43: I would say, like their gaze in general, the student gaze is good, it's higher than their own goal. It's higher than the other instructors. It's been rising over time, that sort of thing. The engagement is also better than their colleagues, but they didn't hit their goal."* Ultimately, the goal of the instructors was to determine when student engagement, or other student related data pointing at engagement (i.e., gaze) or disengagement (i.e., students on the phone), was low and called for improvement or was high and did not need an intervention. This assessment was a first step towards goal setting described in more detail below.

Despite that, there was a minority of instructors who expressed challenges in assessing the performance based on the information provided. In particular, they mentioned they could not tell if the performance was good or bad or if reaching the goal was a good thing only based on a number percentage provided. Similarly, in some cases they mentioned they needed more information on the colleague's classroom to asses the performance. For example, they said it is important for assessment to differentiate somebody who writes on the board from someone who uses slides, in terms of how much they look at their students. Class size (in terms of student engagement percentage), teaching style, type of classroom, etc. were also important according to instructors, to be able to provide a fair assessment. These findings hint at the issue of locus of control, which was also came up in the Chapter 7 and Chapter 8 findings.

Instructor Own Trendlines

Trendlines (i.e, in Prototype 11-3), as a form of mastery experience, were very popular among instructors for reflecting on and assessing performance. Instructors used them to identify increases, positive trends or improvements in performance, declines and dips or when progress had plateaued. As one instructor mentioned, *"ID-15: I look at the trends and all of them, there seems to be an uptick. Whereas the teacher gaze maybe is less pronounced in that way. So that's the part that maybe the teacher is failing more strongly."* Instructors saw trendlines as a way to determine how the colleague was progressing, and in particular to determine and potential room for improvement as a first step towards changing something in the behaviors. As one instructor expressed *"ID-44: On the other hand, it might be plateauing here, at week four or five, there doesn't seem to be much of an increase. If they feel like, you know, there's still good room for improvement here, they may wanna think about new ideas, something maybe they haven't tried before."*

Trendlines were also helpful at different timescales; both at the weekly level as described above, but also at today's level performance (i.e., in Prototype 1, the chart showing engagement over class time). In particular, instructors would find those helpful if annotations of the type of activity happening at any point in time were included in the chart. As one instructor mentioned, *"ID-24: This might be something that, you know, if I want to diagnose what the problem is, and if I say, oh, you know, during the second half of the lecture, I was just doing proofs. I was writing things and, you know, that's why my performance went down."* Overall, trendlines, as a form of mastery experience, were very important to instructors to assess progress and performance and identify areas of improvement.

Social Comparison

Following trendlines, comparison with other instructors' performance (as a form of social comparison) were also used by the majority of instructors to reflect and asses the performance of their "colleague" instructor. In particular, instructors expressed that they wanted to use the social comparison trendline to determine how they are doing, are they average. They thought it was good for them to know where they stand in comparison to others. Instructors mentioned this was a good feedback mechanism on their performance on whether they were doing well, they were quite close or if there were ares for improvement. As one instructor said, *"ID-37: I really liked the comparison with the other instructors just because, you know, it helps us sort of figure out where, where we stand."*

Further, the social comparison trendline was used to identify areas with room for improvement as a first step towards behavior change. As one instructor mentioned, "*ID-44: I think there's also clearly a lot of room for improvement given that, you know, with other instructors they're able to get 75%.*" Instructors assessed the performance of the data shown in the designs as better or worse than other instructors, by comparing the trendline of the colleague with the trendline of others. Some instructors also used it to check if the goal set for them to reach was reasonable or were they aiming too high or too low. As one instructor said, *"ID-99: So I think I would like to learn about my colleagues because like, for example, in the teacher facing forward example, right? So like you set a goal for 65%, but the average is 30%. So don't like, you know, don't be hard on yourself."* This would help them also be more motivated and encouraged. Others mentioned they would use to calibrate their success; even if they have met the goal but they were doing worse then others, than that meant there is room for improvement.

Even thought many instructors found the social comparison trendlines useful, some instructors did not think they were helpful. In fact, they mentioned that comparing yourself to others is unhealthy, not productive and create a culture of competitiveness and uniformity. They mentioned that classes were different in many dimensions (subject, class size, how the material is presented, etc.) and due to this variability, social comparison was not appropriate or accurate. As one instructor mentioned, *"ID-23: [regarding comparison with other instructors] Personally, I think is a bad thing ... Because, different classes, different instructors have different styles. And, the fact that you are doing different things differently from others, even on average, doesn't mean that you're doing worse or even better. You're just doing your own thing. So I don't think we want to like foster climate of competition or uniformity."* Other instructors mentioned that even with looking at others' performance they were not sure whether they were doing well and they did not consider comparison relevant to assessing performance. Lastly, some instructors mentioned that comparison could be discouraging (if you are not doing as well as others) and even harmful (if you are doing better than others) to improving behaviors and practice. As expressed by this instructor, *"ID-51: If it's a relatively flat bar and it's low, it seems like less of incentive for me to try to up my game a little bit ... I'm already doing better than the rest of* *my colleagues, then maybe don't [try to change]. But conversely, I guess if it's a high flat bar too that could be certainly something that depending on the individual, they'll be like, 'Oh, shoot, yeah, I should get my act together and try to improve these things because other people are doing well'. But you could also get into, the fixed mindset of 'Yeah, I can't do this. Other people are just naturally better than me at this than I am. This is, this is not my style'."*

Today's performance and goals set

Finally, as a way to assess their colleague's performance based on the data shown to them in the prototypes, instructors used what their data and performance was today, often combined with the goal set for this week. This is yet another form of mastery experience. For example, instructors used how their colleague's performance was today in Prototypes 1 and 2 to assess whether they were doing well or not well. In Prototype 1 they focused on the relationship between the teacher and student data combined with the spatial and temporal information as a way to assess performance as well as the trendline of student engagement over class time (both described in more detail above). Here is an example of how one instructor did the assessment, *"ID-43: Looking at the rise and fall through the class period, I noticed that engagement was particularly high and then dropped off quickly with group work. Then, in particular, that the end of lecture was bad."* Further, in Prototype 2 instructors used today's performance in the horizontal bar as a way of assessment, *"ID-93: To me, 58% feels low, very low for teacher facing forwards. This means half the time you're not facing the students... And I don't necessarily think there is an upper bound here. I think your goal should be in the eighties or nineties, and that feels very, very low. This is something that I would be very concerned about if someone was facing forward 58% of the time."*

Some instructors used today's performance in combination with the goal set in the designs (Prototype 2) to make an assessment, *"ID-24: And also if I was using this, and if I said 60% and I got 20%, I'm like, okay, why am I not doing right? It's like you know, I should reevaluate whatever strategy I'm using to improve."* Similarly, the assessment with goal was often mixed with other measures (such as social comparison and trendlines described in detail above). As one instructor mentioned, *"ID-57: In this case I'd probably focus mostly on the gaze as the first thing to work on. And especially because they're so far away from their goal and they're far behind where other people are."* Often, goals took secondary importance or no importance to assessment, compared to these other measures (social comparisons and own trends). For example, as discussed above, if the goal had been reached but the colleague was doing worse than other instructors, then the assessment would be that there is still room for improvement. In addition, instructors judged how appropriate the goal was (i.e., too high or too unreasonable) based either on personal opinion, on how the instructors were doing or on the trends for the colleague

11.4.6 Suggestions for behavior change and Goal-setting

From assessment to goal setting: Design considerations that support goal-setting and intentionality for behavior change

As described in the assessment section, during the co-design interviews, instructors used a variety of design elements (i.e., trendlines, social comparison, today's performance, etc.) to assess the data and performance shown to them in the designs. This assessment was crucial to identify where there was room for improvement or where things were progressing well and there was no need for change. Overall, instructors' ultimate goal was to change and improve their behaviors in a way that would help students, i.e. through increasing student engagement or another behavior representing engagement. To determine what they needed to do next, instructors used a combination of the various design considerations in the prototypes to first assess the progress and performance and second offer suggestions on behavior change and goals to set. I will individually highlight and discuss here these design considerations. In the next subsection I will focus on the types of goals instructors set per each prototype and what fueled that decision.

Relationships (as a form of value) between teacher and student data (depicted in Prototype 1 and Prototype 3) were important and helpful to teachers not only to assess progress and performance, but also to set goals and decide on potential behaviors to change. In particular, if teachers noted strong correlations and/or causations in the data, that would mean that to "get more of X student behavior" they needed to "do more of Y of their own behaviors". In particular, if students are low on X behavior, then the teacher can set a goal to do more of Y behavior. In this case, X and Y could be nonverbal behaviors such as students' engagement or students' gaze, and teacher gaze or location respectively. As one instructor mentioned *"ID-27: So clearly there's a relationship between instructor gaze ... and student engagement. And so, you know, one takeaway from this would be to think about how to use gaze as well as physical location, as a way to further engage other students within the class, or maybe even to think about across multiple classes, how to reorganize students in their assignments of seating so that you could get those students more engaged."*

Similarly, **today's performance** (as a form of mastery experience), expressed in the form of relationships (Prototype 1) or number percentage (Prototype 2), was another way for instructors to assess for room for improvement and to decide on a course of action. Along the same lines, **trendlines** (as a form of mastery experience), both within the lecture (Prototype 1) and over multiple class sessions (Prototype 2 and Prototype 3) were extremely helpful to instructors to see progression and trends and decide what action to suggest for taking. For example, upward positive trendlines meant that the instructor was progressing well in their performance, and they should continue doing what they are doing in their classroom. On the other hand, dips in trendlines or plateaued trendlines suggested that the instructors should change something in their behaviors, as what they are doing is not working anymore. As one instructor mentioned, *"ID-51: I guess that I'd be less concerned about the facing forward and location diversity goals. I mean, you can always adjust those, but the trends are going well. If it was goals that got them to that, then you know keep that progress. If every week, we're bumping up that 5% then yeah, keep going with that, if that was helpful for them, but otherwise I wouldn't be as concerned with those".*

Third, **comparisons with other instructors** (as a form of social comparison), not only helped instructors in the co-design session identify if they were doing well or not well, but also determine a concrete goal they should aim to reach. The performance of other instructors was often used as a benchmark to shoot for. For example, if their performance is worse or lower than the other instructors, then the goal would be to be at least be as good as the others, if not be the best over everyone else. As one instructor mentioned *"ID-77: ... my role is probably going to follow where my peers are pretty much. I'm just going to try to like reach that. Exceed it if I can, but generally like, you know, that line is almost gonna serve as my goal with maybe an adjustment depending on whether or not it's like, okay, well I'm in one of those weird classrooms where I don't want to stand in certain places".*

Lastly, there were some other design considerations discussed above that supported both assessment and goal-setting. This involved elements such as providing data with a **spatial and temporal** component, providing different **granularity in the temporal data** and providing the **type of the activity** happening in class, together with the data. For example, instructors used the spatial information to determine the relationships between the data as well as what they might be able to try and do differently today based on that information. Similarly, they would use the activity type to determine when student engagement would drop, as a way to then plan for a different, more engaging type of activity, or to shorten the amount of time spent on the current activity.

Goals teachers set per prototype

Prototype 1: Seeing today's relationships between teacher and student data mapped spatially in the prototype, as well as seeing where the student engagement was high and low physically in the class, instructors suggested a range of goals and gave advice related to how the colleague instructor could improve their performance. For example, as their location was primarily on the right and center sides of the classroom, instructors suggested the colleague to use a technology such as a tablet or a clicker that would allow them to move more around the classroom. In particular, they suggested when possible not so spend time at the podium, and maybe rely less on slides. They encouraged the colleague to move more between students, and in particular pay more attention, either with location or gaze, to the people in the back of the classroom, who show less engagement. Similarly, they suggested the colleague should try and look at all the students equally, and try and spend roughly and equal amount of time in each place in the classroom. One way to accomplish that, in particular if they have to use the podium for an activity, is to move the podium to the center. That would help create a more balanced distribution of their location and haze among students. Some instructors even suggested to get rid of the furniture at the front, such as the table, to be able to move more freely at the front, which would also allow the instructor to be closer to the students. The majority of instructors assessed that the students on the left and those on the back were not getting any location or gaze attention from the teacher and provided the low student engagement in those areas, this should be addressed. Here is how an instructor suggested to do that, *"ID-43: ... they spent most of their time looking at the students in front of the podium, and that resulted in a lot higher engagement for those students versus the ones in the way back. So certainly, you know, spending more time to the left of the board is probably, like standing over there is a good idea. But also gazing over there."*

Finally, some instructors focused their goal setting and suggestions on the student engagement vs activity trendline over class time at the bottom of Prototype 1. This included more pedagogical advice such as not to do anything important in the last half hour (as students' engagement drops after a long class), incorporate more active-learning activities, such as group work, think-pair-share or polls to bring up engagement when it goes down. As one instructor suggested, *"ID-24: If there could be two periods of group activity, it might be worth experimenting with that to see whether things improve maybe. Yeah, this last part [referring to the drop in engagement in the last 20' in the chart], you know, they could experiment with having one hour lectures and still one and a half hour lectures, because that last little 20 minute portion is kind of, it's almost natural."* Instructors also suggested other behaviors they could do such as saying a random swear word (to give a little jolt of energy and wake the class up), cold calling people on the back, asking students to stand up and stretch, etc.

Prototype 2 In Prototype 2a where teachers were presented only with teacher data, the focus of goal setting and behavior change suggestions was mainly around gaze balance. Based on their performance, some instructors suggested the colleague should set a lower goal, as the current one is too high or too aggressive. Others suggested they should try to improve on their gaze balance, for example by doing more "sweeping" throughout the class with their gaze, looking around more, and not focusing on one side of the classroom only. Other instructors suggested more pedagogical related goals such as asking more questions in class to increase the gaze contact, or talking to other colleagues to learn various practices they use in their classrooms. On the positive side, instructors assessed the colleagues location as good and mentioned that they would advise the colleague not focus on that behavior, rather only gaze. As one instructor said *"ID-79: They should face forward a little bit more. Their gaze balance is a mess and presumably they're fixating on a couple, one or two, it's so low that they're probably just looking at the same place, almost. So make sure that you're looking around. And location diversity, the goal was 60%. They're at 80%, so they're doing great."*

In Prototype 2b where teachers were presented only with student data, instructors suggested the colleague should work on increasing student gaze and on banning phones, both with the aim to increase attention and engagement. Some instructors suggested pedagogical goals such as cold calling students or doing more group activities to increase gaze and decrease phone use. Others assessed student engagement as going up, in a positive trend, thus the instructor should keep doing what they are doing. *"ID-15: The student engagement has increased and, you know, whatever they were doing, maybe they should keep doing, because the trend is positive ... and maybe they should work harder on the phone thing."*

Finally, when teachers were presented with Prototype 2c, where teacher and student data was shown together, some instructors were lost for explicit advice or suggestions on goals to set, provided the overload of information, with no concrete relationships and no information on what the colleague has already tried. Their main advice for the colleague was to do some research and experimentation to determine relationships and causality; identify trends that are flat or that are not going up, try to change one of those behaviors (i.e., gaze) while keeping the others constant, and analyze how student engagement and the other student variables changes in that case. Others iterated their suggestions from Prototypes 2a and 2b, such as banning phones and moderating goals.

Prototype 3 Lastly, in the final prototype where trendlines of teacher and student data showed a very strong correlation, instructors agreed that the performance of the colleague was great and they should keep doing what they are doing. As one instructor expressed, *"ID-37: I would basically say you are doing great. Just keep keep doing whatever you have done. Like that has been a really good change. It seems we have been really improving, it's like shocking improvement."* Others suggested for the colleague to start working on improving other areas of their behavior, or further analyzing any dips in the current performance.

Other concerns with goal-setting

The co-design sessions with instructors also helped raise some really interesting questions around goal-setting. For example, when discussing about setting a goal, two new dimensions emerged from the data. First, what is the frequency of setting a goal, and second, how many goals is it reasonable to set at a time. Instructors mentioned that expecting them to set goals daily, or even weekly would be too much. They mentioned they could slightly adjust the goals each week, but not to expect major changes, similar to how you cannot expect to loose 10lb in one week. They would prefer setting a long term goal, over a month or a semester, and continuously work towards achieving that goal. Further, instructors did not want to set multiple goals at once. Rather they preferred to focus on one goal at a time, which according to them would already be hard to juggle with all the other things they have to do and remember in teaching. They also advised their colleague instructor to not try to be the best at everything, rather try to be average on some goals and super on others.

Another interesting dimension for goal-setting that came up during the co-design interviews was the context of the goal. Instructors mentioned that depending on the type of classroom, the goal they would suggest or they would set would be different. For example, they said it would be easier to engage more people in a small classroom than in a very large classroom. Depending the subject of the course and the activities, engagement would look different, teacher behaviors and teaching styles would look different and as a result, the goals to be set for behavior change also need to be adapted to these dimensions. As one teacher expressed, *"ID-27: ... part of that has to do with the variety of classroom teaching styles. You know, if you have a flipped classroom, your engagement style is going to be very different than if you have a lecture style class. And it's not to say one or the other's better. It just depends on how they're executed. And also the size of the class is going to change things. So if there was a goal to include other instructors or some comparison, I think one would need a taxonomy of different kinds of classes and knowledge about what kind of class the instructor is using in that taxonomy, and then to compare to that subset."* Again, even though I do not focus on locus of control in this study, these findings hint towards locus of control being an important factor in instructors goal-setting and interest for behavior change.

Further, Prototypes 2 (all 3) were the only prototypes that had an explicit goal setting design element and provided a goal that the instructor had selected to achieve this week. Some instructors mentioned they did not like this goal-setting feature, and in particular they did not like setting goals or they did not believe in setting goals. They suggested setting a goal as a number is arbitrary, as numbers do not make much sense, and that people set unrealistic goals all the time, and then under-perform or over-perform them. Others said that setting such a goal is too specific, an unnecessary level of detail. In fact, they mentioned it could be harmful to set goals this way, as the colleague may become too focused on the numerical goal rather than the big picture of what they are trying to achieve. They might start teaching to the metric, and gaming the system. As one instructor said, *"ID-93: I don't want to put teachers in a position where they feel like they have to gain the metrics and the metrics then cease to have value because they're a target."* Others suggested that they did not like and did not find helpful similar apps in their lives where they had to set a goal just to make the system happy. Instructors mentioned they would prefer to simply reflect on their performance and have a more general, an internal goal. To them, the awareness of their performance and overall trends was more important than the specific numbers. As one instructor expressed *"ID-97: I don't think the goal is very important for me because, by comparing to these others and by comparing with the historical trend, I will see that, okay, I should do better here. I will try to do better, but it's not really useful to set a specific goal."*

Along the same line, some instructors suggested they would not or cannot set goals about their students. They said that students' actions are independent of their own actions, and that they can try to influence students' behaviors, but they cannot control them or directly affect them. For example, instructors mentioned they can control and address their own habits and behaviors but they cannot control directly student engagement. Further, they mentioned there are other external factors outside of teachers control (i.e., a situation in the news) that affect student behavior. As one instructor mentioned *"ID-93: I wouldn't focus the conversation around what the students are doing. I'd focus the conversation about what the instructor can actually control, which is what the instructor is doing, and find ways to improve that, and then hope that this turns into positive effects on the students later."* And yet another *"ID-57: I just don't really want to say like, I need to increase my student engagement by 17% because I can't directly do that. I can change what I'm doing."*

Some instructors also expressed challenges with the idea of setting a goal; they did not know what would be a good goal to set, they were not sure what specific actions to take and they were confused on how to improve provided the data. Some also mentioned that they did not have or know of a quantitative measure of what is good to set as a goal, or if looking at other instructors as the average is a good way to compare and set goals. As one instructor mentioned, *"ID-43: So it looks like you can set a goal, but like, is there a way to present to you a research paper on what you should be doing. Or, you know, like, am I being asked to pull that number out of thin air? Or is there a good reason for it."* Others expressed difficulties with knowing what actionable items they could implement in the classroom. For example, one instructor acknowledged that the students at the back of the classroom are generally not engaged, but they did not know how to get them to engage.

11.4.7 Co-design design ideas and Feature requests

During the co-design sessions, instructors brainstormed and suggested a variety of designs on how the prototypes shared with them could be improved in order to best support their practice, assessment and goal setting. Here I will share some of the main ideas instructors came up with and were interested in, in addition to what was discussed in the findings above

DEFINITIONS To begin with, instructors were often confused by the definitions of some of the data shared with them by the prototypes. Often, they were confused as there was no definition, while in other cases they were confused how the data was measured and operationalized. Specifically, they asked for the definition of data such as "gaze balance" and "location diversity", what the data meant and how it was measured. Similarly, they expressed confusion on how the student engagement was measured and defined. As one instructor mentioned *"ID-48: Well, I don't know. Does that mean that 78% of the students at some point looked at the teacher or 78 or the average student is looking at the teacher 78% of the time."* Instructors were also confused by how the proxies for measuring engagement (discussed in Prototype 1) made up or resulted in the engagement measure. Instructors were unclear how some proxies such as arm pose, attendance and gaze were measured or how they could be helpful. Similarly students on the phone was another point of confusion for instructors on what this data measured. For example, did it include quick glances to the phone or did it include only cases when students were on the phone for long periods of time.

MORE DATA Despite the large range of data shown to instructors on both teachers and students, they still expressed interest having other types of data. In particular they were interested in student feedback, whether they liked the class and the material, but also, in student learning metrics such as scores, responses in polls, etc. For their own behaviors, they were interested in data that correlated the activity they were conducting with their behavior and students' behaviors. For example, one instructor wanted to know how their board use affected teacher and student gaze. One interesting metric that was also requested was "teacher energy", that could be expressed through movement or through speech. Teacher energy was important according to instructors to student engagement. Lastly, instructors were interested in student engagement in specific activity types such as group work or group discussion.

ACTIVITY Another category largely discussed and requested by instructors was marking the data with the activity type. Instructors wanted to be able to see within the class session, the activities covered that day as well as the type of class (i.e., exam, student presentations) at the class session level. They were interested in marking or annotating the data themselves or having it automatically provided with the rest of their behavior data. Similarly, some instructors wanted even more granular information, such as student and teacher behaviors against the exercises they covered that day or the slides they were covering in their lecture. They mentioned that having this information would help them determine when students' attention or engagement was dropping off. One instructor also mentioned tagging each class data point with the lecture title and integrating these data with a LMS. Finally, along the same line of thought, instructors proposed to have the social comparison data tagged and classified by subject, department level, school level, and university level. This classification is similar to the FCE one, and would better help instructors assess their performance and decide which direction to move forward and change their behaviors.

RESEARCH In addition to being able to see relationships between teacher and student data, such as correlations and causations, some instructors wanted to take on more of the role of the researcher. They wanted to have the ability to download the data shown to them and do their own statistical analysis. They also mentioned they would like to have more detailed statistics as the average is too restrictive in most cases. They suggested other types of statistics the data could show such as distributions, information on quartiles, spiderwebs to represent progress in differing dimensions, as well as scatter plots to represent correlations. As one instructor mentioned, *"ID-24: One thing that I would really like to have if possible would be so, as I said, I'm a bit of a data geek, so I would be happy to have this data available, like downloaded Excel. And then I play with my own data. Right. I do regression on that."* Similarly, having the ability to sweep through the data to be able to explore in more detail what is going on, in particular when the data is spatially and temporally correlated, is one of the other design ideas and suggestions instructors had in relation to the prototypes.

CUSTOMIZABILITY Instructors suggested the data shown to them should be more flexible and customizable. First, they mentioned a progressive disclosure approach would be appropriate, where an overall chart with overlaid is shown, and who has more time and interest can dig deeper in the data. Similarly, they wanted to have the flexibility to select the data that would be displayed, through check boxes. For example, in Prototype 3 they suggested having multiple teacher data on one of the Y-axis as a way for the instructor to select what they want to explore. They also wanted to have the ability to select which class sessions to show or use in their analysis and assessment of the data.

MORE SUPPORT Even though instructors found trendiness and social comparison very helpful, the text shown in Prototypes 2 representing Verbal Persuasion was not helpful to them. Instructors requested for this design element to be removed as it was redundant. Locus of control also came up indirectly in the discussion with instructors (i.e., mentioning of how the classroom structure or the use of the board/slides would affect their data and goal setting), as discussed above. In addition, instructors were interested in having other ways that would better support their practice and behavior change. For example, one instructor suggested having training videos that would help them understand how to change their performance. Others suggested having more qualitative ways of keeping track of goals, or seeing their progression of goals and other instructors' progression of goals over time. An interesting idea that also came up during the co-design sessions was having concrete and actionable suggestions with goals the teacher could set or activities they could try to implement in the classroom, as a way to improve their behaviors and students' learning and engagement in class.

PRIVACY AND SECURITY Very few instructors brought up the issue of the data being used in punitive ways, for example being sent to the head of the department. They did not want this data to be harmful to them or their careers and preferred the data to be used only by them, for practice improving purposes. Few other instructors brought up being uncomfortable with the surveillance with the data and this idea of"big brother". Despite these concerns, some instructors suggested using such data to supervise and give feedback to their TAs in their classrooms.

Overall, instructors expressed that they found useful to some extend all the Prototypes shown to them through the co-design sessions. The majority of instructors when asked, said that they liked the most Prototype 1. This prototype provided them the most interesting data, with relationships expressed in spatial and temporal from within a which allowed them to see what was going on in the data and determine where they could improve. Through the prototype, they could also dig deeper within the lecture, and identify what activities best support student engagement. Instructors mentioned the prototype would also help them visualize their own performance in class and determine what they needed to act on. As one instructor mentioned *"ID-13: Um, most helpful, certainly the first one is, it's telling me much more detail about what I am doing, which students are engaged."*

The second most popular prototype, in often cases taking the first spot over Prototype 1, was Prototype 3. Instructors mentioned this was very easy to understand and provided that relationship in data they were looking for. As one instructor mentioned, *"ID-79: I loved the last one because like, that's something that is actionable to me. At least it's potentially actionable. It's just really easy to reason over."* Some instructors mentioned Prototype 3 would be even more helpful if more data was presented in it, for example, more teacher data.

Finally, all three prototypes within Prototype 2 were generally not popular or useful to instructors. There was a lot of information in these prototypes, that could potentially be overwhelming. As one instructor mentioned, *"ID-27: I think the second one is least helpful because it's really driving decision-making based on the metric without specific recommendations, right. Or context. And the issue there is that you might teach to the metric and ignore the actual learning objective or a larger goal."* Despite that, instructors mentioned this Prototype could be useful if it showed relationships between teacher and student data, as a way for the instructor to dig deeper into their performance. As described above, instructors could see this prototype being helpful to see their progress with the trendlines of their own progress and comparison with other instructors.

11.5 Conclusions

In this chapter I share findings from a co-design study I run with 22 instructors at an R1 institution. The aim of the study was to design for the integration of teacher and student data, while supporting reflection-for-action, namely refection and goal-setting. From prior work, I identified a set of dimensions and challenges in integrating teacher and student data and in supporting reflection for action. Through the findings of this work, I was able to identify the dimensions were most important as well as new dimensions that had not come up in prior work. To the best of my knowledge, this is one of the first studies that focuses on integrating teachers' own data with their students' data. Further, to the best of my knowledge this is also the first study that focuses on supporting reflection-for-action, with teacher and student data.

To begin with, findings showed that seeing the **relationship** between teacher and student data was extremely important to instructors, even more important than what the findings in Chapter 7 and Chapter 8 had suggested. In particular, instructors wanted to see such relationships to assess their performance (i.e., where were the students falling short on) and try to determine how their action could better support or better affect their students. Instructors were able to identify relationships in the data shown, whether those relationships were implicit or explicit in the design. Instructors looked for relationships even in the prototypes that contained no such information. Thus, seeing relationships between teacher and student data does not only bring *Value* to instructors, on the importance of teacher immediacy and nonverbals but also provides them with a means to asses performance and take actions where improvement is needed.

An interesting finding was that instructors wanted to see correlations of their behaviors and their students' behavior, however, many instructors mentioned that correlations would not be enough for them. Instead, they wanted to see **causal relationships**, and the direction of causality between their data and their students data. These findings echos the findings from Chapter 10, that showed that correlations between the data might not be enough of a strong indicator for what behaviors to change and work on. Thus, in order to best support teachers in identifying areas for improvement and taking action on changing their behaviors, tools and dashboards that share with teachers teacher and student data should involve causal relationships between such data. Further, some instructors were interested in running their own "research" or "experiments", by changing something in their behaviors and seeing how that affects their students. Thus, such data sharing technologies should create the opportunity for the teacher to download the data or run statistical analysis within the tool, in addition to supporting experimentation and keeping track of actions taken and how other behaviors changed as a result. Ultimately, by supporting relationships such tools would support both the Value instructors see in the data, and their reflection-for-action.

Secondly, the importance of the relationship between teacher and student data was also emphasized by the representation of the data: in spatial or temporal form. Findings showed that both spatial and temporal information was valuable to instructors. In particular, they wanted to see **spatial and temporal information** together, even though none of the prototypes I shared with them accounted for this design element. Instructors mentioned that overlaying temporal and spatial information together, would better allow them to identify areas they need to intervene, as well as point them to concrete actions they can take to change their behaviors. Thus, the spatial and temporal dimension had an even bigger importance that what I and the designs had foreseen. For designers of data sharing technologies for teachers, in particular when the data is nonverbal behaviors, findings suggest to design the visualizations around a combined spatial and temporal scale.

Further, findings showed that instructors were interested in seeing temporal data at different levels of granularity, which introduces a new dimension for future dashboard designs. Each level of granularity, today's lecture, weekly/semesterly as well as yearly would affect teachers' interventions and support their behavior change at a different scale. Long term behavior change is complex and requires the instructor to initially do small scale change (i.e. at the next-class level), mid scale change (i.e. weekly or semesterly) and then more long term change (yearly). Thus, this level of granularity of temporal data would allow the instructor to take action as appropriate. Designers of tools that aim to support long term behavior change have to think about each of those levels and should design to support teachers' assessment and goal-setting for each of these time scales. A yet another interesting finding was instructors' interest in even more granular time data: zooming into each lecture and being able to see the individual activities or topics they were covering, and how that affected their and their students' behavior. According to instructors, knowing about the relationship between activities and the behaviors in the classroom, would help them determine areas for improvement (i.e., when are they loosing their students' attention) and be able to take action by changing up the activity or what they do in the classroom.

Third, the common denominator of all teacher reflection and assessment, goal-setting and intentionality for behavior change of their performance was student behavior. For the co-design study in particular, the discussion was focused on **student engagement** in the classroom. Instructors mentioned various proxies they use in the classroom, both nonverbal and verbal, to gauge student engagement. For some instructors, proxies like gaze were important to determine engagement, while for others not so much. Designers of technologies that share with teachers data should allow for customizability; instructors should be able to decide what proxies or metrics they want to include in student engagement. Further, multiple instructors mentioned that how they gauge **student engagement depends on the activity** in the classroom. For example, working with laptops might show disengagement during lecture but engagement during group work. As discussed above, it is crucial for technologies that share with teachers data from the classroom to integrate this data with the classroom activity and what is going on during class time. Despite teachers' interest in student engagement, some issues and skepticism was raised around the importance of engagement. In particular, some instructors mentioned that **engagement is not necessary to student learning** and that student learning,as the ultimate goal of their teaching, is more important and should not be "sacrificed" to have more engagement. Thus, designers of technologies that share with teachers such data, should consider sharing with instructors the value of engagement to learning, based on the extensive literature on this topic. Further, they should consider integrating student learning information (such as grades or scores) with the other teacher and student data to show correlations and causations of teacher behavior on student engagement and as a result on student learning, or directly from teacher behaviors to student learning. For example, the integration of teacher behaviors with student scores or grades should be relatively easy in a LMS that already collects and generates student learning data. Ultimately provided the complexity of the student engagement measure, designers of technologies should consider 1. customizing it per instructor, 2. relating it with the activity happening in class, 3. strengthening and better conveying the value of engagement through citing literature and prior work or relating it with other student learning measures.

Even though the co-design study was not aimed at explicitly measuring teachers' goal-setting and behavior change, I investigated teachers' **reflection, assessments**, **goals and suggestions for behavior change** for their colleague instructor based on the data shown by the prototypes. In fact, even though the data shown was mock-up data and certainly not their real data, instructors role-played on their own as if this was their data and provided actionable advice on what they would do in the classroom, if they saw this feedback on their teaching. Findings showed that design elements aimed at supporting *SE (self-efficacy)* and *Value* were crucial to instructors to reflect on the performance, identify areas for improvement and even decide what goals to set or what actions to take and how to move forward. In particular, mastery experiences, represented in the form of trendlines of their progress as well as in the form of today's performance, were invaluable to instructors. A large body of work has shown the importance of mastery experiences to SE (i.e., [34, 35]) and through this co-design study I showed that mastery experiences support teachers' reflection, assessment and goal setting. Both trendlines and today's performance was even more valuable to instructors when they were combined with the relationship between teacher and student data (a combination of support for SE and support for value). Further, social comparison with other instructors, another form of support for SE, even though controversial, were invaluable to instructors both to provide a guideline for assessing the performance (where they are at compared to others) as well as to provide a goal for them to shoot for (try to be as good as or better than other instructors). And finally, as discussed above, relationships between teacher and student data combined in a spatial and temporal format not only conveyed value to instructors but also supported their reflection-for-action.

Findings showed that instructors used a combination of these methods to reflect on and assess the performance thus there is no one-size-fits-all approach for assessment. Further, instructors assessed their performance at different temporal levels (activity type, today's lecture as well as weekly). Ultimately, reflection and assessment, as crucial steps to goal-setting and behavior change, are complex processes that required a variety of support as described here. Designers of technologies should aim to support teachers' SE and value in such tools. Further, more research needs to be conducted as to which of these constructs best support teachers' reflection for action (SE or value) and how to support each construct best (i.e., is mastery experience or social comparison a better support for SE, are causal relationships or student learning better support for value). Finally, even though I did not investigate locus of control in this study, findings again hinted and its importance to teacher goal setting. It is necessary to further investigate the effect of this construct on teachers' reflection-for-action and how this effect compares to the effect of SE and value.

Based on their reflection and assessment of the data described here, teachers set a variety of goals and gave further general practical and pedagogical advice to their colleague instructor, from "continue doing what you are doing", to explicit suggestions and practices they could and should try to change in their classrooms. Despite that, some instructors brought up some challenges in relation to setting goals. They mentioned they did not prefer to set a numerical goal for their performance as that was too prescriptive, too arbitrary and not helpful to them. Instead, they preferred to have a more internal or a qualitative goal of what they wanted to achieve. Further, a new and interesting dimension of goal-setting come up from the data: frequency and quantity of goals to be set. As discussed above, long term behavior change requires shorter term changes. As a result, instructors, did not see themselves setting goals every week, rather setting a goal at the beginning of the semester and slightly changing or adjusting every week. Further, they did not see themselves being able to juggle multiple goals at a time. Rather they would try to focus on one at a time, and once they achieve success there, they would move to the rest. More longitudinal research (i.e. over a semester) is needed to understand teachers' goal-setting behaviors and needs in terms of frequency and quantity. Further, designers of technologies that require instructors to set goals explicitly in the interface, should work closely with instructors to better understand their needs and what would best help them in their goal-setting and behavior change. For example, they can consider the instructor having a long term goal, and then smaller shorter term goals they work towards every week. The goals could also be more qualitative, rather than quantitative. Finally, sharing with teachers suggestions on what goals they can and should set is something that technology designers should consider. During the co-design sessions instructors expressed this explicitly, and it also came up implicitly in the value of social comparisons as it provided instructors with a goal to aim for. Technology can provide teachers both qualitative suggestions on goals they should set by crowd sourcing suggestions and goals from other instructors, as well as quantitative goals from other instructors' performance (in a social comparison setting) or the goals they set in a similar situation to the current instructor.

Lastly, during the co-design sessions, instructors mentioned their confusion with the definitions of the different type of data shown to them, as well as with how certain data is measured and how reliable or accurate it can be. This is a challenge I came across in Chapter 10 as well, as I was creating high-level measures of teacher and student data based on the raw data provided by the EduSense technology. It is extremely important to bridge the gap between teachers' data needs (thoroughly investigated and described in Part 2 and Part 3 of this thesis) and the data that sensors in classroom technologies can measure, generate and infer. Further, this data needs to be accompanied with better definitions are more transparency on the way it was measured and inferred. This is a highly important area to be explored both by researchers and designers of teacher technologies.

Future Work

There are a multitude of avenues that this work can be moved forward both by researchers and designers in the field. To begin with, a first step is to better explore and understand ways to support teacher value and locus of control, in addition to SE. I focused primarily on SE (mastery experience, social comparison and verbal persuasion) and value (relationships between teacher and student data and focusing student engagement). There are many more ways that value can be supported by a technology that are worth exploring. For example, strengthening and designing PD materials that convince the instructor that prior literature in this area matters and shows value of such behaviors to students and their learning. Another way would be to consider showing relationships between such data and student learning, which seems to be the variable that instructors are most interested in. Finally, in terms of locus of control, findings hinted that it affects instructors' goal-setting and behavior change intentionality, but more research is needed to understand the exact mechanisms of this effect and how to better support instructors through the locus of control. Similarly, it is important to better understand teachers' short and long term goal setting. In particular, if teachers were to use such a proposed technology for the long term (sort of like a FitBit), how frequently, and how many goals do they set and should they set as well as what types of goals do they focus on. Finally, another direction important to explore is bridging the gap between teachers' data needs and what the technology currently can provide. If instructors to not understand measures provided to them (lack of definition and explanation), or do not believe they are reliable or measuring the correct thing (lack of transparency) they will not use this information in their practice.

And certainly, the last step would be to integrate the design elements discussed here in a dashboard that shares with teachers teacher and student data, and to run a classroom experiment, over a semester, with multiple instructors, to best study and understand instructor reflection-for-action and behavior change in practice.

Chapter 12

Conclusions, Contributions, and Future Directions

12.1 Conclusions

In this dissertation I focus on supporting teachers in their teaching practice, and help them improve this practice through data and technology. My work is motivated by a practical component and a research aspect. As teachers play an important role in students' learning, it is crucial to support teachers in their practices. However, even though traditional means for support, such as Professional Development (PD), are highly effective, they also tend to be repetitive, not personalized or not scalable and infrequent. There is on opportunity to improve PD by supplementing or replacing it with data and feedback from the classroom. In particular, as classrooms become more instrumented with a variety of educational technologies and sensors, more opportunities emerge to collect and generate data from the classroom, both on teachers and students, and present it back to the instructor as feedback. Prior literature has started to look at this domain, primarily focusing on presenting teachers data in real-time, while they are conducting a class session. While this is helpful to instructors for reducing their cognitive load and helping them make more informed decisions during class time, prior work suggests that a deeper and more focused reflection and goal-setting, outside of class, can better support teachers' reflection-for-action, practice improvement and long term behavior change in the classroom. A small body of work has started investigating this space, primarily focusing on designing technology with data aimed at supporting teachers' reflection outside of glass. Despite that, there still exists a gap in the literature in relation to better understanding teachers data needs and wants, with the aim to design for those needs to support, and also to investigate, how such data affects teacher reflection, goal setting and planning, interest and intentionality for behavior change and actual behavior change in the classroom. Further, there is also a need to investigate how to better support and influence teachers' motivation to engage in goal setting and behavior change.

In this dissertation, I aim to contribute towards both this practical and these research gaps in the literature. I have begun to explore how we can use technology to best support teachers' reflection-for-action outside of class, with data, and with the ultimate goal of helping teachers improve their practices and supporting their behavior change in the classroom. Overall, my work has focused on initially exploring and understanding teachers' data needs, followed by designing dashboard prototypes that meet those needs and then investigating how those dashboards support and affect their teaching practices in the classroom.

I approach this work from various perspectives. First, I investigate teachers' interest around student data (Part 1), teacher data (Part 2) and teacher and student data combined (Part 3). Second, I focus on a variety of data: student learning (Part 1), and teacher and student nonverbal immediacy behaviors (Part 2 and 3). Third, I focus on various technologies that collect data from the classroom: Intelligent Tutoring Systems (Part 1) and instrumented classrooms with sensors (Part 2 and Part 3). Finally, I focus on designing for supporting various constructs that lead to motivation including self-efficacy (Part 2) and self-efficacy and value (Part 3).

In **Part 1** of this thesis work, I started with investigating teachers' data needs in terms of their students' data (**Chapter 3**). I found that teachers want student data; they manually generate it when not provided to them or use it when there is technology that shares it with them. Based on the findings of this work, I created Luna, a dashboard prototype that shares with teachers student learning data (**Chapter 4**). I then investigated how this dashboard affected teacher practices in the classroom as they prepared for the next lesson (**Chapter 5**). I found that the dashboard affected teachers' practice, in particular, what they learned from the dashboard, their lesson plans, and their actions and what they aimed to cover in the next classroom session. I also noticed a "dilution" effect, where teachers learn from the dashboard, but only part of it makes it into the lesson plan, and part of the plan makes it in the class session. To the best of my knowledge, this is the first work to document this phenomenon regarding technologies that share with teachers data. Further, this is one of the first studies that aims to measure the effects that a dashboard with student data has on the full chain of teacher practices in the classroom.

In **Part 2**, I was very interested in investigating how to better support teacher practices with teachers' own data. In Part 1 I focused on student data which has been the focus of much prior work. However student data only represents half of the picture. There has been very little prior work on supporting teachers with their own data. If we want to help teachers improve their practices it is necessary to focus on their own behaviors as well. Further, to address the dilution found in Part 1, I focused on better supporting teachers' reflection-for-action through supporting their self-efficacy (**Chapter 6**). I initially conducted a small scale study to better understand teachers' data interest around their own data and how they score in various measures of value, efficacy, motivations, etc. (**Chapter 7**). I found that teachers show interest in their own data as well as their students' data, and seeing their own data and PD materials encouraged them to set goals on behaviors they wanted to change. Based on these findings, I created ClassInSight, a professional development training and dashboard prototype that shares with teachers their own nonverbal immediacy data (**Chapter 8**). I ran a large scale classroom study to investigate how ClassInSight affects teachers' reflection-for-action and behavior change intentionality. Further, I aimed to evaluate how motivational feedback for supporting self-efficacy affects teachers' values, efficacies, motivations, and reflection-for-action. Results showed that ClassInSight affected teachers' goal-setting and intentionality for behavior change. Findings also showed that teachers who receive motivational feedback through social comparison score higher in proxies for behavior change compared to teachers who receive such feedback through verbal persuasion.

Based on the findings from Parts 1 and 2, there were many interesting directions I was considering taking this work in **Part 3** (**Chapter 9**). I decided to pick the most interesting of those directions and what seemed most important to investigate first, based on what I learned from Part 1 and Part 2. First, I decided to explore patterns of behaviors, in particular with potential for improvement on both teacher and student data. I also aimed to explore any relationships among such data (**Chapter 10**). I found very interesting patterns in teacher behaviors such as them spending the majority of class time immobile or looking at their students on average less than half of class time. Further, I found some weak to moderate correlations among teacher and student behaviors, which hint towards the value and importance of nonverbal immediacy. To the best of my knowledge, this is the first study that uses large amounts of data from the classroom to determine the need for improvement and value in such behaviors as well as the value of nonverbal immediacy in the classroom. Second, I focused on investigating how to integrate teacher and student data while also supporting teachers' reflection for action (**Chapter 11**). Findings from a co-design study with instructors showed that instructors value relationships between teacher and student data, want to see the data integrated in a spatial and temporal form, and are interested in activity information in particular combined with student engagement. Further, self-efficacy support such as mastery experience and social comparison, together with support for value helped instructors assess performance, set concrete goals and provide actionable suggestions on what to change in their practice. To the best of my knowledge, this is the first study that investigates integrating teacher and student data with the aim of supporting reflection-for-action. The majority of prior work, as described throughout this dissertation, has focused either on student data or teacher data or has primarily focused on supporting teachers' reflection.

In conclusion, this dissertation work shows that teachers are interested and want student and teacher data, both individually and even more so combined together. Further, in this dissertation I have worked to design dashboard technology prototypes that share with teachers such data, often accompanied by professional development training. I have evaluated these dashboard prototypes in classroom setting and have shown they affect teachers knowledge, lesson planning and actions (student data) and teachers reflection-for-action and intentionally for behavior change (teacher data). When this data is combined in one dashboard (teacher and student data together), it shows promise and has hinted towards affecting teacher reflection, assessment and goal setting and interest and intentionality in behavior change. Further, designing to support teachers' motivation through the self-efficacy and value constructs has shown to be important to teachers' assessment, goal-setting and interest in behavior change. Through this dissertation work, I also highlight the challenges and the multiple dimensions needed to be considered in designing effective technologies that support teachers in improving their practice and changing their behaviors.

12.2 Summary of Contributions

My dissertation work contributes to research at the intersection of the areas of Learning Sciences and Technologies, as well as to Human-Computer Interaction. Here I will list the contributions of this work and describe the significance of each.

- To begin with, to the best of my knowledge, this is the first work that thoroughly and in-depth investigates teachers' student data needs, their own data needs as well as their combined teacher and student data needs. Further, based on this work, I design technologies that share with teachers such data, while involving the users, the teacher in the design loop. This is important as much prior work has exclusively focused on designing technologies for students, leaving the teacher outside of the design loop, without considering how those tools can be used or helpful to instructors. Moreover, much prior work has not focused on the instructor at all, their needs and how to support their practice in the classroom. My dissertation takes a very important first step into bringing the teacher back in the loop of student and technology.

- Second, this is the first work that focuses on supporting teachers in improving their practice and in changing their behaviors in the classroom. I focus on supporting reflection-for-action through data and design in a dashboard prototype, as a first step towards long term behavior change. Specifically, through my work I show that supporting self-efficacy (through mastery experiences and social comparison) and value (through showing relationships between student and teacher data and showing student engagement) are important and affect teachers reflection and goal-setting, as a first step towards intentionally for behavior change. This is important as very little and more recent prior work has started to think about ways of supporting the teacher reflection outside of class. My dissertation builds on this work moving forward our knowledge as a field of how to best support instructors in reflection, goal-setting and behavior change. Further, to the best of my knowledge this is the first work that aims to use data and technology to affect teacher motivational constructs such as self-efficacy and value, which are the foundation that leads to teacher motivation, goal-setting and behavior change.

- Third, through this dissertation work I provide evidence on how technologies that share with teachers student and teacher data, individually or combined, affect teachers' reflection and knowledge of their behaviors, their lesson plans and goals they set to change their behaviors, as well as their actions and actual behaviors they conduct in the classroom. Prior work has mainly focused on studying parts of this chain (i.e., reflection only) while I focus on the whole chain in this dissertation.

- Fourth, this dissertation work involves one of the first studies aimed at discovering patterns of behaviors in teacher and student nonverbal data from the classroom, as well as relationships between such data. This is an important first step to demonstrating how data collected from the classroom can not only be used in designing technologies such as teacher dashboards, but can also be used to further our understanding and knowledge of teacher and student dynamics in the classroom, and the value such behaviors have on teachers and students.

- Finally, more in general, this work provides a concrete example that data and technology can be used to help other professionals (nurses, police officers, etc.) reflect on their practices, set goals and change their short term and long term behaviors in the workplace. This is an important contribution in particular for the field of Personal Informatics [148] in HCI which should consider further exploring the use of data to support professionals' performance and help improve their in their workplace.

12.3 Discussion on Transferability and Generalizability

There are multiple dimensions that findings and contributions from this work could be transferred and generalizable to different populations of teachers, different sets of practices and different professions. Here I discuss in more detail some of these dimensions.

To begin with, my work in Part 2 and Part 3 of this dissertation was primarily focused on instructors at an R1 institution. I believe these findings are generalizable to instructors and faculty at other non-R1 institutions. For example, as prior literature and the findings of this work suggest, the majority of university instructors do not have training on their teaching and require much more support in their practice. As a result, the value they see in changing their nonverbal immediacy practice may be limited and the support they have in attempting such change might be limited or non-existent. In addition, even though many institutions have different ranks or titles for faculty, the general balance that instructors have to strike between teaching and research is similar to the instructors discussed in this work. Their SE may be different, however interventions such as downwards comparisons should be transferable and generalizable to those populations as well.

In terms of practice and the specific data teachers see, in Part 2 and Part 3 of this work I focused specifically on nonverbal immediacy behaviors while in Part 1 I focused on student learning. Findings and contributions from this work are generalizable to other practices with a caveat: the value instructors see in changing such practices will play a big role in their interest and motivation for changing their behaviors. For example, if instructors were asked to change practices that they see can directly affect student learning, for example by including more learning-by-doing, they may be more motivated to change their behaviors. On the other hand, if they were asked to change practices that may have an indirect affect on student learning, such as fostering a more inclusive classroom environment or spending less time lecturing, they may be less willing to change their behaviors.

Finally, I believe there is a big opportunity for transferability and generalizability of the findings outside of the teaching domain, in other professions more in general. The need to better support professionals through PD and data is a common denominator between teachers and professionals such as nurses, psychotherapists, athletes, police officers, etc. Further, I believe that the interactions of SE, value and Locus of Control are important and generalizable to other professions when it comes to changing practice and behaviors at work.

12.4 Design Recommendations

My work in this dissertation has also resulted in a set of guidelines and design recommendations both for how to design better technologies and what better pedagogical practices can teachers use in the classroom.

To begin with, when designing technologies to support teacher practice and behavior change, it is necessary to present teachers with their own data as well as their students' data. As shown in this dissertation, when combined, teacher and student data help instructors reflect and determine areas for improvement and set goals on what behaviors to change. In particular, I would encourage designers of technologies to always include some measure of student learning in their technologies. Ultimately, teachers improve their teaching and practices so that their students can achieve more and have a better learning experience. Further, regardless of the practice such technologies aim to support (whether it is nonverbal immediacy or some other practice), it is necessary to always design for teacher and student data needs.

Second, such technologies should be designed to support and strengthen teachers' self-efficacy. For example, designing for mastery experience, by showing teachers their performance and their students' performance on a particular day over multiple weeks is important to help them assess their progress and set goals. Similarly, motivational feedback such as social comparisons should be considered for instructors to help them build and strengthen their SE. In particular, designers of technologies should consider using downward comparisons as one of the ways to motivate instructors to change their behaviors and upwards comparisons as a way for instructors to set higher goals to achieve.

Finally, value and locus of control are important constructs that technology designers should consider supporting. Value for example could be supported by showing causal relationships in teacher and student data, or by making the literature on the particular practice more relatable and relevant to the current instructors' class. Similarly, to support challenges due to locus of control,it is necessary to help instructors with concrete recommendations and actionable items they can take to change their behaviors in the classroom. For example, rather than setting a goal such as *"look more towards the students"*, technology can provide instructors with more actionable goals such as *"add a question to your slides and turn towards your students to discuss for 2-3 minutes"*.

12.5 Future Directions

There are multiple very interesting dimensions that I could see this work going forward and that are important and necessary to further explore through research and design.

To begin with, it is necessary to evaluate in a longitudinal study (i.e. semester long study), in a real classroom setting, how teachers use a technology with teacher and student data. In particular, it would be interesting to investigate how such technology affects their reflection, goal-setting and behavior change on a weekly bases.

Second, I think it is necessary to continue investigating which constructs described in Chapter 6 best support reflection-for-action, and in particular, how to support each construct individually. In my work, I primarily focused on supporting self-efficacy and value. A next step would be to explore other ways of supporting self-efficacy, for example by considering sharing with teachers their own videos from the classroom, as a form of mastery experience. Similarly, there are more ways to support value, through combining teacher and student nonverbal immediacy data with student learning, or through carefully designing professional development training materials that convey the importance and value of such behaviors. Finally, it is crucial to further investigate the effect of locus of control on teachers' reflection-for-action, which I did not explicitly measure or investigate in my dissertation, but it came up through the various studies in Part 2 and Part 3. It is also important to determine ways to support teachers locus of control in overcoming challenges they see in the environment (i.e., classroom setup or the furniture). Finally, it is also very important to investigate which construct, self-efficacy, value or locus of control is the most important in affecting teacher goal-setting and behavior change.

Third, my own work as well as findings from Part 2 and Part 3 suggested that there is more to be researched and understood on how to bridge the gap between teachers' data needs and the raw data that technology, such as an instrumented classroom, collects and generates on teachers and students. Any high level measure created (such as the suggested ones, student engagement or teacher gaze balance) needs to be well defined and transparent, for instructors to trust it and see the value in it for changing their behaviors. Ultimately, more work needs to be done to understand how the raw data can be converted into higher level measures and variables, and how those in return can be presented in a transparent and clear way to teachers.

Fourth, even though this was not a focus of my study, it is important to further investigate privacy and surveillance concerns and design for solutions in an environment that collects and generates from the classroom. There are many stakeholders involved in a classroom setting, who have certain power balances among each other. As an example, students are stakeholders in this process, however, TAs and teachers have "power" over them and their grades. Similarly, department heads and tenure granting committees have "power" over instructors, who are also stakeholders in this data. When student and teacher data gets collected from the classroom, who does it belong to and who can it be shared with? It is important to make sure it is not used in punitive ways, for example to damage student grades or instructors' careers. Finally, in a world that is surrounded with technology, how can we make sure that the data collected from the classroom can still be anonymous and secure, to guarantee the privacy of each of the individual in class.

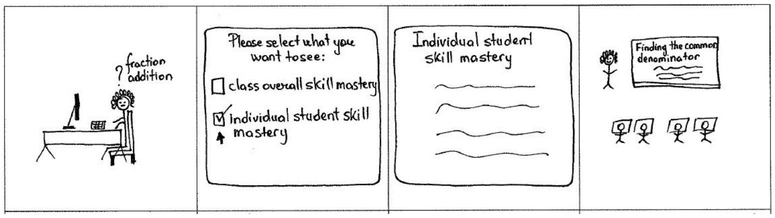
Finally, an interesting direction this work can take is to explore how data from the work environment can support other professionals, in addition to teachers, in their work environment. With more and more workplaces being instrumented with cameras and sensors, the opportunity to collect large amount of data is going to be even more possible, similar to classroom environment. Researchers and designers can investigate how to use this data to enhance professionals' performance as well as their training and professional development requirement.

Appendices

Appendix A

Storyboards for Chapter 2 Study

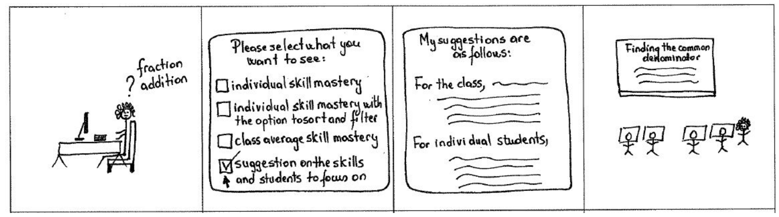
Storyboard_1: Does overall skill information or individual skill information help you make decisions as you prepare for the next class?



Mrs. Byrd is preparing for a lecture on fraction addition, but she is not entirely sure what to cover in class.	The dashboard asks Mrs. Byrd if she wants to see *class overall skill mastery* or *individual student skill mastery* for the skills of (1) finding the common denominator and (2) converting the numerators to a proper form. These are skills related to the topic she wants to discuss in class. Mrs. Byrd chooses the second option.	Mrs. Byrd sees that most of the class has mastered the skill of converting the numerators to a proper form, but few students have mastered the skill of finding the common denominator.	Mrs. Byrd decides to go over finding the common denominator during the next class meeting, but decides not to discuss converting the numerators to a proper form.

1

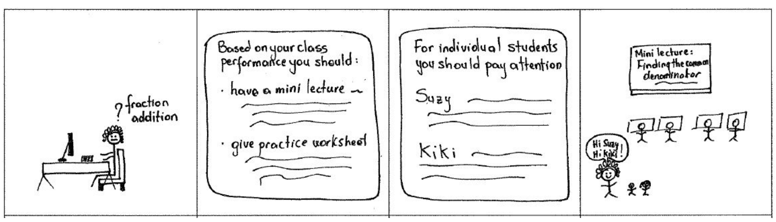
Storyboard_2: What type of skill information helps you make decisions as you prepare for the next class?



Mrs. Byrd is preparing for a lecture on fraction addition, but she is not entirely sure what to cover in class.	The dashboard asks Mrs. Byrd if she wants to see *individual skill mastery, individual skill mastery with the option to sort and filter, class average skill mastery*, or the *dashboard's suggestion on the skills and students she has to focus on*. Mrs. Byrd clicks on the last option.	The dashboard tells Mrs. Byrd that the class is not doing well in finding the common denominator, and she should discuss that. The dashboard also says that Kiki and Mary need particular assistance in converting the numerator to a proper form as they have not mastered that skill at all.	Mrs. Byrd decides to cover in class a mini-lecture on finding the common denominator, and to talk to Kiki and Mary one-on-one about their issues.

2

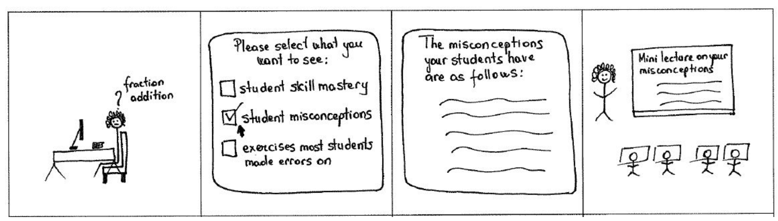
Storyboard_3: Do dashboard suggestions on what to do next with a class or an individual student help guide your instruction?



Mrs. Byrd is preparing for tomorrow's lecture on fraction addition, but she is not entirely sure what to cover in class.	The dashboard tells Mrs. Byrd that, based on the current class performance, she should have *a mini-lecture on how to find the common denominator* and then *give students a practice worksheet* with more exercises on this topic.	The dashboard tells Mrs. Byrd that she should also *spend one-on-one time with Suzy and Kiki* to help them remedy the issues they have with converting the numerators to a proper form.	Mrs. Byrd accepts the dashboard suggestions and decides to have a mini-lecture on fraction addition and give students a worksheet to practice more. Mrs. Byrd also spends one-on-one time with Suzy and Kiki to help them.

3

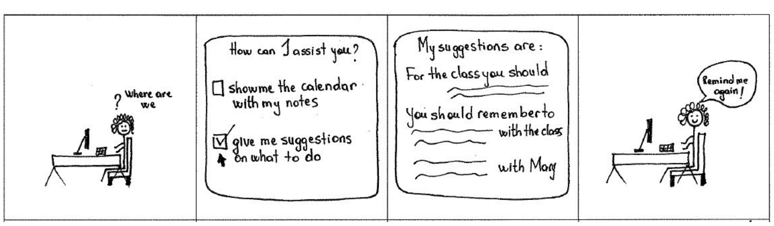
Storyboard_4: Does information on misconception frequency help you make decisions as you prepare for the next class?



Mrs. Byrd is preparing for a lecture on fraction addition, but she is not entirely sure what to cover in class.	The dashboard asks Mrs. Byrd if she wants to see information on *student skill mastery, student misconceptions*, or *exercises most students made errors on*. Mrs. Byrd clicks on the second option.	The dashboard tells Mrs. Byrd that her students have show the misconceptions of (1) adding the given fraction denominators to find the common denominator, and that (2) they simply copy the numerator of the given fraction to the converted fraction.	Mrs. Byrd decides to cover in class a mini-lecture to address those two misconceptions.

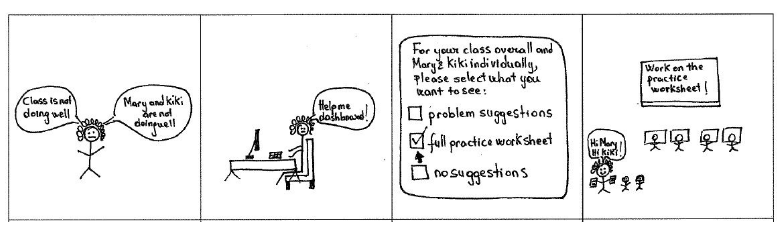
4

Storyboard_5: What notes and reminders from the dashboard help you make decisions as you prepare for the next class?



Mrs. Byrd is preparing for a class, but she has lost track of which topic her students are working with and she is not entirely sure what she has to cover in class.	The dashboard asks Mrs. Byrd if she wants to see *the calendar with her own notes*, or if she wants *the dashboard to assist her with suggestions on what to do*. Mrs. Byrd chooses the second option.	The dashboard tells Mrs. Byrd that she should cover a new lecture on fraction addition with her class today, as they have started the new chapter. The dashboard reminds Mrs. Byrd to briefly talk to the class about their performance in the last exam, and to pay one-on-one attention to Mary who did not do well in that exam.	Mrs. Byrd asks the dashboard to remind her again about what she should do once class starts, and starts preparing to cover fraction addition with the class.

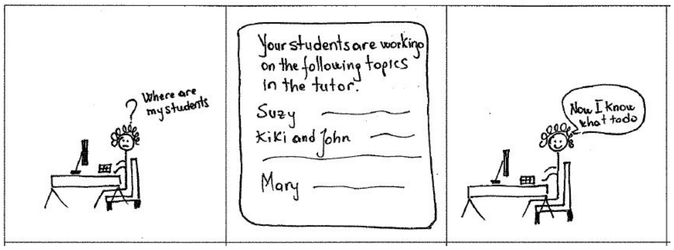
Storyboard_6: Does a dashboard that creates worksheets for you help you guide your instruction?



Mrs. Byrd's class is not doing well on fraction addition, and Mary and Kiki have the worst performance in the topic.	Mrs. Byrd wants to give her class more practice on fraction addition, as well as pay one-on-one attention to Kiki and Mary to help them understand fraction addition. Mrs. Byrd asks the dashboard for help.	The dashboard asks Mrs. Byrd if she wants to see (1) for the class overall and (2) Mary and Kiki individually: *problem suggestions from the dashboard to practice the topic, a full practice worksheet created by the dashboard*, or *no suggestions at all*. Mrs. Byrd chooses to use the full practice worksheet.	Mrs. Byrd gives the full practice worksheet to the class, and takes the individual practice worksheets to work with Mary and Kiki one-on-one.

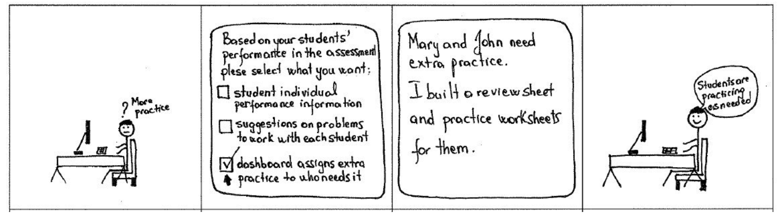
6

Storyboard_7: Does a dashboard that tells you when students are working on different topics in the tutor help you guide your instruction?



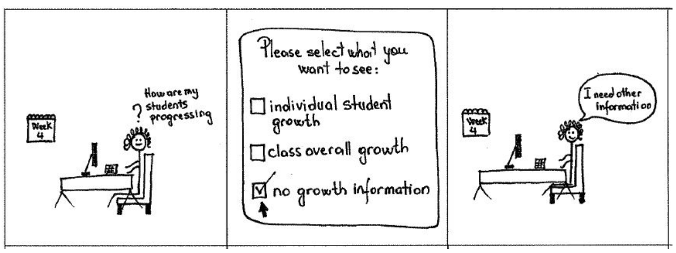
Mrs. Byrd is preparing for the next lecture on fraction addition, but she is not entirely sure on what topic her students are working with the tutor.	The dashboard tells Mrs. Byrd that Suzy is behind on her work in the tutor and is working on last chapter's topics, Kiki and John are on top of their task and they are ready to start the fraction addition topic in the tutor, while Mary is way ahead and has already reached the end of the next chapter.	Mrs. Byrd now knows where each of her students is in the tutor, and she can decide what she should focus on in class

Storyboard_8: Does a dashboard that automatically assigns students extra practice based on their performance help you guide your instruction?



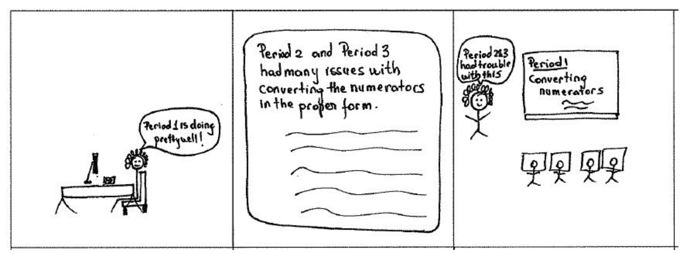
The class has just had an assessment on fraction addition at the end of the chapter in the tutor. Mr. Nice is not entirely sure who still needs practice on the current topic.	The dashboard asks Mr. Nice if based on his student performance he wants to see *student individual performance information*, *suggestions on problems to work with each student*, or if he wants the *dashboard to assign extra practice work to the students who need it*. Mr. Nice chooses the last option.	The dashboard analyzes students performance and concludes that Mary and John did not perform well in the assessment on fraction addition, and builds a review sheet and a practice worksheet based on what they still need to work on.	The dashboard assigns the work to Mary and John. Mr. Nice does not need to worry anymore about the students who need extra practice.

Storyboard_9: Does information on student growth help you guide your instruction?



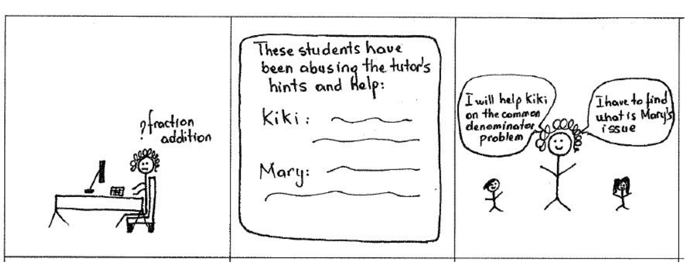
It is half way through the 9 week period, and Mrs. Byrd wants to see how her students are progressing in the tutor.	The dashboard asks Mrs. Byrd if she wants to see information on *individual student growth*, *class overall growth* or *no growth information*. Mrs. Byrd chooses the no growth option.	Mrs. Byrd does not need student growth information to guide her instruction, but uses other information from the dashboard to do so.

Storyboard_10: Does comparing one period's performance with your other periods help guide your instruction?



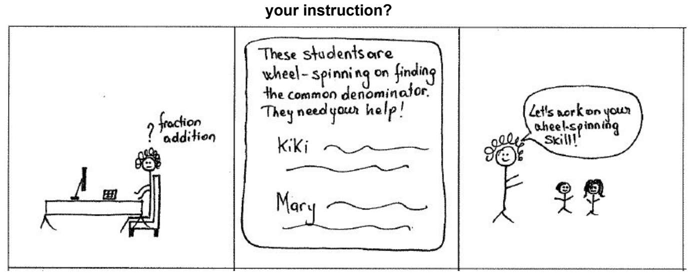
Mrs. Byrd is preparing for tomorrow's lecture on fraction addition with period 1. Mrs. Byrd sees in the dashboard that period 1 is doing pretty well and does not have any issues.	The dashboard notifies Mrs. Byrd that period 2 and period 3 had many issues with converting the numerators in the proper form.	Even though period 1 had no issues, Mrs. Byrd decides that it is beneficial to discuss with period 1 the converting the numerators in the proper form concept that the other periods had trouble with.

Storyboard_11: Does information on student's hint and help abuse in the tutor help guide your instruction?



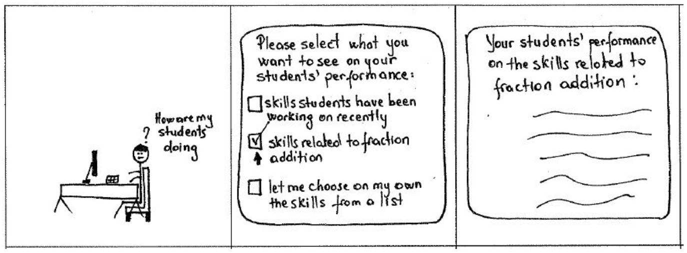
Mrs. Byrd is looking at the dashboard to see her students' performance and progress in the tutor for the fraction addition topic.	The dashboard tells Mrs. Byrd the Kiki and Mary have been abusing the tutor's help by asking for a lot of hints. The dashboard tells Mrs. Byrd that the reason Kiki is doing that is because he does not understand how to find the common denominator. However, the dashboard tells Mrs. Byrd that it does not know why Mary is abusing the hints.	Mrs. Byrd now knows she has to help Kiki, but she does not know what is going on with Mary. Mrs. Byrd spends one-on-one time with Kiki to help him understand how to find the common denominator. Mrs. Byrd also spends one-on-one time with Mary to identify what is her issue.

Storyboard_12: Does information on student's wheel-spinning in the tutor help guide your instruction?



Mrs. Byrd is looking at the dashboard to see her students' performance and progress in the tutor for the fraction addition topic.	The dashboard tells Mrs. Byrd the Kiki and Mary have been wheel-spinning in the tutor on the finding the common denominator skill. This means that Kiki and Mary have been working for a while with exercises to learn this skill, however they have not mastered it yet. The dashboard suggests that Mrs. Byrd's help is needed immediately	Mrs. Byrd now knows that Kiki and Mary are wheel-spinning on finding the common denominator term. Mrs. Byrd spends one-on-one time with each of them to re-teach them the concept, and also works with them through a couple of practice problems.

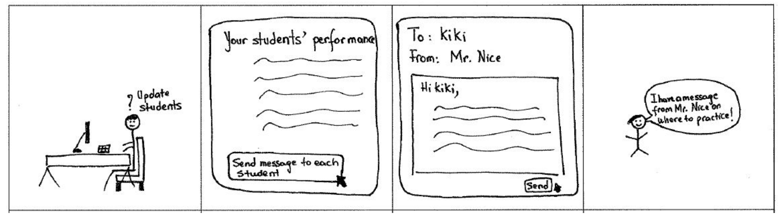
Storyboard_13: What skills would you like to see information about in the dashboard?



Mr. Nice is preparing for a lecture on fraction addition, but he is not entirely sure how his students are doing in the tutor.	The dashboard asks Mr. Nice if he wants to see his students' performance on *the skills they have been working recently*, *the skills related to fraction addition*, or if he wants *to select on his own the skills from a list of given skills.* Mr. Nice chooses the second option.	The dashboard gives Mr. Nice information on his students' performance and skills related to fraction addition. Now Mr. Nice knows how his students are doing in the tutor and can prepare for a lecture on fraction addition.

13

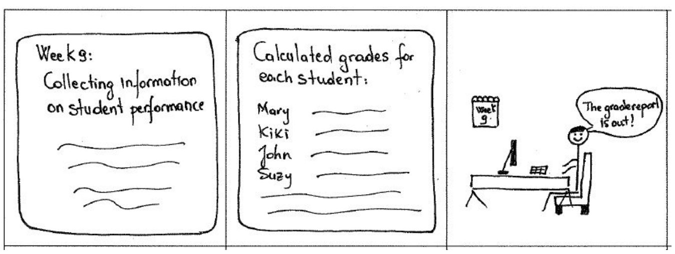
Storyboard_14: Does sending individual messages to students help guide your instruction?



Mr. Nice wants to update students on their performance in the last assignment they did on fraction addition in the tutor.	Mr. Nice sees every student's performance in the dashboard and uses the dashboard to send a personalized message to each student.	Mr. Nice writes to Kiki "*You did very well on the exam, good job!! However, you need to practice a little bit more with converting the numerators to the proper forms. I have assigned you a couple of more exercises to work on.*"	Kiki logs in the tutor, and sees the message that Mr. Nice sent to him. Now Kiki knows where to focus on for his practice.

14

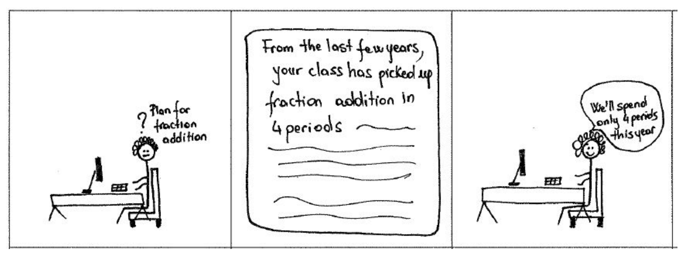
Storyboard_15: Does a dashboard that assigns students grades for their work in the tutor help your instruction?



At the end of the 9 week period the dashboard collects information on each individual student performance for the past 9 weeks in the tutor.	The dashboard calculates students performance in every problem and assignment they worked on and gives each student a grade for their work in the tutor.	The dashboard gives Mr. Nice a grade report with all his students' grades in the past 9 weeks.

15

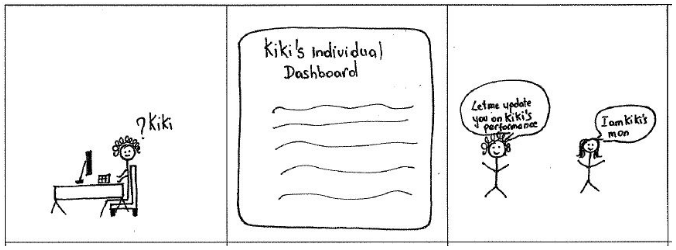
Storyboard_16: Does a dashboard that provides year to year support help guide your instruction?



Mrs. Byrd is preparing her plan on how much time to spend covering fraction addition with her classes this year.	The dashboard shows Mrs. Byrd that the past 3-5 years she spent 7 periods on fraction addition, but her class had picked it up since the 4th period.	Mrs. Byrd decides to only spend 4 periods on fraction addition this year.

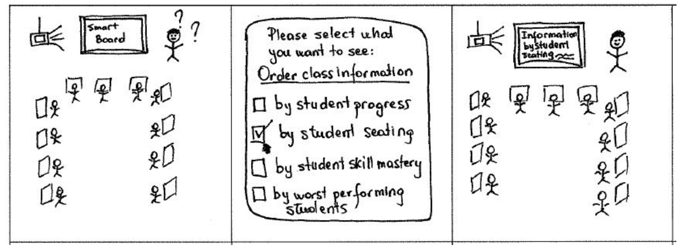
16

Storyboard_17: Does an individual student dashboard better help you with one-on-one student interactions?



Mrs. Byrd is having a hard time giving Kiki a grade for his work in the tutor. Mrs. Byrd is also meeting Kiki's mom later today and she is not entirely sure on what to update her.	The dashboard shows Mrs. Byrd *Kiki's individual dashboard* with information only about the performance and progress of Kiki in the tutor.	Mrs. Byrd now can give a grade to Kiki and can show his mom his performance in the tutor using Kiki's individual dashboard.

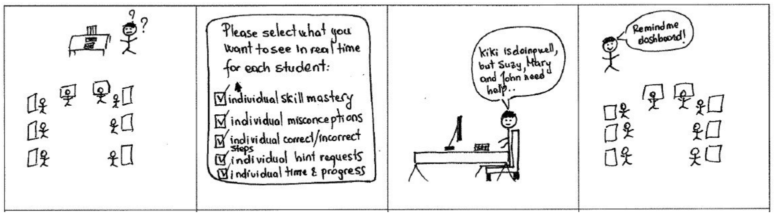
Storyboard_18: Does ordering the students in the dashboard by different criteria, as they are working with the tutor, help you better keep an eye on them?



Mr. Nice takes his class to the lab to work with the tutor, but he cannot keep an eye on all the students at the same time.	The dashboard asks Mr. Nice if he wants to see the class information ordered by *student progress in the tutor*, *student seating* (bird's eye view of class), *student skill mastery*, *students who have the worst performance in the tutor*. Mr. Nice	Mr. Nice projects the dashboard in the smart board, and can now easily map student information in the dashboard with where each student is seated in the class. Mr. Nice can better manage his attention and keep an eye on the students as they are working with the tutor.

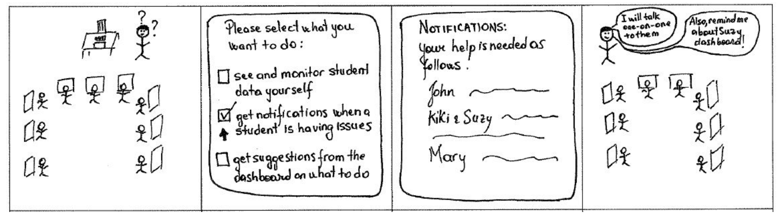
	chooses to see the bird's eye view of the class.	

Storyboard_19: Does detailed information from the dashboard on student performance, as they are working with the tutor, help you better keep an eye on them?



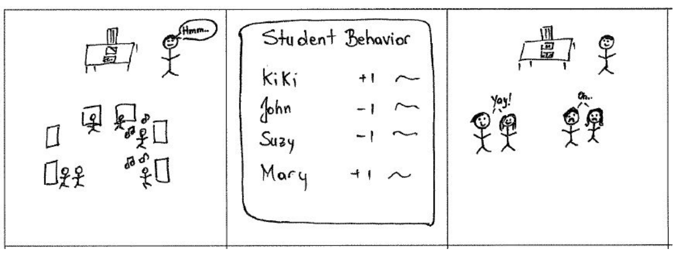
Mr. Nice takes his class to the lab to work with the tutor, but he is having a hard time keeping an eye on all the students at the same time.	The dashboard asks Mr. Nice if he wants to see in real time for each student working with the tutor the *individual skill mastery, individual misconceptions, correct/incorrect steps, hint requests*, or *time and progress in the tutor*. Mr. Nice clicks on all the options.	Based on the detailed information for each student in the dashboard, Mr. Nice notices that Kiki has mastered all the skills related to fraction addition, Suzy is having a lot of misconceptions and errors in problems, Mary is asking for a lot of hints, while John has spent a lot of time in the tutor with almost no progress.	Mr. Nice sets reminders in the dashboard to talk to Suzy, Mary and John and praise Kiki. He starts talking one-on-one to them during the lab time.

Storyboard_20: Do notifications in real time from the dashboard help you better keep an eye on your students?



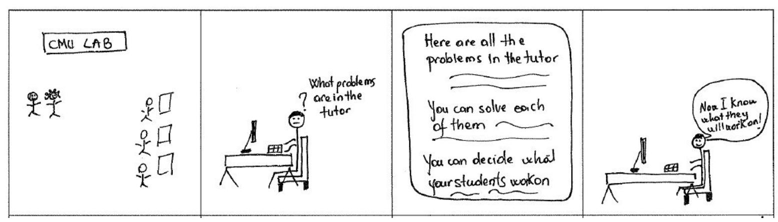
Mr. Nice takes his class to the lab to work with the tutor, but he is having a hard time keeping an eye on all the students at the same time.	The dashboard asks Mr. Nice if he wants to *see and monitor the student data himself*, or *get notifications when a student is having issues with a topic*, or *get suggestions from the dashboard on what to do* on any given point during lab time. Mr. Nice chooses the second option.	The dashboard monitors the class as they work with the tutor and sends notifications to Mr. Nice when his intervention is needed. The dashboard notifies Mr. Nice that John is asking for a lot of hints, Kiki and Suzy have been spending a lot of time with problem 2, and Mary is not mastering the finding the common denominator skill.	Mr. Nice sees the notifications and dismisses them one by one as he talks one-on-one to Kiki, Mary, John. Mr. Nice has no time to talk to Suzy so he asks the dashboard to re-send him the notification in the next lab time.

Storyboard_21: Does a dashboard that helps you keep track of student behavior help your instruction?



Mr. Nice is in the lab monitoring the students, and he notices that Kiki is helping Mary, while John and Suzy are being very noisy.	Mr. Nice adds 1 point to Kiki in the dashboard, for good behavior in the lab, and subtracts 1 point to John and Suzy for bad behavior. Mrs. Byrd gives Mary 1 point as well, for being motivated and hardworking.	Kiki and Mary are happy, while John and Suzy have learned their lesson.

Storyboard_22: Does a dashboard, which allows you to walk yourself through the problems in the tutor and choose what you don't like, help guide your instruction?



Researchers at CMU work day and night to create problems on fraction addition for the tutor.	Mr. Nice wants to check the problems himself and see if there is something that might be hard for students or that students should not practice in the tutor.	The dashboard gives Mr. Nice access to all the problems, and allows him to solve them one by one. Mr. Nice can also decide what his students will and will not work on.	Mr. Nice now knows what his students will be working with in the tutor.

Other terminology:

1. **Intelligent Tutoring System/Tutor** → a computer program where students can work with different practice problems and exercises (similar to Carnegie Learning Tutor or Bruce's tutor)

2. **dashboard** → computer program that shows the teacher summarized information on the student performance in the tutor (similar to Carnegie Learning reports, but can be more visual rather than just numbers. For the purpose of this interview, consider information that you can easily read and understand)

3. **relationship between dashboard and tutor** → tutor collects information on student performance and filters/summarizes it in the dashboard

4. **skills** → concepts such as finding a common denominator in fraction addition, or converting the numerator to the proper form after finding the common denominator

5. **misconceptions** → errors of the type: adding two denominators to get the common denominator, or not re-calculating the value of the numerator as needed when there is a new common denominator

6. **errors** → a problem or exercise students got wrong

7. **time + progress** → problems students have completed in the tutor and the time it took them to do so

Personas

1. **Mrs. Byrd, Mr. Nice** → middle school math teachers
2. **Mary, John, Kiki, Suzy** → middle school students in Mrs. Byrd's and Mr. Nice's class

Appendix B

Recruiting Materials Chapter 7 Study

B.1 Recruiting email for instructors

Sharing a research opportunity:

Franceska Xhakaj <francesx@cs.cmu.edu>
to

May 28, 2019, 12:36 PM

Dear Professor

My name is Franceska and I am a Ph.D. student in the Human-Computer Interaction Institute here at CMU, working with Dr. Amy Ogan.

I am reaching out to ask if it would be possible to briefly chat with you about a research opportunity. Our team focuses on researching ways to support and improve teaching at the university level and we would be interested to run a study in your class

I am attaching with the email a description of the study we would like to run in your class. If you are interested and would like to discuss more, I would like to meet with you for 5 minutes to answer any questions you have and get your permission to contact your students.

If you do not mind, I will stop by after your class on *Friday, May* *at* *PM* to briefly chat with you. I can certainly come and meet you at another time that is more convenient for you this week.

Thank you very much in advance for your time and I am looking forward to your reply.

Sincerely,
Franceska Xhakaj

Franceska Xhakaj
Ph.D. student | Human-Computer Interaction Institute | Carnegie Mellon University
www.franceskaxhakaj.com

Figure B-1: Example of an email sent to instructors as the first step in recruiting.

B.2 Instructor consent form

Consent Form for Participation in Research

Study Title: Instructor Notifications in University Setting

Principal Investigator: Franceska Xhakaj, PhD Student, Human-Computer Interaction Institute
5000 Forbes Ave, Pittsburgh, PA 15213
702-934-3574, francesx@cs.cmu.edu

Faculty Advisor: Amy Ogan, Assistant Professor, HCII
John Zimmerman, Associate Professor, HCII
Christopher Harrison, Assistant Professor, HCII
Yuvraj Agarwal, Assistant Professor, ISR

Sponsor(s): National Science Foundation (NSF)

Purpose of this Study
The purpose of the study is to determine the role of nonverbal behavior in the college classroom.

Summary
Each of the study participants will take part in study activities that will include filling questionnaires, being interviewed as well as seeing summaries about their nonverbal classroom teaching behaviors (as detailed below). We will compensate participants $15/hour for their participation in the study.

Procedures
As the teaching assistant (TA) or instructor responsible for a specific section, you will be asked to do the following:

1. Allow the installation and data collection from a non-obtrusive system in your classroom (described below).
2. Fill out a questionnaire about classroom procedures and demographics.
3. Provide feedback about the system to a researcher through an interview. The interview will be audio and video recorded, but we will only record your hands/working on the table with printed materials or on the computer and we will not record your face.
4. Access reading materials that describe the value of nonverbal behavior, immediacy in the classroom and other pedagogical tips.
5. View nonverbal behavior data in the classroom about you and your students (as described below).
6. All these activities (#2-#5) will take place in one single session that will take no longer than 3hs total. If the participant has time restrictions, we can schedule multiple sessions for the activities, to match the participant's schedule convenience.

The system consists of sensors installed in the classroom you teach. These devices will keep a record of when speech events occur in the class (such as when the TA, instructor, a student, or no one in the class is speaking), when students raise their hands, where in the room people are facing, how many people are in the room, where in the room the instructor is looking, etc.

Consent Form for Participation in Research

The data that we gather from the devices in your classroom will be available for you to view in graphical and visual form through a web portal or in printed form. You may also be able to see the visualizations at any time you choose outside of class.

Participant Requirements
You must be 18 or older. You must be a TA or instructor teaching a class.

If you are a TA, the research team will also obtain permission from the instructor of record/TA supervisor for the recitation. We will get approval from the professors/supervisors via email, stating that you and your students have permission to participate.

Risks
The risks and discomfort associated with participation in this study are no greater than those ordinarily encountered in daily life or during the teaching of a class. If you are a TA, there is a minimal risk of your supervisor discovering information such as how much time you spend speaking in class or facing your students. The research team will not divulge any personal identifiable information outside of its own internal communication.

There is a minimal risk of breach of confidentiality because we are gathering your signature and we have your email address. We will keep this identifiable information private and either in a locked cabinet or a password protected computer/highly secure online location.

Benefits
There may be no personal benefit from your participation in the study but the knowledge received may be of value to humanity.

Compensation & Costs
Compensation for participating in this study will be $15/hour. There will be no cost to you if you participate in this study.

Confidentiality
By participating in the study, you understand and agree that Carnegie Mellon may be required to disclose your consent form, data and other personally identifiable information as required by law, regulation, subpoena or court order. Otherwise, your confidentiality will be maintained in the following manner:

Your data and consent form will be kept separate. Your consent form will be stored in a locked location on Carnegie Mellon property and will not be disclosed to third parties. By participating, you understand and agree that the data and information gathered during this study may be used by Carnegie Mellon and published and/or disclosed by Carnegie Mellon to others outside of Carnegie Mellon. However, your name, address, contact information and other direct personal identifiers in your consent form will

Consent Form for Participation in Research

not be mentioned in any such publication or dissemination of the research data and/or results by Carnegie Mellon.

The researchers will take the following steps to protect participants' identities during this study: (1) Each participant will be assigned a number; (2) The researchers will record any data collected during the study by number, not by name; (3) Any original recordings or data files will be stored in a secured location accessed only by authorized researchers.

De-identified transcripts of classroom events and interview responses may be used in publication and presentation material.

The sponsor of the research (NSF) may have access to research records.

Optional Permission
I understand that the researchers may want to use a short portion of any audio and video recording taken during the interviews for illustrative reasons in presentations of this work for scientific or educational purposes. I give my permission to do so provided that my name and face will not appear.

Please initial here: _______YES ________NO

Rights
Your participation is voluntary. Whether or not you decide to participate will have no bearing on your standing as a CMU student or as a TA with your TA supervisor, the course instructor, either positively or negatively. You are free to stop your participation at any point. Refusal to participate or withdrawal of your consent or discontinued participation in the study will not result in any penalty or loss of benefits or rights to which you might otherwise be entitled. The Principal Investigator may at his/her discretion remove you from the study for any of a number of reasons. In such an event, you will not suffer any penalty or loss of benefits or rights, which you might otherwise be entitled.

Right to Ask Questions & Contact Information
If you have any questions about this study, you should feel free to ask them now. If you have questions later, desire additional information, or wish to withdraw your participation please contact the Principal Investigator by mail, phone or e-mail in accordance with the contact information listed on the first page of this consent.

If you have questions pertaining to your rights as a research participant or to report concerns to this study, you should contact the Office of Research Integrity and Compliance at Carnegie Mellon University. Email: irb-review@andrew.cmu.edu. Phone: 412-268-1901 or 412-268-5460.

Voluntary Consent

Consent Form for Participation in Research

By signing below, you agree that the above information has been explained to you and all your current questions have been answered. You are encouraged ask questions about any aspect of this research study during the course of the study and in the future. By signing this form, you agree to participate in this research study.

____
PRINT PARTICIPANT'S NAME

______________________________ ______________
PARTICIPANT SIGNATURE DATE

I certify that I have explained the nature and purpose of this research study to the above individual and I have discussed the potential benefits and possible risks of participation in the study. Any questions the individual has about this study have been answered and any future questions will be answered as they arise.

______________________________ ______________
SIGNATURE OF PERSON OBTAINING CONSENT DATE

B.3 Study description for instructors, attached to the above email

STUDY ON SUPPORTING AND IMPROVING TEACHING AT THE UNIVERSITY LEVEL

Franceska Xhakaj, PhD Student (francesx@cs.cmu.edu)
Amy Ogan, Assistant Professor (aeo@andrew.cmu.edu)

We are researchers within the School of Computer Science at CMU studying ways to support and improve teaching practices at the university level. We are very interested to run a study in your class. We have permission and have been approved by the Registrar; have an IRB; and actively collaborate with the Eberly Center for Teaching. We would like to get permission from you and your students to run the study this semester. We have been running such studies for the last 3 years and have extensive experience in this domain.

The study details are as follows:

1. We have installed sensors in the classroom(s) you teach
2. We will use these sensors to sense audio and still image frame data unobtrusively (we can activate the sensors remotely)
3. We will process the data to get aggregated features such as: how many students riased their hands during a class session, where were the students overall/on average looking during the class sessions (towards the teacher, towards the board, etc.), where is the teacher looking during class time, how much time is the teacher facing the students vs away from the students, etc.
4. We will then use these data to determine baseline and average nonverbal behavior across multiple classes, class sessions and instructors.
5. The study will not require any time (beyond normal class time) from you and your students.

We will follow our IRB guidelines for the data collection. All the information we collect will be confidential. The data we will report in papers and presentations will only be the aggregated data. The data (audio, still frame image and aggregate data) will be stored in a secure server at CMU for a minimum of 3 years past study completion.

To get your permission:

1. We would like to meet with you for 5 minutes to answer any questions you have and get your permission to run the study by signing our consent form.
2. We would like to have 2 minutes at the beginning/end of your class to get verbal permission from your students. If even one of your students does not agree we run the study, we will not run it. We will also provide a description of the study that you can send to your students to notify them, and they can contact us at any point if they want us to stop running the study.
3. If you have students that are younger than 18 in your classes, we will also not run the study.

1

FAQ

1. I am being recorded!

Below we are sharing an image of the aggregated data we generate and keep for our research purposes. As mentioned above, we process the data we collect so that we get these aggregated features. The data we will report in papers and presentations will only be this aggregated data.

2

2. My face and videos will end up on You Tube/internet!

The confidentiality of the data (audio, still frame image and aggregate data) will be strictly protected; we will store the data on secure servers at CMU. Only the research team will have access to the data -- we will not publicly post or share the audio and still frame image data. The data we will report in papers and presentations will only be the high-level aggregate data.

3. I am being evaluated!

We are not evaluating anyone's teaching. No one besides the research team and you (the instructor) will have access to that data.

4. My students will get stressed!

This information will not be used to observe or evaluate your students in any form.

5. When do I know when the sensors are on in my class!

If you would like to be notified about this, please let us know and we can let you know through email. The sensors will only be turned on after you and your students give us permission.

6. What about students who are not in class when you ask?

We provide a description you can send to your students to notify them, and they can let us know if they do not agree we run the study. They can also email us at any point during the study to stop their participation.

3

B.4 Study description for students

STUDY ON SUPPORTING AND IMPROVING TEACHING AT THE UNIVERSITY LEVEL

Franceska Xhakaj, PhD Student (francesx@cs.cmu.edu)
Amy Ogan, Assistant Professor (aeo@andrew.cmu.edu)

My name is Franceska and I am a PhD student at the Human-Computer Interaction Institute working with Dr. Amy Ogan. My team focuses on researching ways to support and improve teaching at the university level. We would like to get permission from you to run a research study this semester. We have permission and have been approved from your professor, the TAs, the Registrar; have an IRB and we also actively collaborate with the Eberly Center for Teaching. We have been running studies like these for the last 3 years and have extensive experience in this domain.

The study will take no time from you **as the focus of our study is the TA/instructor of your class**. You must be at least 18 to participate in the study. The research study details are as follows:

1. We have installed sensors in your classroom (one at the front and one at the back)
2. We will use these sensors to sense audio data and still image frame data unobtrusively
3. We will process the data to get aggregated features such as: how many students raised their hands during a class session, where were the students overall/on average looking during the class sessions (towards the teacher, towards the board, etc.)

If we get permission from all the students in your class, the data collection will start automatically and on schedule at the beginning of every class while the class continues running during the semester. All the information we collect will be confidential and we will not attempt to personally identify or track you from the data we collect. The data we will report in papers and presentations will only be the high-level data. The data (audio, still frame image and aggregate data) will be stored in a secure server at CMU for a minimum of 3 years past study completion.

We are not evaluating anyone with this data; the data will not be used to evaluate you or your performance or learning in this class. As mentioned above, **our focus for this study is your TA/instructor for this class and not you, the student**. Whether you participate or not, this will not affect your grade in the class in any way. Participation is voluntary.

To get your permission:

1. Are you under 18 years old? If so, please let us know as soon as possible. Please contact Franceska at (francesx@cs.cmu.edu)
2. If you do not agree to let us run the study, or would like to stop participating at any point, please also contact Franceska at (francesx@cs.cmu.edu). Once we get notified that you would like to stop your participation, we will stop the data collection and we will stop running the study in your class.

1

There may no be no personal benefit from your participation in the study but the knowledge received may be of value to humanity. There is no compensation for participation in this study. There will be no cost to you if you participate in this study.

If you have any questions about this study, you should feel free to ask them by contacting the Principal Investigator at [Franceska Xhakaj, PhD Student, Human-Computer Interaction Institute, Forbes Ave, Pittsburgh, PA 15213, 702-934-3574, francesx@cs.cmu.edu]. If you have questions later, desire additional information, or wish to withdraw your participation please contact the Principal Investigator by mail, phone or e-mail in accordance with the contact information listed above.

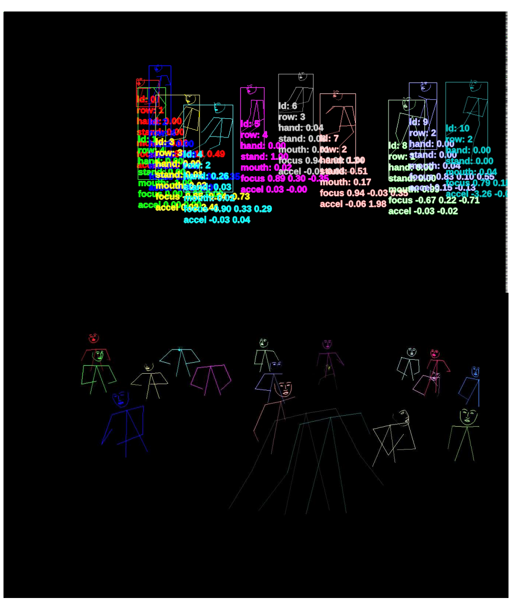
If you have questions pertaining to your rights as a research participant; or to report concerns to this study, you should contact the Office of Research integrity and Compliance at Carnegie Mellon University. Email: irb-review@andrew.cmu.edu . Phone: 412-268-1901 or 412-268-5460.

2

FAQ

1. I am being recorded!

Below we are sharing an image of the aggregated data we generate and keep for our research purposes. As mentioned above, we process the data we collect so that we get these aggregated features. The data we will report in papers and presentations will only be this aggregated data.



3

2. My face and videos will end up on You Tube/internet!

The confidentiality of the data (audio, still frame image and aggregate data) will be strictly protected; we will store the data on secure servers at CMU. Only the research team will have access to the data -- we will not publicly post or share the audio and still fram image data. The data we will report in papers and presentations will only be the high-level aggregate data.

3. I am being evaluated!

We are not evaluating anyone and the data will not be used to evaluate you, your performance in class or your learning. Whether you participate or not, this will not affect your grade in the class in any way.

4

Appendix C

Study Materials Chapter 7 Study

C.1 Pre and post questionnaire emails for instructors

Follow up on research opportunity and looking at your data:

Franceska Xhakaj <francesx@cs.cmu.edu>
to

Dear Professor ,

I hope the semester is going on well for you! I am following up on the research opportunity that you and your class signed up for this semester.

I would like to request a meeting to show you some of your data that we collected as part of this research and to share with you a Professional Development Module on immediacy and nonverbal behaviors. To do that, I would like to ask you to please complete the following.

1. Please fill this survey at your earliest convenience. The survey should not take more than 30 minutes to complete. We will not use your name to identify your, rather we will use an **Anonymous ID**, which for you will be **82.**

2. Once you complete the survey above, please schedule a time (1h) to meet with me to look at your data. You can use this link to schedule. Note: Please make sure you complete the survey above before we meet! If you have an office, please let me know your office number; I can meet you there. Otherwise, please let me know if not, so I can book a conference room.

3. Once you schedule the 1h meeting above, please schedule another time (30 minutes) for a follow-up interview and questionnaire. This follow-up meeting should be after the previous one (it can be immediately after), whenever it is most convenient for you. Please use this other link to schedule this follow up meeting.

If none of those times work for you, please let me know as soon as possible!

Thank you again for your time and for participating! Please contact me with any questions.

Sincerely,
Franceska Xhakaj

Franceska Xhakaj
Ph.D. student | Human-Computer Interaction Institute | Carnegie Mellon University
www.franceskaxhakaj.com

Figure C-1: Email to send pre-questionnaire to instructors and ask to set up a 1 hour meeting time to show them their data and some Professional Development.

C.2 Pre and Post Questionnaires

ClassInSight (Pre)

Welcome to this Professional Development Module and thank you again for your participation!

In the following sections we will ask you to fill a questionnaire. This questionnaire is designed to help us become more familiar with you and your teaching style.

Your answers will be kept strictly confidential and you will not be identified by name. Instead, you will be asked to enter your Anonymous ID below, provided to you by email.

The questionnaire will take approximately 30 minutes to complete.

Please contact francesx@cs.cmu.edu for any questions!

* 1. To begin, please enter your Anonymous ID (provided to you by email)

1

ClassInSight (Pre)

This questionnaire is designed to help us become more familiar with you and your teaching style.

Your answers will be kept strictly confidential and you will not be identified by name.

* 1. Are you familiar with the concept of immediacy or teacher immediacy?

- Yes
- Sort of
- No
- Other (please specify)

* 2. In your own words, can you provide a definition for immediacy or for teacher immediacy?

* 3. Are you familiar with nonverbal behaviors?

- Yes
- Sort of
- No
- Other (please specify)

2

* 4. In your own words, can you provide a definition for nonverbal behaviors?

* 5. Can you provide some examples of nonverbal behaviors you are familiar with?

3

ClassInSight (Pre)

Immediacy and nonverbal behaviors

We will go into more detail later, but below we provide a definition for immediacy and nonverbal behaviors that you can use in the following sections of the questionnaire:

Immediacy is the perceived closeness between people that is achieved through language and communication. *Immediacy behaviors* are behaviors that reduce the physical and/or psychological distance between people and increase the interpersonal closeness.

Teacher immediacy is conceptualized as those nonverbal behaviors that reduce physical and/or psychological distance between teachers and students. *Nonverbal behaviors* are communication behaviors that do not involve verbal communication, which include, but are not limited to, posture, physical distance, gestures, facial expressions, eye contact, etc.

* 1. Please respond to the question below to the best of your ability.

	Not At All Confident	Slightly Confident	Moderately Confident	Very Confident	Extremely Confident
How confident are you in your teacher immediacy skills?	○	○	○	○	○

* 2. Can you name (at most) three nonverbal behaviors that you think affect teaching and the immediacy in the classroom?

* 3. Are there any specific immediacy or nonverbal behavior skills in your teaching that you would like to work and improve on?

4

* 4. Can you provide some examples of nonverbal behaviors you use in your teaching? [*If you do not use nonverbal behaviors in your teaching please say: "I do not use nonverbal behaviors in my teaching"*]

* 5. Please rate your agreement with the following statements.

	Disagree Very Strongly	Disagree Strongly	Disagree	Neutral	Agree	Agree Strongly	Agree Very Strongly
Immediacy and non-verbal behaviors have a significant effect on teaching.	○	○	○	○	○	○	○
Immediacy and non-verbal behaviors have a significant effect on student learning.	○	○	○	○	○	○	○
Movement in class while teaching has a significant effect on fostering immediacy in the classroom.	○	○	○	○	○	○	○
Movement in class while teaching has a significant effect on student learning.	○	○	○	○	○	○	○

ClassInSight (Pre)

Self-efficacy

This questionnaire is designed to help us gain a better understanding of the kinds of things that create challenges for teachers. Your answers are confidential.

Please indicate your opinion about each of the questions below by marking any one of the nine responses in the columns on the right side, ranging from (1) "None at all" to (9) "A great deal" as each represents a degree on the continuum.

* 1. Please respond to each of the questions by considering the combination of your current ability, resources, and opportunity to do each of the following in your present position.

	None at all 1	2	Very little 3	4	Some degree 5	6	Quite a bit 7	8	A great deal 9
How much can you do to get through to the most difficult students?	○	○	○	○	○	○	○	○	○
How much can you do to help your students think critically?	○	○	○	○	○	○	○	○	○
How much can you do to control disruptive behavior in the classroom?	○	○	○	○	○	○	○	○	○
How much can you do to motivate students who show low interest in school work?	○	○	○	○	○	○	○	○	○
To what extent can you make your expectations clear about student behavior?	○	○	○	○	○	○	○	○	○

	None at all 1	2	Very little 3	4	Some degree 5	6	Quite a bit 7	8	A great deal 9
How much can you do to get students to believe they can do well in school work?	○	○	○	○	○	○	○	○	○
How well can you respond to difficult questions from your students?	○	○	○	○	○	○	○	○	○
How well can you establish routines to keep activities running smoothly?	○	○	○	○	○	○	○	○	○
How much can you do to help your students value learning?	○	○	○	○	○	○	○	○	○
How much can you gauge student comprehension of what you have taught?	○	○	○	○	○	○	○	○	○
To what extent can you craft good questions for your students?	○	○	○	○	○	○	○	○	○
How much can you do to foster student creativity?	○	○	○	○	○	○	○	○	○
How much can you do to improve the understanding of a student who is failing?	○	○	○	○	○	○	○	○	○

	None at all 1	2	Very little 3	4	Some degree 5	6	Quite a bit 7	8	A great deal 9
How much can you do to calm a student who is disruptive or noisy?	○	○	○	○	○	○	○	○	○
How well can you establish a classroom management system with each group of students?	○	○	○	○	○	○	○	○	○
How much can you do to adjust your lessons to the proper level for individual students?	○	○	○	○	○	○	○	○	○
How much can you use a variety of assessment strategies?	○	○	○	○	○	○	○	○	○
How well can you keep a few problem students form ruining an entire lesson?	○	○	○	○	○	○	○	○	○
To what extent can you provide an alternative explanation or example when students are confused?	○	○	○	○	○	○	○	○	○
How well can you respond to defiant students?	○	○	○	○	○	○	○	○	○
How well can you implement alternative strategies in your classroom?	○	○	○	○	○	○	○	○	○

	None at all 1	2	Very little 3	4	Some degree 5	6	Quite a bit 7	8	A great deal 9
How well can you provide appropriate challenges for very capable students?									

ClassInSight (Pre)

Self-efficacy for immediacy and nonverbal behaviors

Please rate how certain you are that you can do the things discussed below by selecting the appropriate number. Please mark any one of the nine responses in the columns on the right side, ranging from (1) “Not at all” to (9) “A great deal” as each represents a degree on the continuum.

As a reminder, here are the definitions of immediacy and nonverbal behaviors.

Immediacy is the perceived closeness between people that is achieved through language and communication. *Immediacy behaviors* are behaviors that reduce the physical and/or psychological distance between people and increase the interpersonal closeness.

Teacher immediacy is conceptualized as those nonverbal behaviors that reduce physical and/or psychological distance between teachers and students. *Nonverbal behaviors* are communication behaviors that do not involve verbal communication, which include, but are not limited to, posture, physical distance, gestures, facial expressions, eye contact, etc.

* 1. Please rate your degree of confidence:

	Not at all 1	2	Very little 3	4	Some degree 5	6	Quite a bit 7	8	A great deal 9
I can use teacher immediacy while I am teaching									
I can use teacher immediacy to talk to a student one-on-one									
I can use teacher immediacy to support my students’ learning									
I can use nonverbal behaviors appropriately while I am teaching									

	Not at all 1	2	Very little 3	4	Some degree 5	6	Quite a bit 7	8	A great deal 9
I can use nonverbal behaviors while I am teaching to foster immediacy between me and my students									
I can understand student nonverbal behavior									
I can use movement while I am teaching									
I can use movement while I am teaching to foster immediacy between me and my students									
I can use movement while I am teaching to keep and maintain student attention									

ClassInSight (Pre)

Nonverbal behaviors

The following statements describe the ways some instructors behave while teaching or talking with students.

* 1. Please indicate for each item the degree to which you believe the statement applies TO YOU.

	Never 1	Rarely 2	Occasionally 3	Often 4	Very often 5
I use my hands and arms to gesture while teaching					
I use a monotone or dull voice while teaching					
I look over or away from my students while teaching					
I have a relaxed body position when I teach					
I frown while teaching					
I avoid eye contact while teaching					
I have a tense body position while teaching					
I sit close or stand close to my students while teaching					
My voice is monotonous or dull when I teach					

	Never 1	Rarely 2	Occasionally 3	Often 4	Very often 5
I use a variety of vocal expressions when I teach					
I gesture when I teach					
I am animated when I teach					
I have a bland facial expression when I teach					
I move closer to my students when I teach					
I look directly at my students while teaching					
I am stiff when I teach					
I have a lot of vocal variety when I teach					
I avoid gesturing while I am teaching					
I lean toward my students when I teach					
I maintain eye contact with my students when I teach					
I try not to sit or stand close to my students when I teach					
I lean away from my students when I teach					

	Never 1	Rarely 2	Occasionally 3	Often 4	Very often 5
I smile when I teach					

ClassInSight (Pre)

Motivation

* 1. What things motivate you in trying to do your best in the class(es) you are teaching this semester? Please elaborate.

* 2. What things decrease your motivation in trying to do your best in the class(es) you are teaching this semester? Please elaborate.

* 3. Please answer the question: “Why do you teach?” by rating how much you agree with the following statements.

Why do you teach?

	Totally Disagree 1	Disagree 2	Undecided 3	Agree 4	Totally Agree 5
Because for me, the task of teaching is of personal importance					
Because a good performance in teaching contributes largely to my self-esteem as a professor					

	Totally Disagree 1	Disagree 2	Undecided 3	Agree 4	Totally Agree 5
Because my aspiration is to be successful at teaching, otherwise I would feel like a loser					
Because I feel very uncomfortable if I neglect my teaching					
Because I find the task of teaching interesting					
I don’t know, sometimes I don’t see the actual purpose of teaching [at all]					
Because during teaching I’m in a pleasant mental state of “flow”					
Because the task of teaching provides the chance to realize an aspect of my academic profession that is of personal meaning to me					
I don’t know why, because the work conditions provided for academic teaching are unbearable					

	Totally Disagree 1	Disagree 2	Undecided 3	Agree 4	Totally Agree 5
Because I derive much pleasure from teaching	◯	◯	◯	◯	◯
Because I get paid for it	◯	◯	◯	◯	◯
Because I see my teaching as a significant contribution to my students' overall academic progress	◯	◯	◯	◯	◯
Because I would feel bad if I would neglect my task of teaching	◯	◯	◯	◯	◯
Primarily because I get positive feedback from my students	◯	◯	◯	◯	◯
Because my employment contract demands me to teach	◯	◯	◯	◯	◯
Teaching does not mean a lot to me, because I cannot really see what academic teaching can accomplish in my students	◯	◯	◯	◯	◯

17

ClassInSight (Pre)

Motivation

Please indicate your opinion about each of the questions below by marking any one of the seven responses in the columns on the right side, ranging from (1) "Not at all" to (7) "Extremely" as each represents a degree on the continuum.

* 1.

	Not at all 1	2	Slightly 3	4	Moderately 5	6	Extremely 7
How hard will you strive to be an effective teacher?	◯	◯	◯	◯	◯	◯	◯
How certain are you that you will remain in teaching?	◯	◯	◯	◯	◯	◯	◯
How much will you work at being a good teacher?	◯	◯	◯	◯	◯	◯	◯
How confident are you that you will stick with teaching?	◯	◯	◯	◯	◯	◯	◯
How much effort will you put into your teaching?	◯	◯	◯	◯	◯	◯	◯
How sure are you that you will persist in a teaching career?	◯	◯	◯	◯	◯	◯	◯
How much effort do you plan to exert as a teacher?	◯	◯	◯	◯	◯	◯	◯
How sure are you that you will stay in the teaching profession?	◯	◯	◯	◯	◯	◯	◯

18

* 2. "To what extent are you motivated to ...."

	Not at all 1	2	Slightly 3	4	Moderately 5	6	Extremely 7
...continue learning how to improve your teaching skills?	◯	◯	◯	◯	◯	◯	◯
...undertake further professional development?	◯	◯	◯	◯	◯	◯	◯
...continue to acquire curriculum knowledge?	◯	◯	◯	◯	◯	◯	◯
...participate in professional development courses?	◯	◯	◯	◯	◯	◯	◯
...learn about current educational developments?	◯	◯	◯	◯	◯	◯	◯

19

ClassInSight (Pre)

Demographics

Please answer the following to the best of your ability. Your answers will be kept strictly confidential and you will not be identified by name.

* 1. What is your role at CMU?

- ◯ Undergraduate Student
- ◯ Master Student
- ◯ PhD Student
- ◯ Other (please specify)
- ◯ Postdoc
- ◯ Teaching Track Faculty
- ◯ Faculty

* 2. (If student) What year are you in?

* 3. What is your major (for undergraduates/masters); your PhD (for PhDs)?

* 4. How familiar are you with the US school system? Please check all that apply:

- ☐ I did/am doing my undergraduate in the US
- ☐ I did/am doing my masters in the US
- ☐ I did/am doing my PhD in the US
- ☐ None of the above
- ☐ Other (please specify)

20

ClassInSight (Pre)

On the course you are teaching this semester

Please answer the following *for the course(s) you are teaching this semester.* Your answers will be kept strictly confidential and you will not be identified by name.

* 1. Have you taken this course before?

- Yes
- No
- Other (please specify)

* 2. Have you TAed this course before?

- Yes
- No
- Other (please specify)

* 3. How many times have you taught this course before? Please elaborate.

* 4. Why are you teaching this course?

ClassInSight (Pre)

Experience in teaching

This questionnaire is designed to help us become more familiar with you and your teaching experience. Your answers will be kept strictly confidential and will not be identified by name.

* 1. Are you or have you been a certified professional teacher?

- Yes
- No
- Other (please specify)

* 2. How many years have you been teaching in the classroom? Please elaborate.

* 3. At what levels have you taught (i.e. elementary school, middle school, high school, college, etc.)?

- Elementary School
- Middle School
- High School
- College
- Other (please specify)

* 4. Have you taught other courses before (here at CMU or elsewhere). Please list courses and elaborate below.

* 5. Are you teaching other courses this semester? If so, how many?

* 6. Are you taking any courses this semester? If so, how many?

* 7. Are you conducting research this semester?

- Yes
- No
- Other (please specify)

* 8. Are you involved with the Eberly Center? Please elaborate.

* 9. Have you taken any seminars from the Eberly Center. If so how many?

* 10. Are you part of Future Faculty Program (FFP) at Eberly?

- Yes
- No
- Other (please specify)

* 11. Have you had any other training on teaching or any type of professional development, here at CMU or elsewhere? Please elaborate.

ClassInSight (Pre)

Thank you!

Thank you very much for completing this questionnaire!

1. Please schedule a time (1h) to meet with Franceska to look at your nonverbal behavior data. You can use this link to schedule.

2. Once you schedule the above, please schedule another time (30 minutes) for a follow-up interview and questionnaire. This follow-up meeting should be after the previous one (it can be immediately after), whenever it is most convenient for you. Please use this other link to schedule this follow up meeting.

Thank you again for your time and for participating! Please contact me with any questions at francesx@cs.cmu.edu.

25

ClassInSight (Post)

Welcome to this Professional Development Module and thank you again for your participation!

In the following sections we will ask you to fill a questionnaire similar to the one you filled previously. It is designed to help us become more familiar with you and your teaching style.

Your answers will be kept strictly confidential and you will not be identified by name. Instead, you will be asked to enter your Anonymous ID below, provided to you by email.

The questionnaire will take approximately 30 minutes to complete.

Please contact francesx@cs.cmu.edu for any questions!

* 1. To begin, please enter your Anonymous ID (provided to you by email)

ClassInSight (Post)

Please answer the following to the best of your ability. We use the following terms to refer to the materials ClassInSight presented to you. These were the paper materials that Franceska brought to the 1h interview.

Professional Development Module --> This is the information you read on immediacy and nonverbal behaviors, their definitions and importance

Your proxemics nonverbal behavior data --> This is the data that you saw of your own nonverbal performance (movement at the front of class)

The feedback from ClassInSight --> This is Part 3 of looking at your data, when ClassInSight provided some feedback on your performance

* 1. On a scale of 0-10, how much did you learn in the Professional Development Module that ClassInSight shared with you? Please indicate with 0 meaning you learned nothing and 10 meaning you learned more than in any other professional development or training that you have ever had in the past.

Learned nothing 0	1	2	3	4	Learned Somewhat 5	6	7	8	9	Learned more than in any other professional development 10
○	○	○	○	○	○	○	○	○	○	○

* 2. On a scale of 0-10, how much did you learn from seeing your proxemics nonverbal behavior data that ClassInSight shared with you? Please indicate with 0 meaning you learned nothing and 10 meaning you learned more than in any other of your own teaching-related data that you have ever seen in the past.

Learned Nothing 0	1	2	3	4	Learned Somewhat 5	7	8	9	Learned more than in any other of my own teaching-related data 10
○	○	○	○	○	○	○	○	○	○

ClassInSight (Post)

We use the following terms to refer to the materials ClassInSight presented to you. These were the paper materials that Franceska brought to the 1h interview.

Professional Development Module --> This is the information you read on immediacy and nonverbal behaviors, their definitions and importance

Your proxemics nonverbal behavior data --> This is the data that you saw of your own nonverbal performance (movement at the front of class)

The feedback from ClassInSight --> This is Part 3 of looking at your data, when ClassInSight provided some feedback on your performance

Please select the number for each item which best represents your feelings. Question 1 applies to 2, 3 and 4 as well.

* 1. My attitude about the content of the Professional Development Module.

Good 1	2	3	4	5	6	Bad 7
○	○	○	○	○	○	○

* 2.

Worthless 1	2	3	4	5	6	Valuable 7
○	○	○	○	○	○	○

* 3.

Fair 1	2	3	4	5	6	Unfair 7
○	○	○	○	○	○	○

* 4.

Positive 1	2	3	4	5	6	Negative 7
○	○	○	○	○	○	○

Please select the number for each item which best represents your feelings. Question 5 applies to 6, 7 and 8 as well.

* 5. My attitude about the behaviors recommended in the Professional Development Module.

Good 1	2	3	4	5	6	Bad 7
○	○	○	○	○	○	○

* 6.

Worthless 1	2	3	4	5	6	Valuable 7
○	○	○	○	○	○	○

* 7.

Fair 1	2	3	4	5	6	Unfair 7
○	○	○	○	○	○	○

* 8.

Positive 1	2	3	4	5	6	Negative 7
○	○	○	○	○	○	○

ClassInSight (Post)

Please select the number for each item which best represents your feelings. Question 1 applies to 2, 3 and 4 as well.

* 1. My likelihood of actually attempting to engage in the behaviors recommended in the Professional Development Module.

Likely 1	2	3	4	5	6	Unlikely 7
○	○	○	○	○	○	○

* 2.

Impossible 1	2	3	4	5	6	Possible 7
○	○	○	○	○	○	○

* 3.

Probable 1	2	3	4	5	6	Improbable 7
○	○	○	○	○	○	○

* 4.

Would 1	2	3	4	5	6	Would not 7
○	○	○	○	○	○	○

Please select the number for each item which best represents your feelings. Question 5 applies to 6, 7 and 8 as well.

5

* 5. My likelihood of actually enrolling in another Professional Development Module of related content, if I had the choice and my schedule permits.

Likely 1	2	3	4	5	6	Unlikely 7
○	○	○	○	○	○	○

* 6.

Impossible 1	2	3	4	5	6	Possible 7
○	○	○	○	○	○	○

* 7.

Probable 1	2	3	4	5	6	Improbable 7
○	○	○	○	○	○	○

* 8.

Would 1	2	3	4	5	6	Would not 7
○	○	○	○	○	○	○

6

ClassInSight (Post)

We use the following terms to refer to the materials ClassInSight presented to you. These were the paper materials that Franceska brought to the 1h interview.

Professional Development Module --> This is the information you read on immediacy and nonverbal behaviors, their definitions and importance

Your proxemics nonverbal behavior data --> This is the data that you saw of your own nonverbal performance (movement at the front of class)

The feedback from ClassInSight --> This is Part 3 of looking at your data, when ClassInSight provided some feedback on your performance

Please select the number for each item which best represents your feelings. Question 1 applies to 2, 3 and 4 as well.

* 1. My attitude about my proxemics nonverbal behavior data.

Good 1	2	3	4	5	6	Bad 7
○	○	○	○	○	○	○

* 2.

Worthless 1	2	3	4	5	6	Valuable 7
○	○	○	○	○	○	○

* 3.

Fair 1	2	3	4	5	6	Unfair 7
○	○	○	○	○	○	○

* 4.

Positive 1	2	3	4	5	6	Negative 7
○	○	○	○	○	○	○

7

Please select the number for each item which best represents your feelings. Question 5 applies to 6, 7 and 8 as well.

* 5. My attitude about the feedback from ClassInSight on my performance.

Good 1	2	3	4	5	6	Bad 7
○	○	○	○	○	○	○

* 6.

Worthless 1	2	3	4	5	6	Valuable 7
○	○	○	○	○	○	○

* 7.

Fair 1	2	3	4	5	6	Unfair 7
○	○	○	○	○	○	○

* 8.

Positive 1	2	3	4	5	6	Negative 7
○	○	○	○	○	○	○

8

ClassInSight (Post)

Immediacy and nonverbal behaviors

Below we provide a definition for immediacy and nonverbal behaviors that you can use in the following sections of the questionnaire:

Immediacy is the perceived closeness between people that is achieved through language and communication. *Immediacy behaviors* are behaviors that reduce the physical and/or psychological distance between people and increase the interpersonal closeness.

Teacher immediacy is conceptualized as those nonverbal behaviors that reduce physical and/or psychological distance between teachers and students. *Nonverbal behaviors* are communication behaviors that do not involve verbal communication, which include, but are not limited to, posture, physical distance, gestures, facial expressions, eye contact, etc.

* 1. Please respond to the question below to the best of your ability.

	Not At All Confident	Slightly Confident	Moderately Confident	Very Confident	Extremely Confident
How confident are you in your teacher immediacy skills?	○	○	○	○	○

* 2. Are there any specific immediacy or nonverbal behavior skills in your teaching that you would like to work and improve on?

* 3. Please rate your agreement with the following statements.

	Disagree Very Strongly	Disagree Strongly	Disagree	Neutral	Agree	Agree Strongly	Agree Very Strongly
Immediacy and non-verbal behaviors have a significant effect on teaching.	○	○	○	○	○	○	○
Immediacy and non-verbal behaviors have a significant effect on student learning.	○	○	○	○	○	○	○
Movement in class while teaching has a significant effect on fostering immediacy in the classroom.	○	○	○	○	○	○	○
Movement in class while teaching has a significant effect on student learning.	○	○	○	○	○	○	○

ClassInSight (Post)

Self-efficacy

This questionnaire is designed to help us gain a better understanding of the kinds of things that create challenges for teachers. Your answers are confidential.

Please indicate your opinion about each of the questions below by marking any one of the nine responses in the columns on the right side, ranging from (1) "None at all" to (9) "A great deal" as each represents a degree on the continuum.

* 1. Please respond to each of the questions by considering the combination of your current ability, resources, and opportunity to do each of the following in your present position.

	None at all 1	2	Very little 3	4	Some degree 5	6	Quite a bit 7	8	A great deal 9
How much can you do to get through to the most difficult students?	○	○	○	○	○	○	○	○	○
How much can you do to help your students think critically?	○	○	○	○	○	○	○	○	○
How much can you do to control disruptive behavior in the classroom?	○	○	○	○	○	○	○	○	○
How much can you do to motivate students who show low interest in school work?	○	○	○	○	○	○	○	○	○
To what extent can you make your expectations clear about student behavior?	○	○	○	○	○	○	○	○	○

	None at all 1	2	Very little 3	4	Some degree 5	6	Quite a bit 7	8	A great deal 9
How much can you do to get students to believe they can do well in school work?	○	○	○	○	○	○	○	○	○
How well can you respond to difficult questions from your students?	○	○	○	○	○	○	○	○	○
How well can you establish routines to keep activities running smoothly?	○	○	○	○	○	○	○	○	○
How much can you do to help your students value learning?	○	○	○	○	○	○	○	○	○
How much can you gauge student comprehension of what you have taught?	○	○	○	○	○	○	○	○	○
To what extent can you craft good questions for your students?	○	○	○	○	○	○	○	○	○
How much can you do to foster student creativity?	○	○	○	○	○	○	○	○	○
How much can you do to improve the understanding of a student who is failing?	○	○	○	○	○	○	○	○	○

	None at all 1	2	Very little 3	4	Some degree 5	6	Quite a bit 7	8	A great deal 9
How much can you do to calm a student who is disruptive or noisy?									
How well can you establish a classroom management system with each group of students?									
How much can you do to adjust your lessons to the proper level for individual students?									
How much can you use a variety of assessment strategies?									
How well can you keep a few problem students form ruining an entire lesson?									
To what extent can you provide an alternative explanation or example when students are confused?									
How well can you respond to defiant students?									
How well can you implement alternative strategies in your classroom?									

	None at all 1	2	Very little 3	4	Some degree 5	6	Quite a bit 7	8	A great deal 9
How well can you provide appropriate challenges for very capable students?									

ClassInSight (Post)

Self-efficacy for immediacy and nonverbal behaviors

Please rate how certain you are that you can do the things discussed below by selecting the appropriate number. Please mark any one of the nine responses in the columns on the right side, ranging from (1) “Not at all” to (9) “A great deal” as each represents a degree on the continuum.

As a reminder, here are the definitions of immediacy and nonverbal behaviors.

Immediacy is the perceived closeness between people that is achieved through language and communication. *Immediacy behaviors* are behaviors that reduce the physical and/or psychological distance between people and increase the interpersonal closeness.

Teacher immediacy is conceptualized as those nonverbal behaviors that reduce physical and/or psychological distance between teachers and students. *Nonverbal behaviors* are communication behaviors that do not involve verbal communication, which include, but are not limited to, posture, physical distance, gestures, facial expressions, eye contact, etc.

* 1. Please rate your degree of confidence:

	Not at all 1	2	Very little 3	4	Some degree 5	6	Quite a bit 7	8	A great deal 9
I can use teacher immediacy while I am teaching									
I can use teacher immediacy to talk to a student one-on-one									
I can use teacher immediacy to support my students’ learning									
I can use nonverbal behaviors appropriately while I am teaching									

	Not at all 1	2	Very little 3	4	Some degree 5	6	Quite a bit 7	8	A great deal 9
I can use nonverbal behaviors while I am teaching to foster immediacy between me and my students									
I can understand student nonverbal behavior									
I can use movement while I am teaching									
I can use movement while I am teaching to foster immediacy between me and my students									
I can use movement while I am teaching to keep and maintain student attention									

ClassInSight (Post)

Nonverbal behaviors

The following statements describe the ways some instructors behave while teaching or talking with students.

* 1. Please indicate for each item the degree to which you believe the statement applies TO YOU.

	Never 1	Rarely 2	Occasionally 3	Often 4	Very often 5
I use my hands and arms to gesture while teaching	◯	◯	◯	◯	◯
I use a monotone or dull voice while teaching	◯	◯	◯	◯	◯
I look over or away from my students while teaching	◯	◯	◯	◯	◯
I have a relaxed body position when I teach	◯	◯	◯	◯	◯
I frown while teaching	◯	◯	◯	◯	◯
I avoid eye contact while teaching	◯	◯	◯	◯	◯
I have a tense body position while teaching	◯	◯	◯	◯	◯
I sit close or stand close to my students while teaching	◯	◯	◯	◯	◯
My voice is monotonous or dull when I teach	◯	◯	◯	◯	◯

17

	Never 1	Rarely 2	Occasionally 3	Often 4	Very often 5
I use a variety of vocal expressions when I teach	◯	◯	◯	◯	◯
I gesture when I teach	◯	◯	◯	◯	◯
I am animated when I teach	◯	◯	◯	◯	◯
I have a bland facial expression when I teach	◯	◯	◯	◯	◯
I move closer to my students when I teach	◯	◯	◯	◯	◯
I look directly at my students while teaching	◯	◯	◯	◯	◯
I am stiff when I teach	◯	◯	◯	◯	◯
I have a lot of vocal variety when I teach	◯	◯	◯	◯	◯
I avoid gesturing while I am teaching	◯	◯	◯	◯	◯
I lean toward my students when I teach	◯	◯	◯	◯	◯
I maintain eye contact with my students when I teach	◯	◯	◯	◯	◯
I try not to sit or stand close to my students when I teach	◯	◯	◯	◯	◯
I lean away from my students when I teach	◯	◯	◯	◯	◯

18

	Never 1	Rarely 2	Occasionally 3	Often 4	Very often 5
I smile when I teach	◯	◯	◯	◯	◯

19

ClassInSight (Post)

Motivation

* 1. What things motivate you in trying to do your best in the class(es) you are teaching this semester? Please elaborate.

* 2. What things decrease your motivation in trying to do your best in the class(es) you are teaching this semester? Please elaborate.

* 3. Please answer the question: “Why do you teach?” by rating how much you agree with the following statements.

Why do you teach?

	Totally Disagree 1	Disagree 2	Undecided 3	Agree 4	Totally Agree 5
Because for me, the task of teaching is of personal importance	◯	◯	◯	◯	◯
Because a good performance in teaching contributes largely to my self-esteem as a professor	◯	◯	◯	◯	◯

20

	Totally Disagree 1	Disagree 2	Undecided 3	Agree 4	Totally Agree 5
Because my aspiration is to be successful at teaching, otherwise I would feel like a loser	○	○	○	○	○
Because I feel very uncomfortable if I neglect my teaching	○	○	○	○	○
Because I find the task of teaching interesting	○	○	○	○	○
I don't know, sometimes I don't see the actual purpose of teaching [at all]	○	○	○	○	○
Because during teaching I'm in a pleasant mental state of "flow"	○	○	○	○	○
Because the task of teaching provides the chance to realize an aspect of my academic profession that is of personal meaning to me	○	○	○	○	○
I don't know why, because the work conditions provided for academic teaching are unbearable	○	○	○	○	○

21

	Totally Disagree 1	Disagree 2	Undecided 3	Agree 4	Totally Agree 5
Because I derive much pleasure from teaching	○	○	○	○	○
Because I get paid for it	○	○	○	○	○
Because I see my teaching as a significant contribution to my students' overall academic progress	○	○	○	○	○
Because I would feel bad if I would neglect my task of teaching	○	○	○	○	○
Primarily because I get positive feedback from my students	○	○	○	○	○
Because my employment contract demands me to teach	○	○	○	○	○
Teaching does not mean a lot to me, because I cannot really see what academic teaching can accomplish in my students	○	○	○	○	○

22

ClassInSight (Post)

Motivation

Please indicate your opinion about each of the questions below by marking any one of the seven responses in the columns on the right side, ranging from (1) "Not at all" to (7) "Extremely" as each represents a degree on the continuum.

* 1.

	Not at all 1	2	Slightly 3	4	Moderately 5	6	Extremely 7
How hard will you strive to be an effective teacher?	○	○	○	○	○	○	○
How certain are you that you will remain in teaching?	○	○	○	○	○	○	○
How much will you work at being a good teacher?	○	○	○	○	○	○	○
How confident are you that you will stick with teaching?	○	○	○	○	○	○	○
How much effort will you put into your teaching?	○	○	○	○	○	○	○
How sure are you that you will persist in a teaching career?	○	○	○	○	○	○	○
How much effort do you plan to exert as a teacher?	○	○	○	○	○	○	○
How sure are you that you will stay in the teaching profession?	○	○	○	○	○	○	○

23

* 2. "To what extent are you motivated to ...."

	Not at all 1	2	Slightly 3	4	Moderately 5	6	Extremely 7
...continue learning how to improve your teaching skills?	○	○	○	○	○	○	○
...undertake further professional development?	○	○	○	○	○	○	○
...continue to acquire curriculum knowledge?	○	○	○	○	○	○	○
...participate in professional development courses?	○	○	○	○	○	○	○
...learn about current educational developments?	○	○	○	○	○	○	○

24

ClassInSight (Post)

Motivation

Please rate your agreement with the following statements. We use the following terms to refer to the materials ClassInSight presented to you. These were the paper materials that Franceska brought to the 1h interview.

Professional Development Module --> This is the information you read on immediacy and nonverbal behaviors, their definitions and importance

Your proxemics nonverbal behavior data --> This is the data that you saw of your own nonverbal performance (movement at the front of class)

The feedback from ClassInSight --> This is Part 3 of looking at your data, when ClassInSight provided some feedback on your performance

* 1. Why did you participate in the task of engaging with the Professional Development Module and looking at your own proxemic nonverbal behavior data that ClassInSight shared with you?

	Disagree Very Strongly	Disagree Strongly	Disagree	Neutral	Agree	Agree Strongly	Agree Very Strongly
Because it is pleasant to carry out this task.	○	○	○	○	○	○	○
Because if I don't carry out this task, I will feel bad.	○	○	○	○	○	○	○
Because the school obliges me to do it.	○	○	○	○	○	○	○
Because this task allows me to attain work objectives that I consider important.	○	○	○	○	○	○	○
Because I like doing this task.	○	○	○	○	○	○	○

25

	Disagree Very Strongly	Disagree Strongly	Disagree	Neutral	Agree	Agree Strongly	Agree Very Strongly
I used to know why I was doing this task, but I don't see the reason anymore.	○	○	○	○	○	○	○
To not feel bad if I don't do it.	○	○	○	○	○	○	○
Because I find this task important for the academic success of my students.	○	○	○	○	○	○	○
I don't know, sometimes I don't see its purpose.	○	○	○	○	○	○	○
Because I'm paid to do it.	○	○	○	○	○	○	○
Because I find this task interesting to do.	○	○	○	○	○	○	○
Because I would feel guilty not doing it.	○	○	○	○	○	○	○
Because it is important for me to carry out this task.	○	○	○	○	○	○	○
Because my work demands it.	○	○	○	○	○	○	○
I don't know, I don't always see the relevance of carrying out this task.	○	○	○	○	○	○	○

26

ClassInSight (Post)

Goals

We use the following terms to refer to the materials ClassInSight presented to you. These were the paper materials that Franceska brought to the 1h interview.

Professional Development Module --> This is the information you read on immediacy and nonverbal behaviors, their definitions and importance

Your proxemics nonverbal behavior data --> This is the data that you saw of your own nonverbal performance (movement at the front of class)

The feedback from ClassInSight --> This is Part 3 of looking at your data, when ClassInSight provided some feedback on your performance

27

* 1. Please rate your agreement with the following statements

	Disagree Very Strongly	Disagree Strongly	Disagree	Neutral	Agree	Agree Strongly	Agree Very Strongly
I will change my nonverbal behavior with my students after working with the Professional Development Module that ClassInSight shared with me	○	○	○	○	○	○	○
I will change my nonverbal behavior with my students after seeing my own proxemics nonverbal behavior data that ClassInSight shared with me	○	○	○	○	○	○	○
I will change my nonverbal behavior with my students after seeing the feedback that ClassInSight provided on my performance	○	○	○	○	○	○	○

28

* 2. Please select the point that best describes how ready you are to do do the following:

	Not ready at all 1	2	3	Thinking about it 10	5	6	Planning and making a commitment to it 7	8	9	I already do that 10
How ready are you to change your (general) nonverbal behavior in the classroom?	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
How ready are you to change your proxemic (movement) nonverbal behavior in the classroom?	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

* 3. Based on the Professional Development Module and your nonverbal behavior data, do you think you would like to change something in the nonverbal behavior you use in your class?

If you would like to change something, please list 2-3 ways that you would like to change and why.

If you would not like to change anything, please elaborate on why.

29

ClassInSight (Post)

Thank you!

Thank you very much for completing this questionnaire! You have come to the end of the PD Module and taking part in this research opportunity.

It has been our pleasure to work and collaborate with you. We hope we can have more opportunities in the future to work together.

Thank you again for your time and for participating! Please contact me with any questions at francesx@cs.cmu.edu.

30

C.3 Interview Materials

[Only the researcher sees this part. Researcher reads to participant.]

Setting the setting for the ClassInSight App:

We are working towards the development of an app, which we call the ClassInSight app.

This app aims to provide instructors with Professional Development Modules as well as data on their nonverbal behavior in the classroom.

We are still in the process of creating this app and so today, instead of the app, I have brought in printed form both the Professional Development Module and your data. These materials will eventually be moved to the app, from which instructors can access them. But for today, we will work on paper.

I will not do much talking, rather, let the paper "app" materials guide you through the process. If you have any questions throughout the process, you may certainly ask me.

I may also ask you some questions as you are working with your own data.

Any questions for me now? Ready to begin? :)

ID == 83

Introduction to the ClassInSight App

Welcome to this Professional Development Module (PD Module) and thank you again for your participation!

In the following sections, ClassInSight will provide you with some information on what immediacy and nonverbal behaviors are and their importance to teaching and student learning.

Then, you will see some of your own data that ClassInSight has collected from your class.

Objectives of the PD Module

1. Introduce immediacy and nonverbal behaviors
2. Introduce their importance and benefits to teaching and student learning
3. Present some data on your nonverbal behavior in the classroom

What is Immediacy?

Immediacy is the perceived closeness between people that is achieved through language and communication [1]. **Immediacy behaviors** are behaviors that reduce the physical and/or psychological distance between people and increase their interpersonal closeness [2].

The more immediate a person is, the more likely they are to communicate at close physical distances, smile, engage in eye contact, use direct body orientations, use overall body movement and gestures, touch others, relax and be vocally expressive. In other words, an immediate person is perceived as overtly friendly and warm [2].

What is Teacher Immediacy?

The concept of immediacy is also applicable to a **teacher's relationships with students**. Teacher immediacy is conceptualized as those nonverbal behaviors that reduce physical and/or psychological distance between teachers and students [2].

Teachers can use immediacy behaviors with students such as eye gaze, smiles, nods, relaxed body posture, forward leans, movement, gestures and vocal variety to **enhance the perception of closeness** between them and their students, with the ultimate goal of **enhancing student learning** [2, 3, 4].

Teachers should be aware of their nonverbal communication and their students' nonverbal behavior in the classroom for the following reasons [5]:

1. to become better receivers and to **better understand student nonverbal messages**
2. to gain the ability to **send students positive signals** that reinforce learning and at the same time become more adept at avoiding negative signals that hinder learning

References
[1] Wiener, M., & Mehrabian, A. (1968). Language within language: Immediacy, a channel in verbal communication.
[2] Andersen, J. F. (1979). Teacher immediacy as a predictor of teaching effectiveness. Annals of the International Communication Association, 3(1), 543-559.
[3] Christophel, D. M., & Gorham, J. (1995). A test□retest analysis of student motivation, teacher immediacy, and perceived sources of motivation and demotivation in college classes. Communication education, 44(4), 292-306.
[4] Andersen, J. and Andersen, P. (2008). Teacher Immediacy. In The International Encyclopedia of Communication
[5] Miller, P. W. (1988). Nonverbal Communication. What Research Says to the Teacher. NEA Professional Library, PO
Box 509, West Haven, CT 06516.

The Importance of Immediacy and Nonverbal Behaviors in the Classroom

Nonverbal immediacy skills can help teachers and students have happier, more productive, learning experiences in the classroom.

First, research indicates that **teachers' nonverbal immediacy is meaningfully correlated with student learning** in the classroom [1, 2].

- Teacher immediacy has a positive relationship with students' **attitudes towards learning** (their interest in the class and course material).
- Teacher immediacy positively affects students' **perceptions of their understanding and learning of** the material in the course.
- Additionally, teacher immediacy has a modest relationship with students' actual **learning performance** in the course.

Second, research also shows that when teachers display more (rather than less) immediacy in the classroom, students **evaluate** the class, the instructor, the subject matter and course content **more positively** [2]. Furthermore, immediate teachers are **more motivating** to students and students are more likely to develop positive attitudes toward the class, attend class more and approach rather than avoid the subject.

Lastly, instructor **nonverbal immediacy is positively associated** with a wide range of instructor, student, and classroom variables, such as:

- Perceived instructor variables including credibility, fairness and clarity
- Instructor-student out-of-class communication
- Students' evaluation and affect toward their instructors
- Student affect and interest toward the course and course content
- Student compliance
- Student intent to persist in college

Taken together, this body of research highlights the **strategic and important role of teacher nonverbal immediacy in teaching-learning processes in the classroom**.

References
[1] Witt, P. L., Wheeless, L. R., & Allen, M. (2004). A meta□analytical review of the relationship between teacher immediacy
and student learning. Communication Monographs, 71(2), 184-207.
[2] Andersen, J. and Andersen, P. (2008). Teacher Immediacy. In The International Encyclopedia of Communication

How is Nonverbal Immediacy Communicated?

Nonverbal immediacy is communicated by a set of nonverbal behaviors including [1].

1. **Proxemics → decreased physical distance**
2. Haptics → socially appropriate touch
3. Vocalics → vocal variation and vocal expressiveness
4. Kinesics → facial animation, open postures, gestural activity and body relaxation
5. Oculesics → eye contact
6. Chronemics → spending more time with students, arriving early, staying late
7. Physical appearance → informal but socially appropriate attire

Don't worry about remembering all these categories! In this PD Module, we will only focus on: **#1: Proxemics**. In the following section, we will show you some data on your proxemics nonverbal behavior in the classroom. Specifically, we will show you the percentage of time you spend at different positions at the front of your classroom.

Why do we care about Proxemics?

There exists a large body of research that has studied **the effects of the instructors' use of proxemics** while teaching on their students and the classroom environment.

Immediate teachers communicate at **physically closer distances** and they choose direct unimpeded angles when interacting with their students. They **spend time among their students** rather than behind their desk or a podium [1].

In contrast, a teacher who **stands behind their desk or podium** and rarely approaches their students or allows them to approach her/him is perceived by students as unfriendly, unreceptive, unapproachable, and nonimmediate and noncaring [2].

Similarly, teachers who **sat at, on, beside, or behind their desks** were rated by students as low in both affection and inclusion. Teachers who **moved in front of their desks or among their students** were perceived as warm, friendly, and effective by their students [3].

References
[1] Andersen, J. F., & Andersen, P. A. (1987). Never smile until Christmas? Casting doubt on an old myth. Journal of Thought, 22 (4), 57-61.
[2] Richmond, V. P. (2002). Teacher nonverbal immediacy. Communication for teachers, 65, 82.
[3] Hesler, M. W. (1972). An Investigation of Instructor Use of Space.

[Only the researcher sees this part. Researcher reads to participant.]

Now, ClassInSight will share with you some of your nonverbal behavior data that it collected from the past few classroom sessions in your class.

The data will be shown in three parts. You will have 10-15 minutes to look at each part. If you are done earlier you can move to the next part. Do not worry about the time, as I will give you reminders.

*I will ask you to **think aloud** as you are looking at your data.*

There's a difference between a think aloud and explaining what you're doing. Now I will show a math task to present to you the difference between explanation and think aloud.

Think aloud Example: 14+29= 43
Explaining Example: 14+29 = 43

Explaining something changes your thinking strategy and slows you down performing the task.

I will remind you to please think aloud if you are going quiet for a bit.

Part 1: Your performance

1. In the chart in Figure 1, we show the percentage of time (y-axis) you spent at the front of the classroom on the **right**, **center** and **left** sides of the classroom (x-axis).
   a. Note this is your right and left while facing the students.
   b. This data was calculated over *4 class sessions* from your class *XXXXX: Xxxxx xx Xxxxx Xxxxx Xxxxxx* that you are teaching during Summer I.
   c. When you stand on the right and center side of the classroom, you are often standing behind your podium or table.
2. In Figure 2, we show your class layout in *BLDG XXXX*. With a green dot, we show where you stood on the right, center and left sides of the classroom.
3. In Figure 3 we show one example of how your students sit in class.

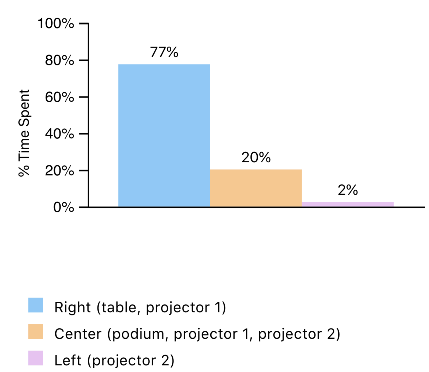


Figure 1: The percentage of time (y-axis) that you spent at the front of the classroom on the right, center and left sides of the classroom (x-axis).

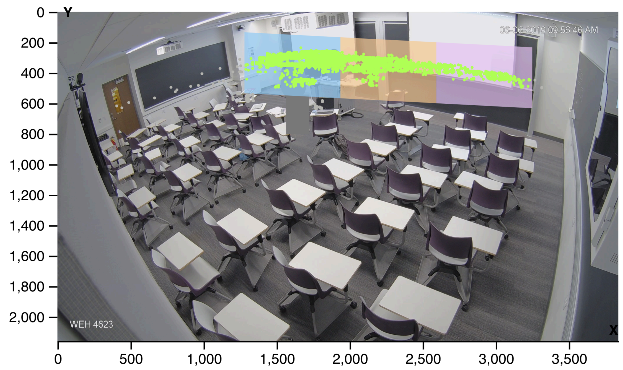


Figure 2: The layout of your class and where you stood on the right, center and left.

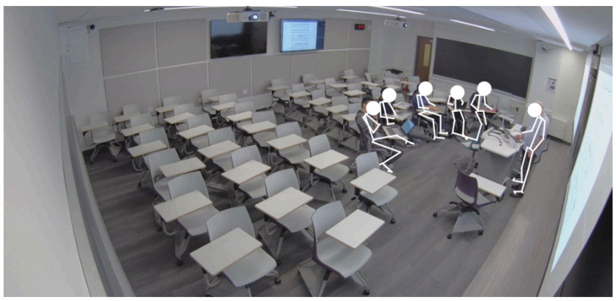


Figure 3: Example of how your students sit in class.

[Only the researcher sees this part. Researcher asks participant in order.]

Based on this information:

1. *How do you think you are doing?*
2. *What other data/information would you like to know?*

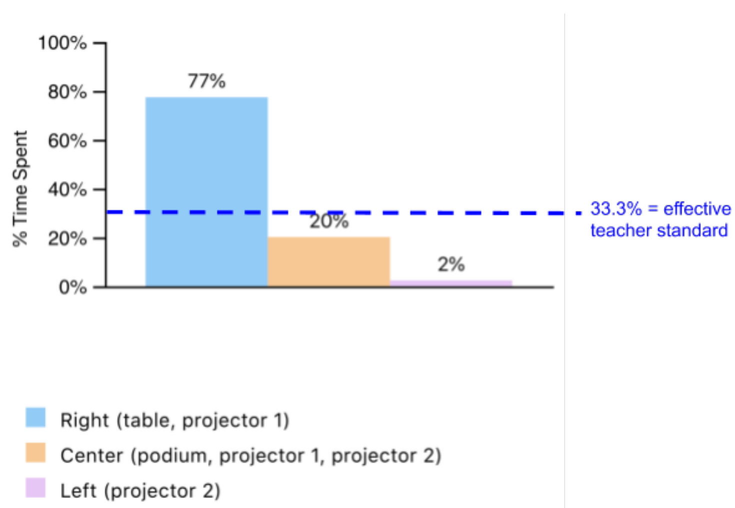
Part 2: Your performance compared to an Effective Teacher Standard

Effective teachers move more around the classroom and spend an equal amount of time at the right, center and left side of the classroom [1, 2, 3], as suggested by the blue dotted line (standard) in the chart below.

- In general, effective teachers spend less time sitting or standing behind the table or podium.
- Being physically closer to their students and moving around the classroom allows effective teachers to foster immediacy with their students.
- In addition, by moving more and spending an equal amount of time in front of each part of the class, effective teachers can give an equal amount of attention to the students in each part of the class. This allows students to be more attentive and engaged in class.
- Generally, a moving object is more compelling than a static one. Moving more around the classroom would allow effective teachers to keep and maintain student attention.

Here is your data compared to this effective teacher standard:

References
[1] Andersen, J. F., & Andersen, P. A. (1987). Never smile until Christmas? Casting doubt on an old myth. Journal of Thought, 22 (4), 57-61.
[2] Richmond, V. P. (2002). Teacher nonverbal immediacy. Communication for teachers, 65, 82.
[3] Hesler, M. W. (1972). An Investigation of Instructor Use of Space.



[Only the researcher sees this part. Researcher asks participant in order.]

Based on this information:

1. *How do you think you are doing?*
2. *What other data/information would you like to know?*

Part 3: ClassInSight Feedback[1]

Our system, ClassInSight, has looked at your nonverbal behavior data. Here is ClassInSight's feedback on your nonverbal behavior performance.

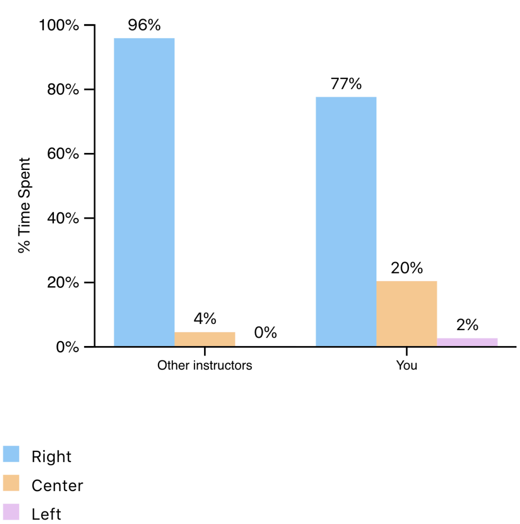
In Part 2, you were shown your nonverbal behavior data compared to an effective teacher standard. You have been doing a very good job with your proxemics nonverbal behavior in the classroom! You most certainly have the ability and skills to improve and reach the standard of effective teachers that was shown to you in Part 2. In fact, the information provided to you in this PD Module is a resource for you to engage in effective nonverbal proxemics behavior. You can do this!

[1] [Note: This page was only shown to the participants in the Verbal persuasion condition]

Part 3: ClassInSight Feedback[2]

Our system, ClassInSight, has looked at your nonverbal behavior data. Here is ClassInSight's feedback on your nonverbal behavior performance.

In Part 2, you were shown your nonverbal behavior data compared to an effective teacher standard. Your performance on the nonverbal proxemics behavior is very high compared to other instructors who have worked with ClassInSight in the past! Below, in the chart on the left, we show how other instructors like you, who worked with ClassInSight, did on their nonverbal proxemic behavior compared to you. We were impressed by how far you got with only a few class sessions!



[2] [Note: This page was only shown to the participants in the Social comparison condition]

[Only the researcher sees this part. Researcher asks participant in order.]

Based on this information:

1. *How do you think you are doing?*
2. *What other data/information would you like to know?*

Goals

[Only the researcher sees this part. Researcher asks participant in order.]

1. *Based on the PD Module that ClassInSight provided on nonverbal behavior and immediacy and your nonverbal behavior data, do you think you would like to change something in the nonverbal behavior you use in your class?*
    a. *If so, please list 2-3 ways that you would like to change. Why?*
2. *Would you like to see some suggestions on how you can change?*

How you might work to change your proxemic nonverbal behavior in the classroom[3]

Spend an equal amount of time in each part of the class.
Before every class session, mentally divide the class in three (right, center, left) or more equal sections based on where your students are sitting. Every 10 minutes of class time, or every time you switch to another topic in your lecture, try to move around the classroom, making sure you spend time in front of each section [1].

Stand in front of the podium or desk.
If your class has a table at the front, move the table against the front wall so you have more space between your and your students. Stand in front of the table to decrease the physical distance with your students.

Try to do the same for the podium by moving it all the way to the front or one of the side walls. Do not stand behind the podium. If you use slides, try to use a pointer. That will give you the flexibility to move around the classroom. Only use the podium when most necessary (i.e. when you need the laptop to show something to your students).

If you often use the board, try to maximize the time you face your students. Don't turn your back on the class for too long. Every 1-3 lines of writing on the board, make sure you are looking at your students. Every 10 minutes, try to ask your students a question to see if they are being attentive and keeping up with the lecture. As you ask the question, try to move around the classroom, making sure you spend time in front of each section as described above.

Use movement to hold students' attention.
A moving object is more compelling than a static one. Every 10 minutes make sure you move about the room. Use deliberate, purposeful, sustained gestures: hold up an object, take off your glasses, push up your sleeves. To invite questions from students, adopt an open, casual stance [1]. To encourage participation, move to a part of the room where quiet students are sitting [2, 3].

Use movement to emphasize an important point or to lead into a new topic.
Some faculty move to one side of the table or podium when presenting one side of an argument and to the other side when presenting the opposing view. This movement not only captures students ' attention but reinforces the opposition between the two points of view [4, 5, 6]. You could try this strategy every time you switch topics or move to a different concept during your lecture.

References
[1] Davis, B. G. (2009). Tools for teaching. John Wiley & Sons.
[2] Faust, D. F., & Courtenay, B. C. (2002). Interaction in the intergenerational freshman class: What matters. Educational Gerontology, 28(5), 401-422.
[3] Rosmarin, A. (1987). The art of leading a discussion. Teaching and the case method: Text, cases, and readings, 235-240.
[4] Heppner, F. (2007). Teaching the large college class: A guidebook for instructors with multitudes (Vol. 116).
[5] Tauber, R. T., & Mester, C. S. (2007). Acting lessons for teachers: Using performance skills in the classroom (Vol. 38).
[6] Weimer, M. (1988). How Am I Teaching? Forms and Activities for Acquiring Instructional Input. Magna Publications.

[3] [Note: This page was only shown to the participants who answered, "Yes" to the "Would you like to see some suggestions on how you can change?" question.]

[Only the researcher sees this part. Researcher asks participant in order.]

Feedback on Our study? [2']

1. *Did the training cover aspects of nonverbal communication behaviors that reinforces your learning and interpretation of these behaviors?*
2. *In what specific aspects of the training did you gain knowledge?*
3. *What aspects of the PD module did you think were most helpful for you ?*
4. *What aspects of the PD module did you think were least helpful for you?*
5. *What aspects of the system feedback on your data did you think were most helpful for you ?*
6. *What aspects of the system feedback on your data did you think were least helpful for you?*
7. *What data of your classroom behavior would you like to see?*
8. *Do you have any further comments to help us improve the feedback information?*

Franceska Xhakaj <francesx@cs.cmu.edu>
to Gloria

Dear Professor ,

Thank you very much again for creating the time and opportunity to meet with me today. Thank you also for all your feedback and comments!

I am sharing with you in this link the post-questionnaire. This should take the same amount of time as the previous questionnaire you filled. Please fill the survey at your earliest convenience. I can send you a reminder over the weekend.

Please let me know if I can do anything else in the meantime or if you have any questions. Thank you again!

Sincerely,
Franceska Xhakaj

Franceska Xhakaj
Ph.D. student | Human-Computer Interaction Institute | Carnegie Mellon University
www.franceskaxhakaj.com

Figure C-2: Email to send post-questionnaire to instructors.

Appendix D

Study Materials Chapter 8 Study

D.1 Training Study for Data Collection in the Classroom

1. Make sure you put the days/times for the class you are going to be in into your calendar!
    a. Please do not miss a class. If you can't make it please let Franceska know asap
    b. You will only be required to do ~5 class sessions. As soon as you do that, please let Franceska know: She will check the data and give you the ok to stop or move to another class
2. Be there 5-10 minutes before class starts: we want to be least disruptive of class time
3. The first time you go, please introduce yourself to the professor. Something along the lines of:
    a. "*Hi Professor XX! I am YY and I am the study team member who will be in your class for participating in the study. If it is ok with you, I will sit at a location that does not interfere or disrupt your class.*" → Note: Prof might say this is not a good day to do recording. Thank them and say you will come next time

4. I am on email/phone most of the time so if anything comes up, email or txt or call me:
    a. francesx@cs.cmu.edu - xhakajf@gmail.com (Hangouts)
    b. 702-934-3574 (txt or call)

5. In this spreadsheet, keep notes of if things went ok or if something happened/something went wrong during class
    a. Follow the format you see currently for the other classes
    b. If you don't have access to the spreadsheet, let me know asap

6. Where to sit in class:
    a. Please sit at the back/end row, in a corner or something like that so that you do not disrupt or interfere with the classroom
    b. For classrooms that sit in a circle, sit outside the circle in the corner or on the back, again so that we are least disruptive of class

7. **VERY IMPORTANT:**
    a. **Your main duty will be to start and stop the recording following the rules below**
    b. **As a second duty will be behavioral coding, but I will get back to you about that soon.**
    c. **ALWAYS** start the recording at the class start time (i.e. if class starts at 9:00AM start recording then!)
        i. Exceptions: It happens sometimes that students from the previous class are still wrapping up when the new class starts, and the prof waits for those previous students to leave before starting. **Please only start the recording when the previous students have left! Even if that is a few minutes after class time.**
        ii. **DO NOT START RECORDING unless everyone from the previous class has left, even if that is after class start time.**
    d. **STOP THE RECORDING** at the end of the class
        i. If class ends at 10:20AM then stop recording then
        ii. Sometimes class ends 10 or so minutes earlier than the actual time. Make sure you stop the recording as soon as class is done!! (i.e. if class goes until 9:30AM but they finish at 9:24AM, then stop the recording at 9:24AM)
    e. **You need to be in class for the whole class time.**
    f. **Keep track of your hours, this and anything else you do in this project is included in your paid time ^.^**

8. **NOTE**: Only stop the recording **DURING CLASS** if something like the following happens.

HOW TOs:

9. How to start/stop recording of sensors:
    a. Meet with Mudar. He will show you how to start and stop recording from your computer

10. **IN GENERAL:**
    a. We are **ONLY allowed** to do data collection with the teachers, TAs and students of the class. This means that we can record class sessions only when teachers/TAs/students are in class.
    b. We are **NOT allowed** to do data collection if third parties, children, guests or anyone else besides teachers, TAs and students are in class.
    c. If you notice something weird or not normal for a class (i.e. guests or others besides teachers and students might be in) please stop data collection and let Franceska know asap

11. **DO NOT START THE RECORDING OF THE SENSORS IF**:
    a. The class is empty (sometimes the teachers cancel class without telling us)
    b. There is an exam for the whole class time (we do not need the data from such classes).
        i. Quick quizzes or half of class time exams are fine, you can continue the recording
    c. Someone who is not an instructor, TA, or student who shows up regularly to the class happens to be in class the day we are doing data collection. Examples include
        i. The teacher brings a guest or someone else to class
        ii. The teacher brings their children to class
        iii. There is a guest lecturer or multiple guest lecturers
        iv. There are invited guests for a panel or something like that
        v. People are skyping in to lecture or there is a phone/video connection with outsiders/others not in class
        vi. A student brings their children to class
        vii. Any other third parties that are not teachers/students/TAs are present in class
    d. → In that case
        i. Do not start the recording
        ii. Email me to let me know
        iii. You are done for this class; that's it! You can leave :) Please be careful not to disrupt class!

12. **STOP THE RECORDING OF THE SENSORS IF**
    a. Someone who is not an instructor, TA, or student who shows up regularly to the class happens to be in class the day we are doing data collection. Examples include:

        i. The teacher brings a guest or someone else to class
        ii. The teacher brings their children to class
        iii. A student brings their children to class
        iv. There is a guest lecturer or multiple guest lecturers
        v. There are invited guests for a panel or something like that
        vi. People are skyping in to lecture or there is a phone/video connection with outsiders/others not in class
        vii. A student brings their children to class
        viii. Any other third parties that are not teachers/students/TAs are present in class
    b. → In that case
        i. Stop the recording
        ii. Email me to let me know
        iii. You are done for this class; that's it! You can leave :) Please be careful not to disrupt class!

13. How to do behavior coding: Coming soon
    a. I am still working on this, so for now either do other work related to our project during the time you are in class or other work you need to do :)

D.2 Training for Behavior Coding in Boris

Getting Started

What we are doing at the high level

- We are trying to code for teacher non-verbel behaviors in the classroom.
- Why? Nonverbal behaviors have been shown by research to improve immediacy in the classroom
- What are some nonverbal behaviors: proxemics (location of teacher), oculesics (gaze of teacher)
- More research on the importance of what we are doing on demand: Let me know if you want to learn more and I can share materials with you!
- The data you code will be visualized and shown to teachers → You are welcome to attend interviews and learn about HCI research
- Skills you will learn in the process
  - How to do behavior coding
  - How to run studies (shadow)
  - How to design studies and experiments (shadow)

When to do behavior coding:

1. We are short for time, so please start behavior coding asap!!
2. You can do behavior coding during class time, after you have started the recording or you can do it at your own time, home, etc.
3. In any case, you will need the hard drives below where we will put the videos to code

Getting the hard drives with the videos to code:

1. We have a limited number of drives so my approach will be to give you 1-2 videos in the drive.
2. As soon as you are done with coding that, you will return it back to me and I will coordinate to give you another one
3. **General rules with the hard drives:**
   a. The information you have in the drives is very sensitive information from classrooms, where you can see both video and audio of the classrooms. As you know from your CITI training, we have to be very careful with this information, to protect the anonymity and confidentiality of the participants.
   b. NEVER share the hard drive with anyone. NEVER share the password of the hard drive with anyone
   c. NEVER copy the videos or the audio or take screenshots of the content or video of the files in the drive. For the screenshots I ask you to take below, make sure you delete them immediately from your computer.

   d. NEVER record with a cellphone or other device the video or the audio of the videos in the drive playing. Never take photos of the videos with your phone or another device.
   e. NEVER share the videos with anyone else, never show the video or audio to anyone else.
   f. Even if you recognize a friend or instructor in the videos, never mention that to anyone; we would be breaching confidentiality and anonymity.
   g. NEVER copy the videos to your computer or another computer or another drive or put them somewhere on a folder online, in the cloud or on the internet. The videos are not supposed to leave the driver EVER.
   h. When you work with the videos, if you use audio, make sure you are using headphones if you are in an environment with other people. If you are watching the video/doing coding in an environment with other people, sit in a position that others cannot see the screen

Downloading the software for coding

1. Download Boris from this site. Boris is the software that we will be using for behavior coding: http://www.boris.unito.it/pages/download.html
2. You can download the software for Windows, Mac or Unix
3. Install the software
   a. For Mac users, you might get a security warning.
   b. No worries go to *Preferences → Security → General* → and click the lock at the bottom left to unlock → Then click *Open Anyways*
4. Install the software
5. Documentation for Boris is here
   a. Feel free to skim through it or watch the videos (I would highly encourage you to do so)

Note (After you have downloaded the .boris files and are ready to code):
1. Create a **New** observation every time you start coding a new class session
2. Choose **Start** observation to resume an old coding you did not finish

Setting up an observation
(when you start coding a new class session)

3. (assuming you have a project open)
4. Go to Observations → New Observation
5. In Observation ID put the name of the video file i.e. (*classinsight-cmu_19646B1_weh_5320_201910070921-back*)
6. Click "seconds" for the time format
7. Under *Media → Media Files* click *Add media* and choose the video from the hard drive
8. Click Save
9. *File → Save project* to save
10. **Note only do this when you are starting with a new class session coding!**

How to start coding or resume coding from a previous session

1. (assuming you have a project open)
2. Click *Observations → Start Observations*
3. From the menu, click the class session you would like to observe
4. You are ready to code

When you want to stop an observation

1. Pause the video
2. *File → Save project* to save
3. You can close Boris now
4. Make sure you backup your .boris project file in Box here
   a. Create a folder with your name
   b. Upload the .boris file so we have a backup in any case
   c. Mark the status of the coding in this folder as "Done" or "In Progress" in the appropriate sheet/line

When you are done with an observation

1. Save the project from Boris
2. Go to Observation → Export events → Tabular events

3. Pick the observation (or multiple observations) you would like to export (the one you are done with) → Click ok
4. Click Select All and then Click ok
5. Save as a csv file (under file type) with the video name + project name (i.e. classinsight-cmu_19646B1_weh_5320_201910070921-back_xlocation)
6. Add to your folder in box
    a. Create a folder with your name (or in the folder with your name you created above)
    b. Upload the .csv file
    c. Upload the .boris file in the same folder
    d. Mark the status of the coding in this folder as "Done" or "In Progress" in the appropriate sheet/line
7. In the appropriate class tab in this sheet, mark the coding that is done as "DONE" if in progress mark it as "IN PROGRESS" (use the classroom code to find the class you are working on)

Using Boris behavior coding

1. **Note**: Play with this on your own for a little and look at the documentation: https://boris.readthedocs.io/en/latest/#coding-your-media
    a. Let me know if you have any issues
    b. I.e. sometimes the widgets disappear. There is a way to fix that for both mac and windows (by removing the configuration file: https://boris.readthedocs.io/en/latest/#configuration-files)
2. Video tools
    a. Play, Pause, Fast forward-backward (use spacebar to pause)
    b. Increase and decrease speed (+, -). Bring to normal speed (=)
3. All widgets are removable (so you can open them up on your screen)
4. *Ethogram* widget
    a. Shows the keys you can press for coding (case sensitive)
5. *Events* widget
    a. This is where your actual coding gets saved
    b. Each event:
        i. Can be modified/edit
        ii. Can be removed/deleted
        iii. You can add events at any point
        iv. Red arrow shows where you are in the video
        v. Double clicking an event takes you to that time stamp in the video
6. Don't worry about the *Subjects* widget
7. The *player* widget
    a. You can zoom in by clicking any point in the video
    b. You can move to any point in the video

CODING SCHEMA

You will go through the video a few times. Some of the following are super easy and can be done with the video 1.2, 1.4, 1.5, to 2 times the speed. However, gaze is trickier so you might need to go to 1.0x speed or even slower (i.e. 0.8 or 0.7). Make sure you work with the highest speed that is comfortable for you! We want to be fast but also accurate. **For x1 and x2 I worked with 1.0 and 1.2 and 1.3 in general and that worked great for me, both as the highest speed but also the least lagging in the video.**

Side note: Sometime the video tends to glitch/lag when you go at a higher speed (or even normal speed). As soon as you notice glitching stop the video, bring the speed to 1.0 and press the << button to move a few seconds before the current point. That should stop the glitching.

Other side note: if during coding, you notice a behavior that is not listed in the keys below, please let me know asap! We might have missed edge cases that we definitely want to make sure to cover.

1. Go to this folder in box (let me know if you do not have access to it)
    a. Download the .boris file respective of the points below

2. Go to this other folder in box (let me know if you do not have access to it)
    a. Look for the classroom you are currently coding
    b. We have marked the left-center-right for location and gaze so use these for the coding below
    c. In Boris go to:
        i. Tools → Image overlay on Video → Add an image overlay
        ii. Select the image of the class you are currently coding
    d. **Take a screenshot of the video opened in boris with the image overlayed and upload it in your folder in Box** → This will help us to know where the podium/table/etc. Was in each class (i.e. left, right, etc)

3. **How to add comments to events:**
    a. Right Click on the event you want to add a comment to in the Event Widget
    b. Click Edit Selected events → You will have a comment box there so enter your comments there

4. **First time you go through the video: Code for teacher x-location at the front of class**
    a. Download the *x-location1.boris* file
    b. Suggested speed: 1.2 or 1.3x
    c. Codes:
        i. **R** (Teacher is standing in front of the classroom, on their right. Check photoshop picture for what counts as right for the classroom you are coding.)
        ii. **L** (Teacher is standing in front of the classroom, on their left. Check photoshop picture for what counts as left for the classroom you are coding.)

        iii. **C** (Teacher is standing in front of the classroom, on the center. Check photoshop picture for what counts as center for the classroom you are coding.)
        iv. **O** (Teacher is **not in the front of the classroom**.This can involve cases when teacher moves across students or sits/stands with students → Please click on the event on the Events widget and add comment as to where the teacher is.)
    d. **NOTE: Sometimes the teacher seems to be somewhere in between two zones in the front of the classroom. Count the side that the body is most on (i.e if 70% on C and 30% on L, then C). If it is equal keep moving from the two codings (i.e. if 50% both C and L keep pressing C and L alternating until the teacher moves)

5. **Second time you go through the video: Code for teacher x-location, other**
    a. Download the *x-location2.boris* file
    b. Suggested speed 1.2 or 1.3x
    c. Codes:
        i. **B** (Teacher is standing/sitting behind the podium or the table)
            1. This only includes cases when the teacher is **at the podium/table**, behind. Not just behind the podium, say writing on the board
        ii. **F** (Teacher is standing/sitting in front of the podium or the table)
            1. Again **at the podium table**, on the front
        iii. **O** (Teacher is **not in front of or behind the podium/table, rather in another location.** This involves cases when the teacher is at the front of the class in another location, or just among students)
        iv. **T** (teacher is sitting)
        v. **Y** (teacher is standing)
        vi. **Q** (only press once!: by mid class, enter a comment to say what the number of students in each quadrant is + how long the video is in seconds)
            1. I.e. Comment: 5 stus on the L, 3 on the C, 7 on the R, video is 3000 seconds
            2. When you are counting students, try your best. Sometimes the camera is not catching all the students on the back. Put that in the comment if that is the case
            3. Sometimes a student is between two zone (i.e. L or C). Pick the one that the most of students' body is in.

6. **Third time you go through the video: Code for gaze**
    a. Download the *gazeLRC.boris* gaze file
    b. Suggested speed 1.0 or slower (0.7, 0.8x)
    c. I suggest you only go at 1.0 speed with gaze. It is fast as it is to catch most behaviors
        i. **L** (Teacher looks at the left portion of the class (their left))
        ii. **R** (Teacher looks at the right portion of the class (their right))

        iii. **C** (Teacher looks at the center portion of the class)
        iv. **H** (Teacher is looking at laptop or table or notes on the podium or in their hand)
        v. **B** (Teacher is looking at the white or black board)
        vi. **P** (Teacher is looking at the slides in the projector)
        vii. **O** (teacher is not looking at any of the above locations)
            1. Includes "transition" gaze, when moving from one of the above objects to another
            2. Sometimes teachers are talking and explaining something, but they look up or on the sides, or no where in particular (the kind of "thinking gaze")
    d. Note: If teacher is in say L location and is looking at the direction of C/R but it is not clear exactly, then code the side that is closest to them, namely C. Similarly, if the teacher is on the R but is looking toward the C/L side, then select C, the closest one.
    e. NOTE: Until you get used to gaze, you might go slow in the beginning. I.e. if you miss a gaze, turn the video a few seconds backwards to make sure you get it. It will get better as you practice more
    f. NOTE: using spacebar actually helps a lot as you are beginning to work with gaze. Press spacebar to stop the video and then you can code the behavior/gaze that just happened
    g. NOTE: Some quick glances are hard to get, so no worries if you miss them! We do not want to miss major things, but little things here and there are fine
    h. NOTE: Videos have voice and that helps sometime with the coding so make sure you are wearing headphones!
    i. NOTE: Another approach is to stop video, roll back a few seconds, and then code the new behavior

Practice round 1

1. Do 10 minutes of behavior coding of the 10/02 video
    a. Go fast but make sure it is comfortable. We care about accuracy. Plus the video gets glitchy if you go too fast
    b. Feel free to go back and forth in the video
    c. Note: How to add comments to events is explained above
    d. Note: How to delete an event. Right click and click delete event
        i. Don't get scared if you do something wrong! You can always delete and recode
    e. Note: How to re-add an event. Click on the time you should add the event, and just recode, as simple as that ^.^
    f. **Note**: In general, if you see something strange or different, make sure you make a comment somewhere and let me know
2. After you are done, add the codes to your folder and Fran will do some calculations for accuracy

Practice round 2

3. Do 10 minutes of behavior coding of the 10/07
4. After you are done, add the codes to your folder and Fran will do some calculations for accuracy

When you are coding in general

1. If you are not sure about something, what you should code it as, what behavior it is, take a screenshot and add it to your folder in Box and email me to let me know what to check.
2. **Never** email screenshots, rather just upload them in Box and I can access them there

D.3 Pre and Post Questionnaires

ClassInSight Fall 2019 (Pre)

Welcome to ClassInSight and thank you for your participation!

This questionnaire is designed to help us become more familiar with you and your teaching style. It will take approximately 20 minutes to complete. Please contact francesx@cs.cmu.edu with any questions!

Your answers will be kept strictly confidential and you will not be identified by your name but by your Anonymous ID.

* 1. Please enter your Anonymous ID (provided to you by email)

ClassInSight Fall 2019 (Pre)

General

* 1. In your own words, can you provide a definition for **teacher immediacy**? Please say "no idea" if you do not know.

* 2. In your own words, can you provide a definition for or some examples of **nonverbal behaviors**? Please say "no idea" if you do not know.

ClassInSight Fall 2019 (Pre)

Immediacy and nonverbal behaviors

Immediacy **is the perceived closeness between people.**

Teacher immediacy **is conceptualized as those nonverbal behaviors that reduce physical and/or psychological distance between teachers and students and increase their interpersonal closeness.**

Nonverbal behaviors **are communication behaviors that do not involve verbal communication, which include location and position, gaze and eye contact, etc.**

* 1. Please respond to the question below to the best of your ability.

	Not At All Confident	Slightly Confident	Moderately Confident	Very Confident	Extremely Confident
How confident are you in your teacher immediacy skills?	○	○	○	○	○

* 2. Are there any specific immediacy or nonverbal behavior skills in your teaching that you would like to improve on? Please elaborate if so or say "No".

* 3. Please rate your agreement with the following statements.

	Disagree Very Strongly	Disagree Strongly	Disagree	Neutral	Agree	Agree Strongly	Agree Very Strongly
Teacher immediacy and non-verbal behaviors have a significant effect on teaching effectiveness.	○	○	○	○	○	○	○
Teacher immediacy and non-verbal behaviors have a significant effect on student learning.	○	○	○	○	○	○	○
The teacher's location and position in class while teaching has a significant effect on fostering immediacy in the classroom.	○	○	○	○	○	○	○
The teacher's location and position in class while teaching has a significant effect on student learning.	○	○	○	○	○	○	○
The teacher's gaze and eye contact while teaching has a significant effect on fostering immediacy in the classroom.	○	○	○	○	○	○	○
The teacher's gaze and eye contact while teaching has a significant effect on student learning.	○	○	○	○	○	○	○

ClassInSight Fall 2019 (Pre)

Self-efficacy

* 1. Please indicate your opinion about each of the questions below by marking any one of the nine responses ranging from (1) “None at all” to (9) “A great deal” as each represents a degree on the continuum. Please respond to each of the questions by considering the combination of your current ability, resources, and opportunity to do each of the following in your present position.

	None at all 1	2	Very little 3	4	Some degree 5	6	Quite a bit 7	8	A great deal 9
How much can you do to get through to the most difficult students?									
How much can you do to help your students think critically?									
How much can you do to control disruptive behavior in the classroom?									
How much can you do to motivate students who show low interest in school work?									
To what extent can you make your expectations clear about student behavior?									
How much can you do to get students to believe they can do well in school work?									
How well can you respond to difficult questions from your students?									
How well can you establish routines to keep activities running smoothly?									
How much can you do to help your students value learning?									

	None at all 1	2	Very little 3	4	Some degree 5	6	Quite a bit 7	8	A great deal 9
How much can you gauge student comprehension of what you have taught?									
To what extent can you craft good questions for your students?									
How much can you do to foster student creativity?									
How much can you do to improve the understanding of a student who is failing?									
How much can you do to calm a student who is disruptive or noisy?									
How well can you establish a classroom management system with each group of students?									
How much can you do to adjust your lessons to the proper level for individual students?									
How much can you use a variety of assessment strategies?									
How well can you keep a few problem students form ruining an entire lesson?									
To what extent can you provide an alternative explanation or example when students are confused?									
How well can you respond to defiant students?									
How well can you implement alternative strategies in your classroom?									

	None at all 1	2	Very little 3	4	Some degree 5	6	Quite a bit 7	8	A great deal 9
How well can you provide appropriate challenges for very capable students?									

ClassInSight Fall 2019 (Pre)

Self-efficacy for immediacy and nonverbal behaviors

Immediacy **is the perceived closeness between people.**

Teacher immediacy **is conceptualized as those nonverbal behaviors that reduce physical and/or psychological distance between teachers and students and increase their interpersonal closeness.**

Nonverbal behaviors **are communication behaviors that do not involve verbal communication, which include location and position, gaze and eye contact, etc.**

* 1. Please rate **your degree of confidence** about each of the items discussed below by marking any one of the nine responses ranging from (1) “None at all” to (9) “A great deal” as each represents a degree on the continuum.

	Not at all 1	2	Very little 3	4	Some degree 5	6	Quite a bit 7	8	A great deal 9
I am able to use nonverbal behaviors while I am teaching to foster immediacy between me and my students									
I am able to use teacher immediacy to support my students' learning									
I am able to use my location and position in class while I am teaching to foster immediacy between me and my students									
I am able to use my location and position in class while I am teaching to keep student attention									
I am able to use my gaze and eye contact while I am teaching to foster immediacy between me and my students									
I am able to use my gaze and eye contact while I am teaching to keep student attention									

ClassInSight Fall 2019 (Pre)

Nonverbal behaviors

* 1. Please indicate for each item the degree to which you believe the statement applies TO YOU.

	Never 1	Rarely 2	Occasionally 3	Often 4	Very often 5
I look over or away from my students while teaching					
I avoid eye contact while teaching					
I sit close or stand close to my students while teaching					
I move closer to my students when I teach					
I look directly at my students while teaching					
I lean toward my students when I teach					
I maintain eye contact with my students when I teach					
I try not to sit or stand close to my students when I teach					
I lean away from my students when I teach					
I move away from my students when I teach					

ClassInSight Fall 2019 (Pre)

Motivation

* 1. What motivates you to do your best in the class you are teaching this semester? Please elaborate.

* 2. Please answer the question: "**Why do you teach?**" by rating how much you agree with the following statements.

	Totally Disagree 1	Disagree 2	Undecided 3	Agree 4	Totally Agree 5
Because I derive much pleasure from teaching					
Because a good performance in teaching contributes largely to my self-esteem as a professor					
Because I see my teaching as a significant contribution to my students' overall academic success					
Because my employment contract demands me to teach					
I don't know, sometimes I don't see the actual purpose of teaching					

ClassInSight Fall 2019 (Pre)

Motivation

* 1. Please indicate your opinion about each of the questions below by marking any one of the seven responses ranging from (1) "Not at all" to (7) "Extremely" as each represents a degree on the continuum.

	Not at all 1	2	Slightly 3	4	Moderately 5	6	Extremely 7
How hard will you strive to be an effective teacher?							
How much effort will you put into your teaching?							

* 2. "To what extent are you motivated to ...."

	Not at all 1	2	Slightly 3	4	Moderately 5	6	Extremely 7
...continue learning how to improve your teaching skills?							
...undertake further professional development?							
...learn about current educational developments?							

ClassInSight Fall 2019 (Pre)

Demographics

* 1. What is your role at CMU?

- PhD Student
- Faculty
- Teaching Faculty
- Other (please specify)

* 2. How familiar are you with the US school system? Please check all that apply:

- I did/am doing my undergraduate in the US
- I did/am doing my masters in the US
- I did/am doing my PhD in the US
- None of the above
- Other (please specify)

ClassInSight Fall 2019 (Pre)

Your course

Please answer the following for your course that is participating in our study.

* 1. Before teaching this course, have you taken it as a student or TAed it? Please elaborate if so or say "No".

* 2. How many times have you taught this course before? Please elaborate.

ClassInSight Fall 2019 (Pre)

Teaching Experience

* 1. How many years have you been teaching in the classroom (at CMU or elsewhere)? Please list courses and elaborate.

* 2. At what levels have you taught?

- Elementary School
- Middle School
- High School
- College
- Other (please specify)

* 3. Are you involved with the Eberly Center (i.e. have you taken any seminars, are you part of the Future Faculty Program (FFP), etc.)? Please elaborate if so or say "No".

* 4. Have you had any training on teaching or any type of professional development, at CMU or elsewhere? Please elaborate if so or say "No".

ClassInSight Fall 2019 (Pre)

Thank you very much for completing this questionnaire!

Please schedule a time (1h) to meet with Franceska to look at your nonverbal behavior data. You can use this link to schedule (available times start on Nov 18th, 2019) .

Please contact Franceska with any questions at francesx@cs.cmu.edu.

ClassInSight Fall 2019 (Post)

Welcome to ClassInSight and thank you for your participation!

This questionnaire, similar to the previous one you filled, is designed to help us become more familiar with you and your teaching style. It will take approximately 20 minutes to complete. Please contact francesx@cs.cmu.edu with any questions!

Your answers will be kept strictly confidential and you will not be identified by your name but by your Anonymous ID.

* 1. To begin, please enter your Anonymous ID (provided to you by email)

1

ClassInSight Fall 2019 (Post)

We use the following terms to refer to the ClassInSight on-paper materials that Franceska brought to the 1h interview.

***Professional Development Module* --> The information on immediacy and nonverbal behaviors, their definitions and importance**

***Dashboard Module* --> The dashboard with the data on your nonverbal behaviors**

* 1. On a scale of 0-10, how much did you learn in the *Professional Development Module*? Please indicate with 0 meaning you learned nothing and 10 meaning you learned more than in any other professional development or training that you have ever had in the past.

Learned nothing					Learned Somewhat					Learned more than in any other professional development
0	1	2	3	4	5	6	7	8	9	10

* 2. On a scale of 0-10, how much did you learn from seeing your data in the *Dashboard Module*? Please indicate with 0 meaning you learned nothing and 10 meaning you learned more than in any other of your own teaching-related data that you have ever seen in the past.

Learned Nothing					Learned Somewhat				Learned more than in any other of my own teaching-related data
0	1	2	3	4	5	7	8	9	10

2

ClassInSight Fall 2019 (Post)

Professional Development Module --> The information on immediacy and nonverbal behaviors, their definitions and importance

Dashboard Module --> The dashboard with the data on your nonverbal behaviors

Please select the number for each item which best represents your feelings.

* 1. My attitude about the *Professional Development Module*.

Worthless						Valuable
1	2	3	4	5	6	7

* 2. My attitude about the Professional Development Module. (different scale)

Fair						Unfair
1	2	3	4	5	6	7

* 3. My likelihood of actually attempting to engage in the behaviors recommended in the *Professional Development Module*.

Likely						Unlikely
1	2	3	4	5	6	7

* 4. My likelihood of actually enrolling in another *Professional Development Module* of related content, if I had the choice and my schedule permits.

Likely						Unlikely
1	2	3	4	5	6	7

3

ClassInSight Fall 2019 (Post)

Professional Development Module --> The information on immediacy and nonverbal behaviors, their definitions and importance

Dashboard Module --> The dashboard with the data on your nonverbal behaviors

Please select the number for each item which best represents your feelings.

* 1. My attitude about the *Dashboard Module*.

Worthless						Valuable
1	2	3	4	5	6	7

* 2. My attitude about the *Dashboard Module*. (different scale)

Fair						Unfair
1	2	3	4	5	6	7

* 3. My attitude about my location (proxemics) nonverbal behavior data.

Good						Bad
1	2	3	4	5	6	7

* 4. My attitude about my location (proxemics) nonverbal behavior data. (different scale)

Fair						Unfair
1	2	3	4	5	6	7

* 5. My attitude about my gaze (oculesics) nonverbal behavior data.

Good						Bad
1	2	3	4	5	6	7

* 6. My attitude about my gaze (oculesics) nonverbal behavior data. (different scale)

Fair						Unfair
1	2	3	4	5	6	7

4

ClassInSight Fall 2019 (Post)

Immediacy and nonverbal behaviors

Immediacy **is the perceived closeness between people.**

Teacher immediacy **is conceptualized as those nonverbal behaviors that reduce physical and/or psychological distance between teachers and students and increase their interpersonal closeness.**

Nonverbal behaviors **are communication behaviors that do not involve verbal communication, which include location and position, gaze and eye contact, etc.**

* 1. Please respond to the question below to the best of your ability.

	Not At All Confident	Slightly Confident	Moderately Confident	Very Confident	Extremely Confident
How confident are you in your teacher immediacy skills?	○	○	○	○	○

* 2. Are there any specific immediacy or nonverbal behavior skills in your teaching that you would like to improve on? Please elaborate if so or say "No".

* 3. Please rate your agreement with the following statements.

	Disagree Very Strongly	Disagree Strongly	Disagree	Neutral	Agree	Agree Strongly	Agree Very Strongly
Teacher immediacy and non-verbal behaviors have a significant effect on teaching effectiveness.	○	○	○	○	○	○	○
Teacher immediacy and non-verbal behaviors have a significant effect on student learning.	○	○	○	○	○	○	○
The teacher's location and position in class while teaching has a significant effect on fostering immediacy in the classroom.	○	○	○	○	○	○	○
The teacher's location and position in class while teaching has a significant effect on student learning.	○	○	○	○	○	○	○
The teacher's gaze and eye contact while teaching has a significant effect on fostering immediacy in the classroom.	○	○	○	○	○	○	○
The teacher's gaze and eye contact while teaching has a significant effect on student learning.	○	○	○	○	○	○	○

ClassInSight Fall 2019 (Post)

Self-efficacy

* 1. Please indicate your opinion about each of the questions below by marking any one of the nine responses ranging from (1) “None at all” to (9) “A great deal” as each represents a degree on the continuum. Please respond to each of the questions by considering the combination of your current ability, resources, and opportunity to do each of the following in your present position.

	None at all 1	2	Very little 3	4	Some degree 5	6	Quite a bit 7	8	A great deal 9
How much can you do to get through to the most difficult students?	○	○	○	○	○	○	○	○	○
How much can you do to help your students think critically?	○	○	○	○	○	○	○	○	○
How much can you do to control disruptive behavior in the classroom?	○	○	○	○	○	○	○	○	○
How much can you do to motivate students who show low interest in school work?	○	○	○	○	○	○	○	○	○
To what extent can you make your expectations clear about student behavior?	○	○	○	○	○	○	○	○	○
How much can you do to get students to believe they can do well in school work?	○	○	○	○	○	○	○	○	○
How well can you respond to difficult questions from your students?	○	○	○	○	○	○	○	○	○
How well can you establish routines to keep activities running smoothly?	○	○	○	○	○	○	○	○	○
How much can you do to help your students value learning?	○	○	○	○	○	○	○	○	○

	None at all 1	2	Very little 3	4	Some degree 5	6	Quite a bit 7	8	A great deal 9
How much can you gauge student comprehension of what you have taught?									
To what extent can you craft good questions for your students?									
How much can you do to foster student creativity?									
How much can you do to improve the understanding of a student who is failing?									
How much can you do to calm a student who is disruptive or noisy?									
How well can you establish a classroom management system with each group of students?									
How much can you do to adjust your lessons to the proper level for individual students?									
How much can you use a variety of assessment strategies?									
How well can you keep a few problem students form ruining an entire lesson?									
To what extent can you provide an alternative explanation or example when students are confused?									
How well can you respond to defiant students?									
How well can you implement alternative strategies in your classroom?									

9

	None at all 1	2	Very little 3	4	Some degree 5	6	Quite a bit 7	8	A great deal 9
How well can you provide appropriate challenges for very capable students?									

10

ClassInSight Fall 2019 (Post)

Self-efficacy for immediacy and nonverbal behaviors

***Immediacy* is the perceived closeness between people.**

***Teacher immediacy* is conceptualized as those nonverbal behaviors that reduce physical and/or psychological distance between teachers and students and increase their interpersonal closeness.**

***Nonverbal behaviors* are communication behaviors that do not involve verbal communication, which include location and position, gaze and eye contact, etc.**

* 1. Please rate **your degree of confidence** about each of the items discussed below by marking any one of the nine responses ranging from (1) “None at all” to (9) “A great deal” as each represents a degree on the continuum.

	Not at all 1	2	Very little 3	4	Some degree 5	6	Quite a bit 7	8	A great deal 9
I am able to use nonverbal behaviors while I am teaching to foster immediacy between me and my students									
I am able to use teacher immediacy to support my students’ learning									
I am able to use my location and position in class while I am teaching to foster immediacy between me and my students									
I am able to use my location and position in class while I am teaching to keep student attention									
I am able to use my gaze and eye contact while I am teaching to foster immediacy between me and my students									
I am able to use my gaze and eye contact while I am teaching to keep student attention									

11

ClassInSight Fall 2019 (Post)

Nonverbal behaviors

* 1. Please indicate for each item the degree to which you believe the statement applies TO YOU.

	Never 1	Rarely 2	Occasionally 3	Often 4	Very often 5
I look over or away from my students while teaching					
I avoid eye contact while teaching					
I sit close or stand close to my students while teaching					
I move closer to my students when I teach					
I look directly at my students while teaching					
I lean toward my students when I teach					
I maintain eye contact with my students when I teach					
I try not to sit or stand close to my students when I teach					
I lean away from my students when I teach					
I move away from my students when I teach					

12

ClassInSight Fall 2019 (Post)

Motivation

* 1. What motivates you to do your best in the class you are teaching this semester? Please elaborate.

* 2. Please answer the question: "**Why do you teach?**" by rating how much you agree with the following statements.

	Totally Disagree 1	Disagree 2	Undecided 3	Agree 4	Totally Agree 5
Because I derive much pleasure from teaching	◯	◯	◯	◯	◯
Because a good performance in teaching contributes largely to my self-esteem as a professor	◯	◯	◯	◯	◯
Because I see my teaching as a significant contribution to my students' overall academic success	◯	◯	◯	◯	◯
Because my employment contract demands me to teach	◯	◯	◯	◯	◯
I don't know, sometimes I don't see the actual purpose of teaching	◯	◯	◯	◯	◯

ClassInSight Fall 2019 (Post)

Motivation

* 1. Please indicate your opinion about each of the questions below by marking any one of the seven responses ranging from (1) "Not at all" to (7) "Extremely" as each represents a degree on the continuum.

	Not at all 1	2	Slightly 3	4	Moderately 5	6	Extremely 7
How hard will you strive to be an effective teacher?	◯	◯	◯	◯	◯	◯	◯
How much effort will you put into your teaching?	◯	◯	◯	◯	◯	◯	◯

* 2. "To what extent are you motivated to ...."

	Not at all 1	2	Slightly 3	4	Moderately 5	6	Extremely 7
...continue learning how to improve your teaching skills?	◯	◯	◯	◯	◯	◯	◯
...undertake further professional development?	◯	◯	◯	◯	◯	◯	◯
...learn about current educational developments?	◯	◯	◯	◯	◯	◯	◯

ClassInSight Fall 2019 (Post)

Motivation

* 1. Why did you participate in the task of engaging with the *Professional Development Module* and *Dashboard Module* in ClassInSight?

	Disagree Very Strongly	Disagree Strongly	Disagree	Neutral	Agree	Agree Strongly	Agree Very Strongly
Because it is pleasant to carry out this task.	◯	◯	◯	◯	◯	◯	◯
To not feel bad if I don't do it.	◯	◯	◯	◯	◯	◯	◯
Because I find this task important for the academic success of my students.	◯	◯	◯	◯	◯	◯	◯
Because I'm paid to do it.	◯	◯	◯	◯	◯	◯	◯
I don't know, I don't always see the relevance of carrying out this task.	◯	◯	◯	◯	◯	◯	◯

ClassInSight Fall 2019 (Post)

Goals

* 1. Please select the point that best describes how ready you are to do do the following:

	Not ready at all 1	2	3	Thinking about it 4	5	6	Planning and making a commitment to it 7	8	9	I already do that 10
How ready are you to change your (general) nonverbal behavior in the classroom?	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
How ready are you to change your location (proxemic) nonverbal behavior in the classroom?	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
How ready are you to change your gaze (oculesics) nonverbal behavior in the classroom?	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

* 2. Please rate your agreement with the following statements

	Disagree Very Strongly	Disagree Strongly	Disagree	Neutral	Agree	Agree Strongly	Agree Very Strongly
I will change my nonverbal behavior during class after reading the information on the ClassInsight Professional Development Module	○	○	○	○	○	○	○
I will change my nonverbal behavior during class after seeing my data in the ClassInSight Dashboard Module	○	○	○	○	○	○	○
I will change my location (proxemics) behavior during class after seeing my own proxemics data in the ClassInSight Dashboard Module	○	○	○	○	○	○	○
I will change my gaze (oculesics) behavior during class after seeing my own oculesics data in the ClassInSight Dashboard Module	○	○	○	○	○	○	○

* 3. Given your responses above, what would like to change in the nonverbal behaviors (general, proxemics/location, oculesics/gaze) you use in your class?

Please list 2-3 ways that you would like to change and elaborate on why. If you would not like to change anything, please elaborate on why.

17

ClassInSight Fall 2019 (Post)

Thank you very much for completing this questionnaire!

It has been our pleasure to work and collaborate with you in this research study. We hope we can have more opportunities in the future to work together.

Please contact Franceska with any questions at francesx@cs.cmu.edu.

18

D.4 Interview Materials

[Only the researcher sees this part. Researcher reads to participant.]

Setting the setting for the ClassInSight App:

We are working towards the development of an app called the ***ClassInSight App****.*

This app aims to provide instructors with a:

- *Professional Development Module and*
- *Dashboard Module*

We are still in the process of creating this app and today, instead of the app, I have brought in printed form both the Professional Development Module and your data presented in a dashboard form. These materials will eventually be integrated into the app and will be accessible to the instructors. But for today, we will work on paper.

If you have any questions at any point during this process, please feel free to ask me.

Ready to begin? :)

Welcome to ClassInSight!

ClassInSight will share with you a:

1. ***Professional Development Module*** → information on immediacy and nonverbal behaviors, their definitions and importance to teaching and student learning
2. ***Dashboard Module*** → data on your nonverbal behaviors in your teaching

Professional Development Module

What is Teacher Immediacy?

Immediacy is the perceived closeness between people that is achieved through language and communication [1].

Teacher immediacy is conceptualized as those nonverbal behaviors that reduce physical and/or psychological distance between teachers and students and increase their interpersonal closeness, with the ultimate goal of enhancing student learning [2, 3, 4, 5].

Nonverbal behaviors are behaviors that do not involve verbal communication. Nonverbal behaviors that teachers can use in their teaching include location and movement in the classroom, eye gaze, smiles, nods, relaxed body posture, forward leans, gestures and vocal variety [6].

References
[1] Wiener, M., & Mehrabian, A. (1968). Language within language: Immediacy, a channel in verbal communication.
[2] Andersen, J. F. (1979). Teacher immediacy as a predictor of teaching effectiveness. Annals of the International Communication Association, 3(1), 543-559.
[3] Andersen, J. and Andersen, P. (2008). Teacher Immediacy. In The International Encyclopedia of Communication
[4] Gorham, J. (1988). The relationship between verbal teacher immediacy behaviors and student learning. Communication education, 37(1), 40-53.
[5] Richmond, V. P. (2002). Teacher nonverbal immediacy. Communication for teachers, 65, 82.
[6] Andersen , J., Andersen, P., & Jensen, A. D. (1979) The measurement of nonverbal immediacy, Journal of Applied Communication Research, 7:2, 153-180

The Importance of Teacher Immediacy and Nonverbal Behaviors in the Classroom

Nonverbal immediacy behaviors are some of the most valuable communication tools instructors have available to them [5]. These nonverbal immediacy skills can help teachers and students have a happier, more productive, classroom experience.

1. **Importance to Teachers**
   Teachers should be aware of their and their students' nonverbal behavior to [3]:
   - **better understand student nonverbal messages**
   - gain the ability to **send students positive signals** that reinforce learning and **avoid negative signals** that hinder learning
2. **Importance to Student Learning**
   Teachers' immediacy [1, 2]:
   - is meaningfully **correlated with student learning** in the course
   - positively affects students' **perceptions of their understanding and learning**
   - has a modest relationship with students' **actual learning performance**
3. **Importance to Attitudes Towards Learning**
   - When teachers display more immediacy, **students evaluate more positively** the class, instructor, subject matter and course content [2].
   - Teacher immediacy has a positive relationship with students' **attitudes towards learning**. More immediate teachers are **more motivating** to students and their students are more likely to develop positive attitudes toward the class, attend class more and approach rather than avoid the subject [2, 4].
4. **Importance more in general**
   Teacher immediacy **is positively associated** with a range of variables, including [1]:
   - Perceived instructor credibility, fairness and clarity
   - Student compliance
   - Students' perceptions of being mentored
   - Student intent to persist in college

★ Taken together, this body of research highlights the **strategic and important role of teacher nonverbal immediacy in teaching-learning processes in the classroom**. ★

References
[1] Witt, P. L., Wheeless, L. R., & Allen, M. (2004). A meta-analytical review of the relationship between teacher immediacy and student learning. Communication Monographs, 71(2), 184-207.
[2] Andersen, J. and Andersen, P. (2008). Teacher Immediacy. In The International Encyclopedia of Communication
[3] Miller, P. W. (1988). Nonverbal Communication. What Research Says to the Teacher. NEA Professional Library.
[4] Christophel, D. M., & Gorham, J. (1995). A test-retest analysis of student motivation, teacher immediacy, and perceived sources of motivation and demotivation in college classes. Communication education, 44(4), 292-306.
[5] Richmond, V. P. (2002). Teacher nonverbal immediacy. Communication for teachers, 65, 82.

Nonverbal immediacy is communicated by a set of behaviors including [1]:
1. Proxemics → decreased physical distance, location and position
2. Oculesics → gaze and eye contact

Importance of Proxemics

Immediate teachers communicate at **physically closer distances** and choose direct angles when interacting with their students. They **spend time among their students** rather than behind their desk or podium [1].

In contrast, a teacher who **stands behind their desk or podium** and rarely approaches students or allows them to approach her/him is perceived by students as unfriendly, unreceptive, unapproachable. The teacher who **withdraws from students** is perceived as non immediate and noncaring [2].

Teachers who **sat at, on, beside, or behind their desks** were rated by students as low in affection and inclusion. Teachers who **moved in front of their desks or among students** were perceived as warm, friendly, and effective. A positive relationship was found between the teachers' spending time in front of the desk and the students' feeling that they were part of a class unit [3].

Importance of Oculesics

Direct eye contact and gaze can provide psychological closeness between teachers and students and is an important component of the teacher's immediacy. **Good eye contact** increases rapport [4, 5].

Eye contact permits teachers to monitor and regulate their classes while simultaneously signaling warmth, attentiveness and immediacy [1]. **High levels of gaze** make students more attentive to the teacher [6]. Students in **high eye contact** availability are more likely to participate than those in **low eye contact** availability.

The teacher who **rarely looks at a student** when talking is communicating that she/he is not very interested in that student and that the teacher is not approachable [6]. Teachers **who look at their students** are perceived as more interested and more immediable [2].

Eye contact is such a basic immediacy cue that its absence makes the warmest teachers seem cold and distant [1]. [6] found that the **absence of eye contact** between teachers and university students usually produces negative feelings in students.

References
[1] Andersen, J. F., & Andersen, P. A. (1987). Never smile until Christmas? Casting doubt on an old myth. Journal of Thought, 22 (4), 57-61.
[2] Richmond, V. P. (2002). Teacher nonverbal immediacy. Communication for teachers, 65, 82.
[3] Hesler, M. W. (1972). An Investigation of Instructor Use of Space.
[4] Andersen, J. F. (1979). Teacher immediacy as a predictor of teaching effectiveness. Annals of the International Association, 3(1), 543-559.
[5] Andersen , J., Andersen, P., & Jensen, A. D. (1979) The measurement of nonverbal immediacy, Journal of Applied Communication Research, 7:2, 153-180
[6] Breed, G. (1971). Nonverbal behavior and teaching effectiveness. Vermillion: University of South Dakota

[Only the researcher sees this part. Researcher reads to participant.]

Now, ClassInSight will share with you some of your nonverbal behavior data from the past few classroom sessions in your class. The data will be shown in a mini-dashboard form.

The data will be shown in three parts. You will have time to look at the data and then we will discuss about it.

Feel free to think aloud and talk through or read aloud as you are looking at your data.

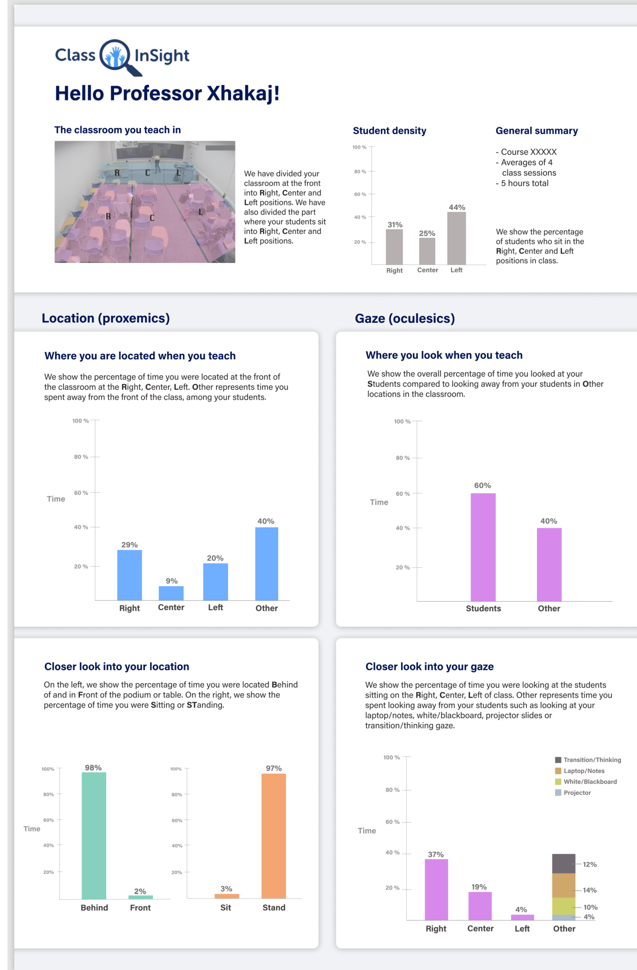
Ready for your data? :)

Class InSight

Dashboard Module

Part 1: Your data

9



10

[Only the researcher sees this part. Researcher reads to participant.]

1. *[Noticing] What do you see? What do you notice?*
2. *[Reflecting] What do you think about your data?*
    a. *How do you think you are doing? How would you evaluate your performance based on the data that you see?*
3. *[Planning] Do you want to change anything in your behavior?*
    a. *What would you like to change?*
    b. *How would you change it?*

11

Part 2: An Effective Teacher Model

Effective teachers use nonverbal behaviors to foster immediacy with their students [1, 2, 3, 4, 5, 6]. Effective teachers might:

- **Divide their time and attention equally** among all of their students. Proportionally to where students sit, effective teachers might:
    - **equally distribute their location** at the right, center and left of the front of the class. For example, if there are more students on the left, then effective teachers are proportionally located more to the left.
    - **equally distribute their gaze** to the right, center and left side of the class. For example, if more students sit on the right, then effective teachers proportionally maintain more eye contact with the right part of the class
- Spend **less time behind the podium/table** and more in front of it or among students.
- Spend **more time looking at and facing their students** instead of the laptop, notes, board or projector slides.

In the following dashboard we show your nonverbal behavior data compared to such **an effective teacher model (**represented by the **black dotted line).**

References
[1] Andersen, J. F., & Andersen, P. A. (1987). Never smile until Christmas? Casting doubt on an old myth. Jour. of Thought, 22 (4), 57-61.
[2] Richmond, V. P. (2002). Teacher nonverbal immediacy. Communication for teachers, 65, 82.
[3] Hesler, M. W. (1972). An Investigation of Instructor Use of Space.
[4] Breed, G. (1971). Nonverbal behavior and teaching effectiveness. Vermillion: University of South Dakota
[5] Andersen, J. F. (1979). Teacher immediacy as a predictor of teaching effectiveness. Annals of the Intern. Assoc., 3(1), 543-559.
[6] Ledbury, R., White, I., & Darn, S. (2004). The Importance of eye contact in the classroom. The Internet TESL Journal, 10(8), 1-2.

12

13

[Only the researcher sees this part. Researcher reads to participant.]

1. *[Noticing] What do you see? What do you notice?*
2. *[Reflecting] What do you think about your data?*
    a. *How do you think you are doing? How would you evaluate your performance based on the data that you see?*
3. *[Planning] Do you want to change anything in your behavior?*
    a. *What would you like to change?*
    b. *How would you change it?*

14

Part 3: ClassInSight Feedback[1]

ClassInSight has looked at your nonverbal behavior data. Here is ClassInSight's feedback on your performance.

In Part 2, you were shown your nonverbal behavior data compared to an effective teacher. You have been doing a very good job with your location and gaze nonverbal behaviors in the classroom! You most certainly have the ability and skills to improve and reach the effective teacher that was shown to you in Part 2. In fact, the information provided to you in this document is a resource for you to engage in effective location and gaze nonverbal behaviors. You can do this!

[1] [Note: This page was only shown to the participants in the Verbal persuasion condition]

15

Part 3: ClassInSight Feedback[2]

ClassInSight has looked at your nonverbal behavior data. Here is ClassInSight's feedback on your performance.

In Part 2, you were shown your nonverbal behavior data compared to an effective teacher. Your performance on the nonverbal location and gaze behaviors is very high compared to other instructors who have completed this study before you! In the following dashboard, we show how other instructors who took this Professional Development module like you, did on their location and gaze nonverbal behaviors compared to you. We were impressed by how far you got with only a few class sessions!

[2] [Note: This page and the following were only shown to the participants in the Social comparison condition]

16

[Only the researcher sees this part. Researcher reads to participant.]

1. *[Noticing] What do you see? What do you notice?*
2. *[Reflecting] What do you think about your data?*
    a. *How do you think you are doing? How would you evaluate your performance based on the data that you see?*
3. *[Planning] Do you want to change anything in your behavior?*
    a. *What would you like to change?*
    b. *How would you change it?*

[Only the researcher sees this part. Researcher reads to participant.]

1. *What other data/information would you like to know, see or have?*
2. *What aspects of the modules did you think were*
    a. *most helpful*
    b. *least helpful to you*
3. *Would you like so see some suggestions on how you can change?*

How you might work to change your location and gaze nonverbal behavior[3]

Divide your attention proportionally and equally

Mentally divide the room in three or more sections, based on where students sit.

- Every 10 minutes or every time you switch topic, try to move around the room, making sure you proportionally spend time in front of each section [1].
- Similarly, try to make eye contact proportionally to each section during the course of your lecture. Pick out friendly faces, but include others as well. If direct eye contact upsets your concentration, look between two students or at foreheads [7].
- Good eye contact does not mean staring or gazing. Many learners find this uncomfortable, consequently avert their eyes and lose concentration. Neither does good eye contact mean eyes darting from learner to learner. Look directly at your students one at a time. It is recommended that there should be 3-5 seconds of eye contact for nonverbal communication to take place [7].

Encourage participation and hold student attention

- A moving object is more compelling than a static one. Every 10 minutes try to move about the room. Use deliberate, purposeful gestures: hold up an object, take off your glasses, push up your sleeves [1].
- To invite questions from students, adopt an open, casual stance [1]. To encourage participation, move to a part of the room where quiet students are sitting [2, 3].
- Smile and make eye contact to encourage students to speak up. Nominate and invite responses by eye. If the nominee is not watching, someone will give her/him a nudge. Keep eye contact as speaking or listening to students' answers to show interest and support [7].
- One-on-one eye contact will increase students ' attentiveness and enable you to catch facial expressions and body language that indicate whether you are speaking too slowly or too quickly, or whether students need another example or explanation. A common mistake lecturers make is to become so absorbed in the material that they fail to notice whether students are paying attention and following along.

Get around the classroom furnishing

- To decrease the physical distance with your students, move the table and podium against the front/side walls. Stand in front of the table and do not stand behind the podium.
- Try to use a pointer with slides to have the flexibility to move around the room as well as keep continuous eye contact with your students. Only use the podium when most necessary.
- Talk to your learners, not to the book/your notes, the board or the screen/slides [7].
- When using the board, maximize the time you face your students. Don't turn your back on the class for too long. Every 1-3 lines of writing on the board, turn around and look at your students. Don't talk when you are writing on the board. Rather, wait to finish writing and then turn, make eye contact and continue talking with your students.

[3] [Note: This page was only shown to the participants who answered, "Yes" to the "Would you like to see some suggestions on how you can change?" question.]

References

[1] Davis, B. G. (2009). Tools for teaching. John Wiley & Sons.
[2] Faust, D. F., & Courtenay, B. C. (2002). Interaction in the intergenerational freshman class: What matters. Educational Gerontology, 28(5), 401-422.
[3] Rosmarin, A. (1987). The art of leading a discussion. Teaching and the case method: Text, cases, and readings, 235-240.
[4] Heppner, F. (2007). Teaching the large college class: A guidebook for instructors with multitudes (Vol. 116).
[5] Tauber, R. T., & Mester, C. S. (2007). Acting lessons for teachers: Using performance skills in the classroom (Vol. 38).
[6] Weimer, M. (1988). How Am I Teaching? Forms and Activities for Acquiring Instructional Input. Magna Publications.
[7] Ledbury, R., White, I., & Darn, S. (2004). The Importance of eye contact in the classroom. The Internet TESL Journal, 10(8), 1-2.

D.5 IRB

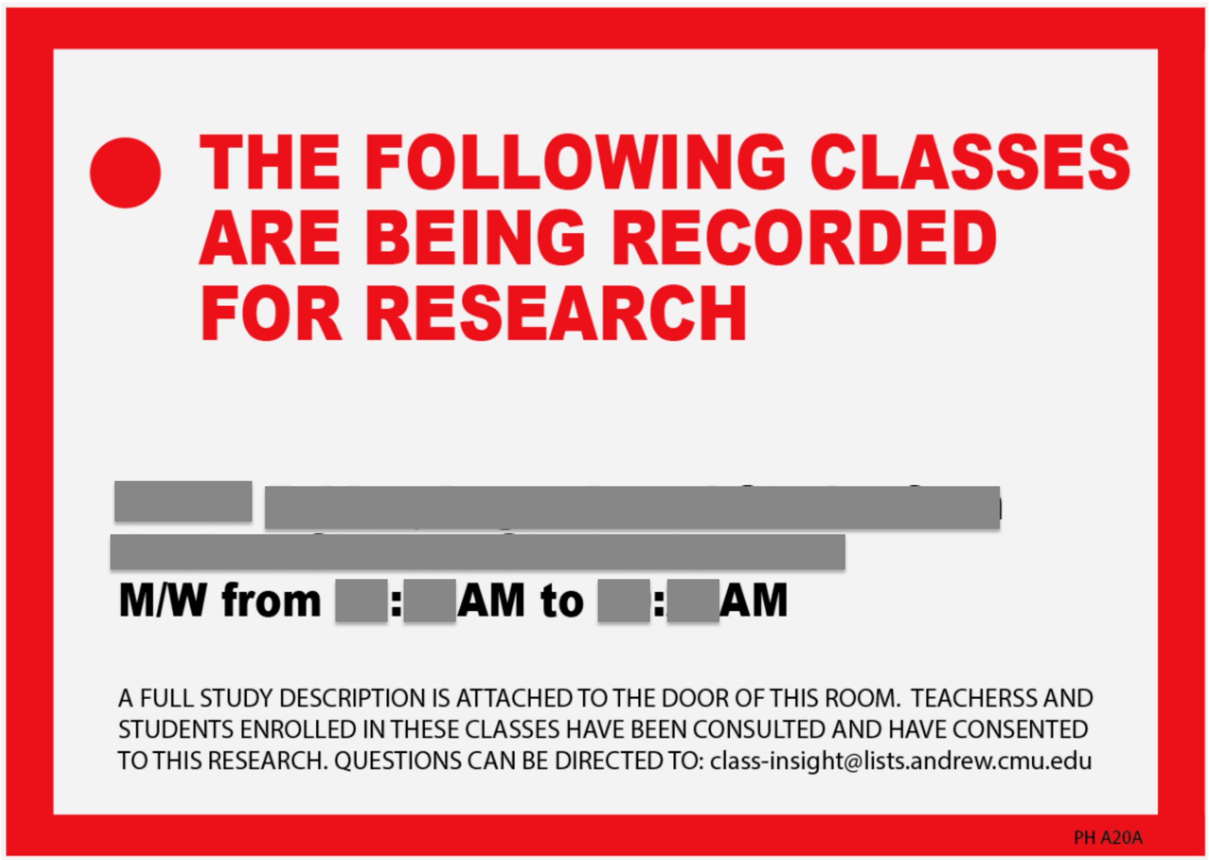


Figure D-1: The signs my team and I put outside and in each class to inform that data collection is going on.

Appendix E

Chapter 11 Study Materials and Recruitment

E.1 Email template for recruiting participants

Dear Professor XYZ,

My name is Franceska, and I am a final year Ph.D. student in the Human-Computer Interaction Institute here at CMU, working with Dr. Amy Ogan.

I am reaching out to ask if you would be interested in the following research opportunity. My team (cced) and I focus on researching ways to support and improve teaching at the university level. We are creating a dashboard that will share with teachers teacher and student behavior data from the classroom. We have created several prototypes of this dashboard and are very interested in having a brief discussion with you to get your feedback on our prototypes and your suggestions on how to improve the design of the dashboard.

The interview will last **1 hour**. It will happen over **Zoom**, and it will be audio and video recorded. We are happy to schedule it whenever it is most convenient for you in the upcoming weeks. We will compensate you with a $30 Amazon Gift card for your time.

Please let me know if you would be interested, and if so, I can send you a link to schedule a time slot and the consent form for the study.

Thank you very much in advance for your time, and I am looking forward to your reply!

Sincerely,
Franceska Xhakaj

E.2 Semi-structured interview protocol for co-design study

Protocol

INTRO [7']

Hello there Professor XYZ! How are you doing today?

Thank you very much again for your time and for taking part in our study. Just to double check, are you okay with us audio/video recording this interview? Before we start, please make sure you are in a space without interruptions as we are not allowed to record other parties that may pop-in during the interview.

//if they only want to be audio recorded, tell them to turn off the camera
//Note: if you hear/see a third party on video/audio, stop the recording

[START RECORDING]

I just started the recording.

Thank you again for your time! Your information and this recording will be kept anonymous and confidential. Your participation is completely voluntary, and if you feel uncomfortable at any point during the interview you'd like to stop, we can do that. The interview is 1h and, at certain points I might interrupt or move us on so we can get through all the parts of the interview.

Before we begin, I would like to ask some very quick questions:

- What is your role at CMU and what courses do you teach?
- How many years have you been teaching in general?

I will share with you my screen now, please let me know if you cannot see it *[shares screen]*

As I mentioned in the email, we are creating a dashboard that will share with teachers teacher and student behaviors from the classroom. We are focusing on a construct called:

> ***Teacher immediacy*** *is conceptualized as those nonverbal behaviors that reduce physical and/or psychological distance between teachers and students and increase their interpersonal closeness, with the ultimate goal of enhancing student learning*
>
> ***Nonverbal behaviors*** *are behaviors that do not involve verbal communication: location and movement in the classroom, eye gaze, smiles, nods, relaxed body posture, forward leans, gestures, etc.*
>
> *Prior literature has shown that those behaviors are important both to student learning as well as to students' attitudes about learning such as their motivation or interest in the course or subject.*

I will now share with you some prototypes of a dashboard that shares with teachers nonverbal behavior data. These prototypes are "sketches" not final versions of the dashboard. My team and I created them based on prior studies we have run with instructors and what we learned is important to them. **Our aim for the interview** today is to get your feedback and opinion on these prototypes and find out what would be important to you if you were to use such a dashboard. Thus, feel free to critique the designs, what you would find useful or not useful, this is not the final dashboard and we are looking to get your ideas for new designs.

To make this process easier for you, I will ask some questions along the way. In addition, we have here **XYZ**, one of my awesome RAs who will have the role of your personal "sketch artist". XYZ will translate your ideas and words into designs on the dashboard.

→ *if no RA*: In addition, I will play the role of a "sketch artist". I will translate your ideas and words into designs on the dashboard.

Proto 1 [15']

Now, imagine this is data from one of your colleagues' classrooms. I will give you a minute to look over it…. Now assume you are trying to give feedback and advice to your colleague based on this data.

- **Integrating student and teacher data:**
  - What do you notice in what is shown here/this design/sketch/prototype?
    - What relationships between T + S data can you identify?
    - What relationship do you see between this teachers' nonverbal behaviors and their student engagement?
    - Where are the students most engaged? Why/What is causing that (teacher behavior or classroom activity)
- **Engagement:**
  - In terms of engagement, which of the ones listed here would you select if you were to use this dashboard?
  - What are we missing?
  - *[added halfway through the interviews]* Engagement, paying attention, learning:
    - What is the relationship between engagement and paying attention? Are they the same thing, are they related to each other, are they different?
    - What about those constructs and learning/understanding?
    - Nonverbals and other data to student learning. Are they important to learning/do they have an effect on learning? And if so how big?
- **Goal-setting and behavior change:**
  - After seeing this data, what would be your advice for your colleague instructor?
  - Would you and if so what would you suggest they change in their practice of behaviors?
    - What should they change, why and how?
- What do you find helpful/useful in what we showed you here? What do you see yourself using?
- What don't you find helpful and want to remove or change?
- What don't you see here that you would want to have?

Proto2

Proto 2a [8'] (2 mins to look at the interface)'

I will share with you another design. Imagine this is data from one of your colleagues' classrooms. I will give you a minute to look over it.…. Now assume you are trying to give feedback and advice to your colleague based on this data.

- **Assessment of data**
  - How would you assess your colleagues' performance based on what is shown here?
    - What do you think of the performance Today compared to the goal your colleague set last week?
    - What about the performance compared to other instructors?
- **Goal-setting and behavior change:**
  - After seeing this data, what would be your advice for your colleague instructor?
  - Would you and if so what would you suggest they change in their practice of behaviors?
    - What goals should they set and why?
  - What do you find helpful/useful in this design? What do you see yourself using?
  - What don't you find helpful and want to remove or change?
  - What don't you see here that you would want to have?

Proto 2b [8']

I will show you a similar chart but now with your students' data. I will give you a minute to look over it.….

- **Assessment of data**
  - How would you assess your colleagues' performance based on this data?
    - What do you think of the performance Today compared to the goal your colleague set last week?
    - What about the performance compared to other instructors?
- **Goal-setting and behavior change:**

- After seeing this data, what would be your advice for your colleague instructor?
- Would you and if so what would you suggest they change in their practice of behaviors?
  - What goals should they set and why?

- What do you find helpful/useful in this design? What do you see yourself using?
- What don't you find helpful and want to remove or change from what is shown here?
- What don't you see here that you would want to have?

Proto 2a+2b [6']

I will now show you both designs together in the same chart.

1. Does this change your answers? Seeing them together, how would you assess your colleagues' performance based on this data now all this data combined? Compared to your previous assessment does it change, the same?
2. Seeing them together, would you change your suggestions and advice on the goals your colleague needs to set and what they need to change in their practice?
3. Something in this interface that is helpful or not helpful?

Proto 3 [7']

- **Integrating student and teacher data:**
  - What do you notice from what it is shown here ~~in the interface or the data~~?
    - What relationships between T + S data can you identify?

- **Goal-setting and behavior change:**
  - After seeing this data, what would be your advice for your colleague instructor?
  - Would you and if so what would you suggest they change in their practice of behaviors?
    - What should they change, why and how?

  - What do you find helpful/useful in this design? What do you see yourself using?
  - What don't you find helpful and want to remove or change?
  - What don't you see here that you would want to have?

FINAL: Which is most helpful and least helpful out of the 3 designs I showed you today? Which one would you see yourself using in the classroom?

Wrap up [5']

This is the end of the interview. I will stop the recording now!

Thank you again for your participation and for sharing with us your thoughts and feedback. Your expertise and experience is invaluable to our project so thank you again!

The project pays $30 for your participation. I know it is not much, but it is a small thank you for your time.

(if they push back on the money say we can donate it)

Is there an email address that you would prefer for us to share with you the Amazon Gift card?

Bibliography

[1] Carnegie learning. https://www.carnegielearning.com/.

[2] How to do a thematic analysis. https://medium.com/usabilitygeek/thematic-analysis-in-hci-57edae583ca9.

[3] How to do a thematic analysis of user interviews. https://www.interaction-design.org/literature/article/how-to-do-a-thematic-analysis-of-user-interviews.

[4] Intraclass correlations. https://www.itl.nist.gov/div898/software/dataplot/refman2/auxillar/icc.htm.

[5] Standardized variables: Definition, examples. https://www.statisticshowto.com/standardized-variables/.

[6] Thematic analysis: How to do thematic analysis. https://www.scribbr.com/methodology/thematic-analysis/.

[7] Thematic analysis: Inductive or deductive? two different approaches. https://saylordotorg.github.io/text_principles-of-sociological-inquiry-qualitative-and-quantitative-methods/s05-03-inductive-or-deductive-two-dif.html.

[8] Thematic analysis: What is thematic analysis? https://sites.google.com/site/howtousethematicanalysis/home/what-is-thematic-analysis.

[9] Troy D Abel and Michael Evans. Cross-disciplinary participatory & contextual design research: Creating a teacher dashboard application. *IxD&A*, 19:63–76, 2013.

[10] A Louis Abrahamson et al. An overview of teaching and learning research with classroom communication systems. paper presented at. In *the Samos International Conference on the Teaching of Mathematics, Village of Pythagorion, Samos*. Citeseer, 1998.

[11] Karan Ahuja, Dohyun Kim, Franceska Xhakaj, Virag Varga, Anne Xie, Stanley Zhang, Jay Eric Townsend, Chris Harrison, Amy Ogan, and Yuvraj Agarwal. Edusense: Practical classroom sensing at scale. *Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies*, 3(3):1–26, 2019.

[12] Hamed S Alavi and Pierre Dillenbourg. An ambient awareness tool for supporting supervised collaborative problem solving. *IEEE Transactions on Learning Technologies*, 5(3):264–274, 2012.

[13] Vincent Aleven, Franceska Xhakaj, Kenneth Holstein, and Bruce M McLaren. Developing a teacher dashboard for use with intelligent tutoring systems. *technology*, 34:44, 2010.

[14] Alex Alexandrou and John Dwyfor Davies. Continuing professional development in the police service: the reality of the rhetoric and the way forward. *Research in Post-Compulsory Education*, 5(1):39–50, 2000.

[15] Liaqat Ali, Marek Hatala, Dragan Gašević, and Jelena Jovanović. A qualitative evaluation of evolution of a learning analytics tool. *Computers & Education*, 58(1):470–489, 2012.

[16] Dwight William Allen, James Michael Cooper, and Lorraine Poliakoff. *Microteaching*. Number 17. US Department of Health, Education, and Welfare, Office of Education . . . , 1972.

[17] Rose M Allinder. The relationship between efficacy and the instructional practices of special education teachers and consultants. *Teacher education and special education*, 17(2):86–95, 1994.

[18] Erik van Alphen and Saskia Bakker. Lernanto: using an ambient display during differentiated instruction. In *Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems*, pages 2334–2340, 2016.

[19] Susan A Ambrose, Michael W Bridges, Michele DiPietro, Marsha C Lovett, and Marie K Norman. *How learning works: Seven research-based principles for smart teaching*. John Wiley & Sons, 2010.

[20] Pengcheng An, Saskia Bakker, Sara Ordanovski, Ruurd Taconis, Chris LE Paffen, and Berry Eggen. Unobtrusively enhancing reflection-in-action of teachers through spatially distributed ambient information. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*, pages 1–14, 2019.

[21] Pengcheng An, Kenneth Holstein, Bernice d'Anjou, Berry Eggen, and Saskia Bakker. The ta framework: Designing real-time teaching augmentation for k-12 classrooms. *arXiv preprint arXiv:2001.02985*, 2020.

[22] Janis Andersen and Peter Andersen. Teacher immediacy. *The International Encyclopedia of Communication*, 2008.

[23] Janis F Andersen. Teacher immediacy as a predictor of teaching effectiveness. *Annals of the International Communication Association*, 3(1):543–559, 1979.

[24] Janis F Andersen and Peter A Andersen. Never smile until christmas? casting doubt on an old myth. *Journal of Thought*, pages 57–61, 1987.

[25] Janis F Andersen, Peter A Andersen, and Arthur D Jensen. The measurement of nonverbal immediacy. *Journal of applied communication research*, 7(2):153–180, 1979.

[26] John R Anderson, Albert T Corbett, Kenneth R Koedinger, and Ray Pelletier. Cognitive tutors: Lessons learned. *The journal of the learning sciences*, 4(2):167–207, 1995.

[27] Ivon Arroyo, David G Cooper, Winslow Burleson, Beverly Park Woolf, Kasia Muldner, and Robert Christopherson. Emotion sensors go to school. In *AIED*, volume 200, pages 17–24. Citeseer, 2009.

[28] John W Atkinson. Motivational determinants of risk-taking behavior. *Psychological review*, 64(6p1):359, 1957.

[29] John William Atkinson. An introduction to motivation. 1964.

[30] Beatrice Avalos. Teacher professional development in teaching and teacher education over ten years. *Teaching and teacher education*, 27(1):10–20, 2011.

[31] Roger Azevedo and Robert M Bernard. A meta-analysis of the effects of feedback in computer-based instruction. *Journal of Educational Computing Research*, 13(2):111–127, 1995.

[32] Ryan Baker, Jason Walonoski, Neil Heffernan, Ido Roll, Albert Corbett, and Kenneth Koedinger. Why students engage in "gaming the system" behavior in interactive learning environments. *Journal of Interactive Learning Research*, 19(2):185–224, 2008.

[33] Aneesha Bakharia, Linda Corrin, Paula De Barba, Gregor Kennedy, Dragan Gašević, Raoul Mulder, David Williams, Shane Dawson, and Lori Lockyer. A conceptual framework linking learning design with learning analytics. In *Proceedings of the Sixth International Conference on Learning Analytics & Knowledge*, pages 329–338, 2016.

[34] Albert Bandura. Self-efficacy: toward a unifying theory of behavioral change. *Psychological review*, 84(2):191, 1977.

[35] Albert Bandura. Self-efficacy mechanism in human agency. *American psychologist*, 37(2):122, 1982.

[36] Albert Bandura. Social foundations of thought and action. *Englewood Cliffs, NJ*, 1986, 1986.

[37] Albert Bandura. Self-regulation of motivation and action through goal systems. In *Cognitive perspectives on emotion and motivation*, pages 37–61. Springer, 1988.

[38] Albert Bandura. Perceived self-efficacy in cognitive development and functioning. *Educational psychologist*, 28(2):117–148, 1993.

[39] Albert Bandura. The anatomy of stages of change. *American journal of health promotion: AJHP*, 12(1):8–10, 1997.

[40] Albert Bandura. Guide for constructing self-efficacy scales. *Self-efficacy beliefs of adolescents*, 5(1):307–337, 2006.

[41] Albert Bandura and Daniel Cervone. Self-evaluative and self-efficacy mechanisms governing the motivational effects of goal systems. *Journal of personality and social psychology*, 45(5):1017, 1983.

[42] Albert Bandura et al. Social cognitive theory of self-regulation. *Organizational behavior and human decision processes*, 50(2):248–287, 1991.

[43] Robert L Bangert-Drowns, Chen-Lin C Kulik, James A Kulik, and MaryTeresa Morgan. The instructional effect of feedback in test-like events. *Review of educational research*, 61(2):213–238, 1991.

[44] Joseph E Beck and Yue Gong. Wheel-spinning: Students who fail to master a skill. In *International conference on artificial intelligence in education*, pages 431–440. Springer, 2013.

[45] Brooke L Bennett, Carly M Goldstein, Emily C Gathright, Joel W Hughes, and Janet D Latner. Internal health locus of control predicts willingness to track health behaviors

online and with smartphone applications. *Psychology, health & medicine*, 22(10):1224–1229, 2017.

[46] Robert Bodily, Judy Kay, Vincent Aleven, Ioana Jivet, Dan Davis, Franceska Xhakaj, and Katrien Verbert. Open learner models and learning analytics dashboards: a systematic review. In *Proceedings of the 8th international conference on learning analytics and knowledge*, pages 41–50, 2018.

[47] Walter R Borg et al. The minicourse. a microteaching approach to teacher education. 1970.

[48] David Boud. Experience as the base for learning. *Higher education research and development*, 12(1):33–44, 1993.

[49] David Boud, Rosemary Keogh, and David Walker. Promoting reflection in learning: A model. *Boundaries of adult learning*, 1:32–56, 1996.

[50] George Breed. Nonverbal behavior and teaching effectiveness. final report. 1971.

[51] Kathleen T Brinko and Robert J Menges. *The interactions of teaching improvement*, chapter 1. ERIC, 1997.

[52] CA Brown, CR Belfield, and SJ Field. Cost effectiveness of continuing professional development in health care: a critical review of the evidence. *Bmj*, 324(7338):652–655, 2002.

[53] Sara E Brownell and Kimberly D Tanner. Barriers to faculty pedagogical change: Lack of training, time, incentives, and... tensions with professional identity? *CBE—Life Sciences Education*, 11(4):339–346, 2012.

[54] Susan Bull and Judy Kay. Open learner models. In *Advances in intelligent tutoring systems*, pages 301–322. Springer, 2010.

[55] Brigid M Burke. Experiential professional development: A model for meaningful and long-lasting change in classrooms. *Journal of Experiential Education*, 36(3):247–263, 2013.

[56] Bill Buxton. *Sketching user experiences: getting the design right and the right design*. Morgan kaufmann, 2010.

[57] Eberly Center. *Eberly Center for Teaching Excellence Educational Innovation*, 2020 (accessed June 14, 2020).

[58] Ronald M Cervero. Continuing professional education in transition, 1981? 2000. *International Journal of Lifelong Education*, 20(1-2):16–30, 2001.

[59] Lisa Jane Chaffey, Evelyne Johanna Janet de Leeuw, Gerard Anthony Finnigan, et al. Facilitating students' reflective practice in a medical course: literature review. *Education for Health*, 25(3):198, 2012.

[60] Giorgio Cherubini, Franco Zambelli, and Pietro Boscolo. Student motivation: an experience of inservice education as a context for professional development of teachers. *Teaching and Teacher Education*, 18(3):273–288, 2002.

[61] Nancy Van Note Chism, Matthew Holley, and Cameron J Harris. 9: Researching the impact of educational development: Basis for informed practice. *To improve the academy*, 31(1):129–145, 2012.

[62] Eun Kyoung Choe, Nicole B Lee, Bongshin Lee, Wanda Pratt, and Julie A Kientz. Understanding quantified-selfers' practices in collecting and exploring personal data. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 1143–1152, 2014.

[63] Diane M Christophel. The relationships among teacher immediacy behaviors, student motivation, and learning. *Communication education*, 39(4):323–340, 1990.

[64] Diane M Christophel and Joan Gorham. A test-retest analysis of student motivation, teacher immediacy, and perceived sources of motivation and demotivation in college classes. *Communication education*, 44(4):292–306, 1995.

[65] Mary P Clynes and Sara EC Raftery. Feedback: an essential element of student learning in clinical practice. *Nurse Education in practice*, 8(6):405–411, 2008.

[66] AT Corbett and John R Anderson. Feedback timing and student control in the lisp intelligent tutoring system. In *Proceedings of the Fourth International Conference on AI and Education*, pages 64–72, 1989.

[67] National Research Council et al. *Promising practices in undergraduate science, technology, engineering, and mathematics education: Summary of two workshops*. National Academies Press, 2011.

[68] Milton D Cox. Introduction to faculty learning communities. *New directions for teaching and learning*, 2004(97):5–23, 2004.

[69] Lee J Cronbach. Coefficient alpha and the internal structure of tests. *psychometrika*, 16(3):297–334, 1951.

[70] Andrew Cross, Edward Cutrell, and William Thies. Low-cost audience polling using computer vision. In *Proceedings of the 25th annual ACM symposium on User interface software and technology*, pages 45–54, 2012.

[71] Christopher J. Cushion, Kathy M. Armour, and Robyn L. Jones. Coach education and continuing professional development: Experience and learning to coach. *Quest*, 55(3):215–230, 2003.

[72] Gloria Dall'Alba and Jörgen Sandberg. Unveiling professional development: A critical review of stage models. *Review of educational research*, 76(3):383–412, 2006.

[73] Bernice d'Anjou, Saskia Bakker, Pengcheng An, and Tilde Bekker. How peripheral data visualisation systems support secondary school teachers during vle-supported lessons. In *Proceedings of the 2019 on Designing Interactive Systems Conference*, pages 859–870, 2019.

[74] Marilyn Wood Daudelin. Learning from experience through reflection. *Organizational dynamics*, 24(3):36–48, 1996.

[75] Scott Davidoff, Min Kyung Lee, Anind K Dey, and John Zimmerman. Rapidly exploring application design through speed dating. In *International Conference on Ubiquitous Computing*, pages 429–446. Springer, 2007.

[76] J Dewey. How we think. a restatement of the relation of reflective thinking to the educative process, boston etc.(dc heath and company) 1933. 1933.

[77] Pierre Dillenbourg and Patrick Jermann. Technology for classroom orchestration. In *New science of learning*, pages 525–552. Springer, 2010.

[78] Pierre Dillenbourg, Miguel Nussbaum, Yannis Dimitriadis, and Jeremy Roschelle. Design for classroom orchestration. *Computers & Education*, 69(0):485–492, 2013.

[79] Sidney K D'Mello, Andrew M Olney, Nathan Blanchard, Borhan Samei, Xiaoyi Sun, Brooke Ward, and Sean Kelly. Multimodal capture of teacher-student interactions for automated dialogic analysis in live classrooms. In *Proceedings of the 2015 ACM on international conference on multimodal interaction*, pages 557–566, 2015.

[80] Stephen W Draper, Julie Cargill, and Quintin Cutts. Electronically enhanced classroom interaction. *Australasian Journal of Educational Technology*, 18(1), 2002.

[81] Jacquelynne Eccles. Expectancies, values and academic behaviors. *Achievement and achievement motives*, 1983.

[82] Daniel A Epstein, An Ping, James Fogarty, and Sean A Munson. A lived informatics model of personal informatics. In *Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing*, pages 731–742, 2015.

[83] Michael L Epstein, Amber D Lazarus, Tammy B Calvano, Kelly A Matthews, Rachel A Hendel, Beth B Epstein, and Gary M Brosvic. Immediate feedback assessment technique promotes learning and corrects inaccurate first responses. *The Psychological Record*, 52(2):187–201, 2002.

[84] Bradley A Ermeling. Tracing the effects of teacher inquiry on classroom practice. *Teaching and teacher education*, 26(3):377–388, 2010.

[85] Thomas SC Farrell. *Reflective practice in action: 80 reflection breaks for busy teachers.* Corwin Press, 2003.

[86] Thomas SC Farrell. Reflecting on esl teacher expertise: A case study. *System*, 41(4):1070–1082, 2013.

[87] Donald B Fedor. Recipient responses to performance feedback: A proposed model and its implications. *Research in personnel and human resources management*, 9(73):120, 1991.

[88] Claude Fernet, Caroline Senécal, Frédéric Guay, Herbert Marsh, and Martin Dowson. The work tasks motivation scale for teachers (wtmst). *Journal of Career assessment*, 16(2):256–279, 2008.

[89] Carmen Fies and Jill Marshall. Classroom response systems: A review of the literature. *Journal of Science Education and Technology*, 15(1):101–109, 2006.

[90] Stacey R Finkelstein and Ayelet Fishbach. Tell me what i did wrong: Experts seek and respond to negative feedback. *Journal of Consumer Research*, 39(1):22–38, 2012.

[91] Barry J Fishman, Ronald W Marx, Stephen Best, and Revital T Tal. Linking teacher and student learning to improve professional development in systemic reform. *Teaching and teacher education*, 19(6):643–658, 2003.

[92] Center for Evidence-Based Practices at Case Western Reserve University. Readiness ruler, 2010.

[93] Edith M Freeman. The importance of feedback in clinical supervision: Implications for direct practice. *The Clinical Supervisor*, 3(1):5–26, 1985.

[94] Nancy Frey and Douglas Fisher. Using common formative assessments as a source of professional development in an urban american elementary school. *Teaching and Teacher Education*, 25(5):674–680, 2009.

[95] Olivier Friard and Marco Gamba. Boris: a free, versatile open-source event-logging software for video/audio coding and live observations. *Methods in Ecology and Evolution*, 7(11):1325–1330, 2016.

[96] Jon Froehlich, Tawanna Dillahunt, Predrag Klasnja, Jennifer Mankoff, Sunny Consolvo, Beverly Harrison, and James A Landay. Ubigreen: investigating a mobile tool for tracking and supporting green transportation habits. In *Proceedings of the sigchi conference on human factors in computing systems*, pages 1043–1052, 2009.

[97] Tom Ganser. An ambitious vision of professional development for teachers. *NASSP bulletin*, 84(618):6–12, 2000.

[98] David Gerritsen. *A socio-technical approach to feedback and instructional development for teaching assistants*. PhD thesis, 2018.

[99] David Gerritsen, John Zimmerman, and Amy Ogan. Towards a framework for smart classrooms that teach instructors to teach. International Society of the Learning Sciences, Inc.[ISLS]., 2018.

[100] Sherri Gibson and Myron H Dembo. Teacher efficacy: A construct validation. *Journal of educational psychology*, 76(4):569, 1984.

[101] Allan Glatthorn. Teacher development. *International encyclopedia of teaching and teacher education*, 2:412–422, 1995.

[102] Joan Gorham. The relationship between verbal teacher immediacy behaviors and student learning. *Communication education*, 37(1):40–53, 1988.

[103] Cara Gormally, Mara Evans, and Peggy Brickman. Feedback about teaching in higher ed: Neglected opportunities to promote change. *CBE—Life Sciences Education*, 13(2):187–199, 2014.

[104] Ruth Grant. Obsolescence or lifelong education: Choices and challenges. *Physiotherapy*, 78(3):167–171, 1992.

[105] Sue Grossman and Judy Williston. Teaching strategies: Strategies for helping early childhood students learn appropriate teaching practices. *Childhood Education*, 79(2):103–107, 2002.

[106] Kath Grushka, Julie Hinde McLeod, and Ruth Reynolds. Reflecting upon reflection: Theory and practice in one australian university teacher education program. *Reflective Practice*, 6(2):239–246, 2005.

[107] Thomas R Guskey. The influence of change in instructional effectiveness upon the affective characteristics of teachers. *American Educational Research Journal*, 21(2):245–259, 1984.

[108] Thomas R Guskey. Teacher efficacy, self-concept, and attitudes toward the implementation of instructional innovation. *Teaching and teacher education*, 4(1):63–69, 1988.

[109] Penelope J Haines. Professionalization through cpd: is it realistic for achieving our goals? *British Journal of Therapy and Rehabilitation*, 4(8):428–447, 1997.

[110] Benjamin Hall, W Burley, M Villeme, and L Brockmeier. An attempt to explicate teacher efficacy beliefs among first year teachers. In *annual meeting of the American Educational Research Association, San Francisco*, 1992.

[111] Laura Hamilton, Richard Halverson, Sharnell S Jackson, Ellen Mandinach, Jonathan A Supovitz, Jeffrey C Wayman, Cassandra Pickens, Emma Sama Martin, and Jennifer L Steele. Using student achievement data to support instructional decision making. 2009.

[112] Patricia L Hardré. Instructional design as a professional development tool-of-choice for graduate teaching assistants. *Innovative Higher Education*, 30(3):163–175, 2005.

[113] Patricia L Hardré and Alicia O Burris. What contributes to teaching assistant development: differential responses to key design features. *Instructional Science*, 40(1):93–118, 2012.

[114] Mariam Hassib, Stefan Schneegass, Philipp Eiglsperger, Niels Henze, Albrecht Schmidt, and Florian Alt. Engagemeter: A system for implicit audience engagement sensing using electroencephalography. In *Proceedings of the 2017 Chi conference on human factors in computing systems*, pages 5114–5119, 2017.

[115] JT Hattie Helen, J Hattie, and H Timperley. The power of feedback.[references]. *Rev Educ Res*, 77(1):16–17, 2007.

[116] Stephen R Hawk. Locus of control and computer attitude: The effect of user involvement. *Computers in Human Behavior*, 5(3):199–206, 1989.

[117] Neil T Heffernan and Cristina Lindquist Heffernan. The assistments ecosystem: Building a platform that brings scientists and teachers together for minimally invasive research on human learning and teaching. *International Journal of Artificial Intelligence in Education*, 24(4):470–497, 2014.

[118] Charles Henderson, Andrea Beach, and Noah Finkelstein. Facilitating change in undergraduate stem instructional practices: An analytic review of the literature. *Journal of research in science teaching*, 48(8):952–984, 2011.

[119] Marjorie Walsh Hesler. An investigation of instructor use of space. 1972.

[120] Heather C Hill. Fixing teacher professional development. *Phi Delta Kappan*, 90(7):470–476, 2009.

[121] Tad Hirsch, Christina Soma, Kritzia Merced, Patty Kuo, Aaron Dembe, Derek D Caperton, David C Atkins, and Zac E Imel. " it's hard to argue with a computer" investigating psychotherapists' attitudes towards automated evaluation. In *Proceedings of the 2018 Designing Interactive Systems Conference*, pages 559–571, 2018.

[122] Kenneth Holstein, Gena Hong, Mera Tegene, Bruce M McLaren, and Vincent Aleven. The classroom as a dashboard: co-designing wearable cognitive augmentation for k-12 teachers. In *Proceedings of the 8th international conference on learning Analytics and knowledge*, pages 79–88, 2018.

[123] Kenneth Holstein, Bruce M McLaren, and Vincent Aleven. Student learning benefits

of a mixed-reality teacher awareness tool in ai-enhanced classrooms. In *International conference on artificial intelligence in education*, pages 154–168. Springer, 2018.

[124] Kenneth Holstein, Bruce M McLaren, and Vincent Aleven. Designing for complementarity: Teacher and student needs for orchestration support in ai-enhanced classrooms. In *International Conference on Artificial Intelligence in Education*, pages 157–171. Springer, 2019.

[125] Kenneth Holstein, Franceska Xhakaj, Vincent Aleven, and Bruce McLaren. Luna: a dashboard for teachers using intelligent tutoring systems. *Education*, 60(1):159–171, 2010.

[126] Karen Holtzblatt and Hugh Beyer. *Contextual design: defining customer-centered systems*. Elsevier, 1997.

[127] Ralph W Hooreman, Piet AM Kommers, and Wim MG Jochems. Effects of synchronous coaching in teacher training. *International Journal of Continuing Engineering Education and Life Long Learning*, 18(3):338–350, 2008.

[128] Jung-Wen Hsia, Chia-Chi Chang, and Ai-Hua Tseng. Effects of individuals' locus of control and computer self-efficacy on their e-learning acceptance in high-tech companies. *Behaviour & Information Technology*, 33(1):51–64, 2014.

[129] Susan B Hudson, Kelly C McMahon, and Christina M Overstreet. The 2000 national survey of science and mathematics education: Compendium of tables. *Chapel Hill, NC: Horizon Research*, 2002.

[130] Daniel R Ilgen, Cynthia D Fisher, and M Susan Taylor. Consequences of individual feedback on behavior in organizations. *Journal of applied psychology*, 64(4):349, 1979.

[131] The Monarch System™ Inc. A precontemplation stage tool: Readiness rulers, 2012.

[132] W James Jacob, Weiyan Xiong, and Huiyuan Ye. Professional development programmes at world-class universities. *Palgrave Communications*, 1(1):1–27, 2015.

[133] Aaron R Jensen, Andrew S Wright, Sara Kim, Karen D Horvath, and Kristine E Calhoun. Educational feedback in the operating room: a gap between resident and faculty perceptions. *The American journal of surgery*, 204(2):248–255, 2012.

[134] Young Ju Joo, Kyu Yon Lim, and Jiyeon Kim. Locus of control, self-efficacy, and task value as predictors of learning outcome in an online university context. *Computers & Education*, 62:149–158, 2013.

[135] Jelena Jovanović, Dragan Gašević, Christopher Brooks, Vladan Devedžić, and Marek Hatala. Loco-analyst: A tool for raising teachers' awareness in online learning environments. In *European Conference on Technology Enhanced Learning*, pages 112–126. Springer, 2007.

[136] S Kamin, Boris Capitanu, Michael Twidale, and Chad Peiper. A teacher's dashboard for a high school algebra class. *The impact of tablet PCs and pen-based technology on education: Evidence and outcomes*, pages 63–71, 2009.

[137] Larry Keig. Formative peer review of teaching: Attitudes of faculty at liberal arts colleges toward colleague assessment. *Journal of Personnel Evaluation in Education*, 14(1):67–87, 2000.

[138] Kim Kelly, Neil Heffernan, Cristina Heffernan, Susan Goldman, James Pellegrino, and Deena Soffer Goldstein. Estimating the effect of web-based homework. pages 824–827, 2013.

[139] Ahmed Kharrufa, Sally Rix, Timur Osadchiy, Anne Preston, and Patrick Olivier. Group spinner: recognizing and visualizing learning in the classroom for reflection, communication, and planning. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*, pages 5556–5567, 2017.

[140] Joellen P Killion and Guy R Todnem. A process for personal theory building. *Educational leadership*, 48(6):14–16, 1991.

[141] Avraham N Kluger and Angelo DeNisi. The effects of feedback interventions on performance: A historical review, a meta-analysis, and a preliminary feedback intervention theory. *Psychological bulletin*, 119(2):254, 1996.

[142] Raymond W Kulhavy and Walter Wager. Feedback in programmed instruction: Historical context and implications for practice. *Interactive instruction and feedback*, 320, 1993.

[143] Chen-Lin C Kulik, James A Kulik, and Robert L Bangert-Drowns. Effectiveness of mastery learning programs: A meta-analysis. *Review of educational research*, 60(2):265–299, 1990.

[144] James A Kulik and JD Fletcher. *Review of educational research*, 86(1):42–78, 2016.

[145] James A Kulik and Chen-Lin C Kulik. Timing of feedback and verbal learning. *Review of educational research*, 58(1):79–97, 1988.

[146] Mark R Lepper and Ruth W Chabay. Intrinsic motivation and instruction: Conflicting views on the role of motivational processes in computer-based education. *Educational Psychologist*, 20(4):217–230, 1985.

[147] Thomas H Levine and Alan S Marcus. How the structure and focus of teachers' collaborative activities facilitate and constrain teacher learning. *Teaching and teacher education*, 26(3):389–398, 2010.

[148] Ian Li, Anind Dey, and Jodi Forlizzi. A stage-based model of personal informatics systems. In *Proceedings of the SIGCHI conference on human factors in computing systems*, pages 557–566, 2010.

[149] James J Lin, Lena Mamykina, Silvia Lindtner, Gregory Delajoux, and Henry B Strub. Fish'n'steps: Encouraging physical activity with an interactive computer game. In *International conference on ubiquitous computing*, pages 261–278. Springer, 2006.

[150] Chunfeng Liu, Rafael A Calvo, and Renee Lim. Improving medical students' awareness of their non-verbal communication through automated non-verbal behavior feedback. *Frontiers in ICT*, 3:11, 2016.

[151] Edwin A Locke and Gary P Latham. *A theory of goal setting & task performance.* Prentice-Hall, Inc, 1990.

[152] Edwin A Locke and Gary P Latham. Building a practically useful theory of goal setting and task motivation: A 35-year odyssey. *American psychologist*, 57(9):705, 2002.

[153] L Loeher. An examination of research university faculty evaluation policies and practice. *Portland, OR: Professional and Organizational Development*, 2006.

[154] Yanjin Long and Vincent Aleven. Mastery-oriented shared student/system control over problem selection in a linear equation tutor. In *International conference on intelligent tutoring systems*, pages 90–100. Springer, 2016.

[155] Marsha Lovett, Oded Meyer, and Candace Thille. The open learning initiative: Measuring the effectiveness of the oli statistics course in accelerating student learning. *Journal of Interactive Media in Education*, 2008.

[156] Maureen W Lovett, Léa Lacerenza, Maria De Palma, Nancy J Benson, Karen A Steinbach, and Jan C Frijters. Preparing teachers to remediate reading disabilities in high school: What is needed for effective professional development? *Teaching and Teacher Education*, 24(4):1083–1097, 2008.

[157] Wenting Ma, Olusola O Adesope, John C Nesbit, and Qing Liu. Intelligent tutoring systems and learning outcomes: A meta-analysis. *Journal of educational psychology*, 106(4):901, 2014.

[158] Roberto Martinez Maldonado, Judy Kay, Kalina Yacef, and Beat Schwendimann. An interactive teacher's dashboard for monitoring groups in a multi-tabletop learning environment. In *International Conference on Intelligent Tutoring Systems*, pages 482–492. Springer, 2012.

[159] Roberto Martinez-Maldonado, Andrew Clayphan, Kalina Yacef, and Judy Kay. Mtfeedback: providing notifications to enhance teacher awareness of small group work in the classroom. *IEEE Transactions on Learning Technologies*, 8(2):187–200, 2014.

[160] Roberto Martinez-Maldonado, Vanessa Echeverria, Gloria Fernandez Nieto, and Simon Buckingham Shum. From data to insights: a layered storytelling approach for multimodal learning analytics. In *Proceedings of the 2020 chi conference on human factors in computing systems*, pages 1–15, 2020.

[161] Roberto Martinez-Maldonado, Vanessa Echeverria, Jurgen Schulte, Antonette Shibani, Katerina Mangaroska, and Simon Buckingham Shum. Moodoo: indoor positioning analytics for characterising classroom teaching. In *International Conference on Artificial Intelligence in Education*, pages 360–373. Springer, 2020.

[162] Roberto Martinez-Maldonado, Katerina Mangaroska, Jurgen Schulte, Doug Elliott, Carmen Axisa, and Simon Buckingham Shum. Teacher tracking with integrity: What indoor positioning can reveal about instructional proxemics. *Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies*, 4(1):1–27, 2020.

[163] Roberto Martinez-Maldonado, Abelardo Pardo, Negin Mirriahi, Kalina Yacef, Judy Kay, and Andrew Clayphan. The latux workflow: designing and deploying awareness tools in technology-enabled learning settings. In *Proceedings of the Fifth International Conference on Learning Analytics and Knowledge*, pages 1–10, 2015.

[164] Roberto Martinez-Maldonado, Jurgen Schulte, Vanessa Echeverria, Yuveena Gopalan, and Simon Buckingham Shum. Where is the teacher? digital analytics for classroom proxemics. *Journal of Computer Assisted Learning*, 36(5):741–762, 2020.

[165] Manolis Mavrikis, Sergio Gutierrez-Santos, and Alex Poulovassilis. Design and evaluation of teacher assistance tools for exploratory learning environments. In *Proceedings of the Sixth International Conference on Learning Analytics & Knowledge*, pages 168–172, 2016.

[166] Elena Mazareanu. *Training Industry: U.S. Expenditure 2019.*, 2019 (accessed June 14, 2020).

[167] Riccardo Mazza and Vania Dimitrova. Coursevis: A graphical student monitoring tool for supporting instructors in web-based distance courses. *International Journal of Human-Computer Studies*, 65(2):125–139, 2007.

[168] James C McCroskey, Virginia P Richmond, Timothy G Plax, and Patricia Kearney. Power in the classroom v: Behavior alteration techniques, communication training and learning. *Communication Education*, 34(3):214–226, 1985.

[169] RP McDonald. Test theory: a unified approach mahwah. *NJ: Lawrence*, 1999.

[170] Bruce M McLaren, Oliver Scheuer, and Jan Mikšátko. Supporting collaborative learning and e-discussions using artificial intelligence techniques. *International Journal of Artificial Intelligence in Education*, 20(1):1–46, 2010.

[171] Judy McShannon, Pat Hynes, N Nirmalakhandan, Gadhamshetty Venkataramana, C Ricketts, April Ulery, and Robert Steiner. Gaining retention and achievement for students program: A faculty development program. *Journal of Professional Issues in Engineering Education and Practice*, 132(3):204–208, 2006.

[172] Albert Mehrabian. Silent messages: implicit communication of emotions and attitudes, wadsworth pub. *Co.* , 1981.

[173] Patrick W Miller. *Nonverbal Communication. What Research Says to the Teacher.* ERIC, 1988.

[174] Motoki Miura and Toyohisa Nakada. Device-free personal response system based on fiducial markers. In *2012 IEEE Seventh International Conference on Wireless, Mobile and Ubiquitous Technology in Education*, pages 87–91. IEEE, 2012.

[175] Hayes Mizell. *Why Professional Development Matters.* ERIC, 2010.

[176] Ahmad Mojavezi and Marzieh Poodineh Tamiz. The impact of teacher self-efficacy on the students' motivation and achievement. *Theory & Practice in Language Studies*, 2(3), 2012.

[177] Inge Molenaar and Carolien AN Knoop-van Campen. How teachers make dashboard information actionable. *IEEE Transactions on Learning Technologies*, 12(3):347–355, 2018.

[178] Ana M Morais, Isabel P Neves, and Margarida Afonso. Teacher training processes and teachers' competence—a sociological study in the primary school. *Teaching and Teacher Education*, 21(4):415–437, 2005.

[179] Roxana Moreno. Decreasing cognitive load for novice students: Effects of explanatory versus corrective feedback in discovery-based multimedia. *Instructional science*, 32(1-2):99–113, 2004.

[180] Selene Mota and Rosalind W Picard. Automated posture analysis for detecting learner's interest level. In *2003 Conference on Computer Vision and Pattern Recognition Workshop*, volume 5, pages 49–49. IEEE, 2003.

[181] Thirusha Naidu and Arno K Kumagai. Troubling muddy waters: problematizing reflective practice in global medical education. *Academic Medicine*, 91(3):317–321, 2016.

[182] Susanne Narciss and Katja Huth. How to design informative tutoring feedback for multimedia learning. *Instructional design for multimedia learning*, 181195, 2004.

[183] Iryna Nikolayeva, Amel Yessad, Marie Thuet, Françoise Chenevotot, Julia Pilet, Dominique Prévit, Brigitte Grugeon-Allys, and Vanda Luengo. How to help teachers adapt to learners? teachers' perspective on a competency and error-type centered dashboard for algebra. 2018.

[184] Lorelli S. Nowell, Jill M. Norris, Deborah E. White, and Nancy J. Moules. Thematic analysis: Striving to meet the trustworthiness criteria. *International Journal of Qualitative Methods*, 16(1):1609406917733847, 2017.

[185] Angela M O'Donnell, Johnmarshall Reeve, and Jeffrey K Smith. *Educational psychology: Reflection for action*. John Wiley & Sons, 2011.

[186] Amy Ogan. Reframing classroom sensing: promise and peril. *interactions*, 26(6):26–32, 2019.

[187] Jennifer Olsen, Nikol Rummel, and Vincent Aleven. Co-designing orchestration support for social plane transitions with teachers: Balancing automation and teacher autonomy. International Society of the Learning Sciences, Inc.[ISLS]., 2018.

[188] Julia O'sullivan. Unlocking the workforce potential: is support for effective continuing professional development the key? *Research in Post-Compulsory Education*, 8(1):107–122, 2003.

[189] Viktoria Pammer, Birgit Krogstie, and Michael Prilla. Let's talk about reflection at work. *International journal of technology enhanced learning*, 9(2-3):151–168, 2017.

[190] Stéphane Perreault. Locus of control. *The SAGE Encyclopedia of Political Behavior*, page 452–452, 2017.

[191] Herbert L Petri and John M Govern. *Motivation: Theory, research, and application*. Cengage Learning, 2012.

[192] Rosalind W Picard. Measuring affect in the wild. In *International Conference on Affective Computing and Intelligent Interaction*, pages 3–3. Springer, 2011.

[193] Doris R Pridemore and James D Klein. Control of practice and level of feedback in computer-based instruction. *Contemporary Educational Psychology*, 20(4):444–450, 1995.

[194] Luis P Prieto, Paul Magnuson, Pierre Dillenbourg, and Merike Saar. Reflection for action: Designing tools to support teacher reflection on everyday evidence. *Technology, Pedagogy and Education*, pages 1–17, 2020.

[195] Luis P Prieto, Kshitij Sharma, Pierre Dillenbourg, and María Jesús. Teaching analytics: towards automatic extraction of orchestration graphs using wearable sensors. In *Proceedings of the sixth international conference on learning analytics & knowledge*, pages 148–157, 2016.

[196] Stephen W Raudenbush and Anthony S Bryk. *Hierarchical linear models: Applications and data analysis methods*, volume 1. sage, 2002.

[197] Bettina Renner, Gudrun Wesiak, Viktoria Pammer-Schindler, Michael Prilla, Lars Müller, Dalia Morosini, Simone Mora, Nils Faltin, and Ulrike Cress. Computer-supported reflective

learning: how apps can foster reflection at work. *Behaviour & Information Technology*, 39(2):167–187, 2020.

[198] McCroskey J. C. Johnson A. D. Richmond, V. P. Nonverbal immediacy scale-self report (nis-s)., 2013.

[199] Virginia P Richmond, Joan S Gorham, and James C McCroskey. The relationship between selected immediacy behaviors and cognitive learning. *Annals of the International Communication Association*, 10(1):574–590, 1987.

[200] Virginia P Richmond, James C McCroskey, and Aaron D Johnson. Development of the nonverbal immediacy scale (nis): Measures of self-and other-perceived nonverbal immediacy. *Communication Quarterly*, 51(4):504–517, 2003.

[201] VP Richmond. Teacher nonverbal immediacy. *Communication for teachers*, 65:82, 2002.

[202] Berger Rod. *Hacking Education Change For The Professional Development Market*, 2019 (accessed June 14, 2020).

[203] Maria Jesus Rodriguez Triana, Luis Pablo Prieto Santos, Andrii Vozniuk, Mina Shirvani Boroujeni, Beat Adrian Schwendimann, Adrian Christian Holzer, and Denis Gillet. Monitoring, awareness and reflection in blended technology enhanced learning: a systematic review. *International Journal of Technology Enhanced Learning*, 9(ARTICLE):126–150, 2017.

[204] Julian B Rotter. Generalized expectancies for internal versus external control of reinforcement. *Psychological monographs: General and applied*, 80(1):1, 1966.

[205] Michael J Rouse. Continuing professional development in pharmacy. *Journal of Pharmacy Technology*, 20(5):303–306, 2004.

[206] Richard M Ryan and Edward L Deci. Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary educational psychology*, 25(1):54–67, 2000.

[207] Seyedeh Azadeh Safavi, Kamariah Abu Bakar, Rohani Ahmad Tarmizi, and Nor Hayati Alwi. Faculty perception of improvements to instructional practices in response to student ratings. *Educational Assessment, Evaluation and Accountability*, 25(2):143–153, 2013.

[208] Mary Catherine Scheeler, Kathleen McKinnon, and Jonathan Stout. Effects of immediate feedback delivered via webcam and bug-in-ear technology on preservice teacher performance. *Teacher Education and Special Education*, 35(1):77–90, 2012.

[209] Donald Schon. Educating the reflective practitioner jossey-bass inc. *San Francisco, California*, 1987.

[210] Donald A Schon. *Reflective practitioner*, volume 5126. Basic books, 1983.

[211] Donald A Schon. Quotations. a symposium on schon's concept of reflective practice: Critiques, commentaries, illustrations. *Journal of Curriculum and Supervision*, 5(1):6–9, 1989.

[212] Dale H Schunk. Social cognitive theory and self-regulated learning. In *Self-regulated learning and academic achievement*, pages 83–110. Springer, 1989.

[213] Dale H Schunk, Paul R Pintrich, and Judith L Meece. Motivation in education: Theory, research, and applications.(2008). *Englewood Cliffs, NJ: Merrill*, 2008.

[214] Beat A Schwendimann, María Jesús Rodríguez-Triana, Andrii Vozniuk, Luis P Prieto, Mina Shirvani Boroujeni, Adrian Holzer, Denis Gillet, and Pierre Dillenbourg. Understanding learning at a glance: An overview of learning dashboard studies. In *Proceedings of the sixth international conference on learning analytics & knowledge*, pages 532–533, 2016.

[215] Peter Seldin. Changing practices in evaluating teaching. 1999.

[216] Jennifer R Seymour and Helena P Osana. Reciprocal teaching procedures and principles: Two teachers' developing understanding. *Teaching and Teacher Education*, 19(3):325–344, 2003.

[217] Yuanchun Shi, Weikai Xie, Guangyou Xu, Runting Shi, Enyi Chen, Yanhua Mao, and Fang Liu. The smart classroom: merging technologies for seamless tele-education. *IEEE Pervasive Computing*, (2):47–55, 2003.

[218] Valerie J Shute. Focus on formative feedback. *Review of educational research*, 78(1):153–189, 2008.

[219] Susan Leigh Star and James R Griesemer. Institutional ecology,translations' and boundary objects: Amateurs and professionals in berkeley's museum of vertebrate zoology, 1907-39. *Social studies of science*, 19(3):387–420, 1989.

[220] Saiying Steenbergen-Hu and Harris Cooper. A meta-analysis of the effectiveness of intelligent tutoring systems on k–12 students' mathematical learning. *Journal of Educational Psychology*, 105(4):970, 2013.

[221] Saiying Steenbergen-Hu and Harris Cooper. A meta-analysis of the effectiveness of intelligent tutoring systems on college students' academic learning. *Journal of Educational Psychology*, 106(2):331, 2014.

[222] Mary Kay Stein and Margaret C Wang. Teacher development and school improvement: The process of teacher change. *Teaching and teacher education*, 4(2):171–187, 1988.

[223] Ann Stes, Mariska Min-Leliveld, David Gijbels, and Peter Van Petegem. The impact of instructional development in higher education: The state-of-the-art of the research. *Educational research review*, 5(1):25–49, 2010.

[224] Dennis W Sunal, Jeanelle Hodges, Cynthia S Sunal, Kevin W Whitaker, L Michael Freeman, Leo Edwards, Ronald A Johnston, and Michael Odell. Teaching science in higher education: Faculty professional development and barriers to change. *School Science and mathematics*, 101(5):246–257, 2001.

[225] Mike Tissenbaum, Camillia Matuk, Matthew Berland, Leila Lyons, Felipe Cocco, Marcia Linn, Jan L Plass, Nik Hajny, Al Olsen, Beat Schwendimann, et al. Real-time visualization of student activities to support classroom orchestration. Singapore: International Society of the Learning Sciences, 2016.

[226] Mike Tissenbaum and James D Slotta. Developing an orchestrational framework for collective inquiry in smart classrooms: Sail smart space (s3). Boulder, CO: International Society of the Learning Sciences, 2014.

[227] M Tschannen-Moran and A Woolfolk Hoy. Teacher efficacy: Capturing an elusive construct teaching and teacher education, 17, 783-805, 2001.

[228] Indiana Univeristy. Readiness ruler, 2016.

[229] Naim Uzun. A sample of microteaching in environmental education and its effect on pre-service teachers' presenting effective lessons. In *Asia-Pacific Forum on Science Learning and Teaching*, volume 13, pages 1–21. The Education University of Hong Kong, Department of Science and . . . , 2012.

[230] Linda Valli. Listening to other voices: A description of teacher reflection in the united states. *Peabody journal of Education*, 72(1):67–88, 1997.

[231] Erik van Alphen and Saskia Bakker. Lernanto: an ambient display to support differentiated instruction. 2015.

[232] Elizabeth A Van Es and Miriam Gamoran Sherin. Learning to notice: Scaffolding new teachers' interpretations of classroom interactions. *Journal of technology and teacher education*, 10(4):571–596, 2002.

[233] Anouschka Van Leeuwen, Jeroen Janssen, Gijsbert Erkens, and Mieke Brekelmans. Supporting teachers in guiding collaborating students: Effects of learning analytics in cscl. *Computers & Education*, 79:28–39, 2014.

[234] Anouschka van Leeuwen, Nikol Rummel, Kenneth Holstein, Bruce M McLaren, Vincent Aleven, Inge Molenaar, Carolien Knoop-van Campen, Baruch Schwarz, Naomi Prusak, Osama Swidan, et al. Orchestration tools for teachers in the context of individual and collaborative learning: what information do teachers need and what do they do with it? International Society of the Learning Sciences, Inc.[ISLS]., 2018.

[235] Kurt Vanlehn. The behavior of tutoring systems. *International journal of artificial intelligence in education*, 16(3):227–265, 2006.

[236] Kurt VanLehn. The relative effectiveness of human tutoring, intelligent tutoring systems, and other tutoring systems. *Educational Psychologist*, 46(4):197–221, 2011.

[237] Kurt VanLehn, Hugh Burkhardt, Salman Cheema, Seokmin Kang, Daniel Pead, Alan Schoenfeld, and Jon Wetzel. Can an orchestration system increase collaborative, productive struggle in teaching-by-eliciting classrooms? *Interactive Learning Environments*, pages 1–19, 2019.

[238] Katrien Verbert, Sten Govaerts, Erik Duval, Jose Luis Santos, Frans Van Assche, Gonzalo Parra, and Joris Klerkx. Learning dashboards: an overview and future research opportunities. *Personal and Ubiquitous Computing*, 18(6):1499–1514, 2014.

[239] Vicki Vescio, Dorene Ross, and Alyson Adams. A review of research on the impact of professional learning communities on teaching practice and student learning. *Teaching and teacher education*, 24(1):80–91, 2008.

[240] Eleonora Villegas-Reimers et al. *Teacher professional development: an international review of the literature*. International Institute for Educational Planning Paris, 2003.

[241] Franziska Vogt and Marion Rogalla. Developing adaptive teaching competency through coaching. *Teaching and Teacher Education*, (8):1051–1060, 2009.

[242] Hsuying C Ward and Paula M Selvester. Faculty learning communities: Improving teaching in higher education. *Educational Studies*, 38(1):111–121, 2012.

[243] Beverly Jean Warden. *Self-evaluation of reflective thinking among pre-service and in-service teachers.* PhD thesis, Oklahoma State University, 2004.

[244] Helen MG Watt and Paul W Richardson. Motivations, perceptions, and aspirations concerning teaching as a career for different types of beginning teachers. *Learning and instruction*, 18(5):408–428, 2008.

[245] Jeffrey C Wayman. Involving teachers in data-driven decision making: Using computer data systems to support teacher inquiry and reflection. *Journal of education for students placed at risk*, 10(3):295–308, 2005.

[246] Rodman B Webb and Patricia T Ashton. Teacher motivation and the conditions of teaching: A call for ecological reform. *Journal of Thought*, pages 43–60, 1986.

[247] Morton Wiener and Albert Mehrabian. *Language within language: Immediacy, a channel in verbal communication.* Ardent Media, 1968.

[248] Allan Wigfield and Jacquelynne S Eccles. The development of achievement task values: A theoretical analysis. *Developmental review*, 12(3):265–310, 1992.

[249] Allan Wigfield and Jacquelynne S Eccles. Expectancy–value theory of achievement motivation. *Contemporary educational psychology*, 25(1):68–81, 2000.

[250] Uwe Wilkesmann and Christian J. Schmid. Intrinsic and internalized modes of teaching motivation. *Evidence - Based HRM*, 2(1):6–27, 2014. Copyright - Copyright Emerald Group Publishing Limited 2014; Last updated - 2019-09-06; SubjectsTermNotLitGenreText - Germany.

[251] Paul Witt. *Communication and learning*, volume 16. Walter de Gruyter GmbH & Co KG, 2016.

[252] Paul L Witt and Lawrence R Wheeless. An experimental study of teachers' verbal and nonverbal immediacy and students' affective and cognitive learning. *Communication Education*, 50(4):327–342, 2001.

[253] Paul L Witt, Lawrence R Wheeless, and Mike Allen. A meta-analytical review of the relationship between teacher immediacy and student learning. *Communication Monographs*, 71(2):184–207, 2004.

[254] Christopher A Wolters and Stacy G Daugherty. Goal structures and teachers' sense of efficacy: Their relation and association to teaching experience and academic level. *Journal of educational psychology*, 99(1):181, 2007.

[255] Beverly Park Woolf. *Building intelligent interactive tutors: Student-centered strategies for revolutionizing e-learning.* Morgan Kaufmann, 2010.

[256] Françeska Xhakaj, Vincent Aleven, and Bruce M McLaren. How teachers use data to help students learn: Contextual inquiry for the design of a dashboard. In *European Conference on Technology Enhanced Learning*, pages 340–354. Springer, 2016.

[257] Françeska Xhakaj, Vincent Aleven, and Bruce M McLaren. Effects of a dashboard for an intelligent tutoring system on teacher knowledge, lesson plans and class sessions. In *International Conference on Artificial Intelligence in Education*, pages 582–585. Springer, 2017.

[258] Françeska Xhakaj, Vincent Aleven, and Bruce M McLaren. Effects of a teacher dashboard for an intelligent tutoring system on teacher knowledge, lesson planning, lessons and student learning. In *European conference on technology enhanced learning*, pages 315–329. Springer, 2017.

[259] Franceska Xhakaj, Na Young Lee, Erik Ulberg, Amy Luo, Seoyoung Lee, Katrina Hu, and Amy Ogan. Investigating teacher data needs in terms of teacher immediacy and nonverbal behaviors. *In de Vries, E., Hod, Y., Ahn J. (Eds.). (2021) Proceedings of the 15th International Conference of the Learning Sciences - ICLS 2021*, 3(3):1133–1134, 2021.

[260] Kenneth M Zeichner and DP Liston. Reflective teaching: an introduction. mahwah, nj: L, 1996.

[261] Barry J Zimmerman. Self-efficacy: An essential motive to learn. *Contemporary educational psychology*, 25(1):82–91, 2000.

[262] John Zimmerman and Jodi Forlizzi. Speed dating: providing a menu of possible futures. *She Ji: The Journal of Design, Economics, and Innovation*, 3(1):30–50, 2017.