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How Graduate Teaching Assistants Developed Their Understandings of Various Teaching Practices as They Engaged with Professional Development

Author
Milbourne, Hayley Miles-Leighton

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How Graduate Teaching Assistants Developed Their Understandings of Various Teaching Practices as They Engaged with Professional Development

A dissertation submitted in partial satisfaction of the requirements for the degree Doctor of Philosophy

in

Mathematics and Science Education

by

Hayley Miles-Leighton Milbourne

Committee in charge:

University of California, San Diego

Christopher P. Halter
Jeffrey Rabin

San Diego State University

Susan Nickerson, Chair
Janet Bowers
Chris Rasmussen

2018

The Dissertation of Hayley Miles-Leighton Milbourne is approved, and it is acceptable in quality and form for publication on microfilm and electronically:

Chair

University of California, San Diego

San Diego State University

2018

DEDICATION

For my Grandparents—

Your love and support helped me get to where I am today.
I am forever grateful for all you have done for me.
I love you all so much.

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ACKNOWLEDGEMENTS

While there may be only one name listed as the author of this dissertation, it was by no means completed by only one person. Sure, I collected the data, analyzed it, and wrote all of the words that went into this dissertation, but there are many people behind every one of those words. In more ways than one, this dissertation would not have been completed without the support, love, and help of many others in my life.

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VITA

2018 Doctor of Philosophy, Mathematics and Science Education, University of California, San Diego & San Diego State University

2013 Master of Science, Applied Mathematics, University of Arizona

2011 Bachelor of Science, Scientific Computation - Mathematics, University of California, San Diego

ACADEMIC APPOINTMENTS AND TEACHING EXPERIENCE

2017–2018 Graduate Teaching Associate, Department of Mathematics and Statistics, San Diego State University

2016–2017 Graduate Research Assistant, Center for Research in Mathematics and Science Education, San Diego State University

2015–2016 Graduate Teaching Associate, Department of Mathematics and Statistics, San Diego State University

2013–2015 Graduate Research Assistant, Center for Research in Mathematics and Science Education, San Diego State University

2012–2013 Graduate Teaching Assistant, Department of Mathematics, University of Arizona

PUBLICATIONS

Zahner, W., Milbourne, H., & Wynn, L. (in press). Examining secondary mathematics teachers' interpretations of mathematical and linguistic complexity in tasks related to rates of change. *Journal of Mathematical Behavior.*

Selinski, N. & Milbourne, H. (2015). The institutional context. In D. Bressoud, V. Mesa, & C. Rasmussen (Eds.), *Insights and recommendations from the MAA national study of college calculus.* Washington, D.C.: Mathematical Association of America.

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ABSTRACT OF THE DISSERTATION

How Graduate Teaching Assistants Developed Their Understandings of Various Teaching Practices as They Engaged with Professional Development

by

Hayley Miles-Leighton Milbourne

Doctor of Philosophy in Mathematics and Science Education

University of California, San Diego, 2018
San Diego State University, 2018

Professor Susan Nickerson, Chair

Across the nation, there is increasing national interest in improving the way mathematics departments prepare their graduate teaching assistants (GTAs) because of their integral role in teaching lower division mathematics courses, particularly within the Calculus sequence (Speer, Deshler, & Ellis, 2017). While there have been several studies that look into the ways departments prepare their GTAs (Belnap & Allred, 2009; Speer, Smith, & Horvath, 2010), little is still known about how GTAs understand the active-learning teaching practices introduced to them. In order to better support GTAs, we need to understand how GTAs are interpreting and making sense of these teaching practices.

The GTAs within this study were running break-out sections twice a week for Calculus I and II, with one of the break-out sections involving the facilitation of activities and group work. GTAs engaged in a three-day pre-term seminar, a semester-long PD course on leading student-

centered classes, and weekly meetings with the course coordinators. Lead TAs provided support and feedback to their fellow GTAs.

Using a modified framework based on a socio-cultural learning theory, known as the Vygotsky Space (Harré, 1983), I analyzed the ways in which the discourse around the teaching practices, for both "active-learning" and "traditional" classrooms, changed over the course of a semester and the role lead TAs and others had in their publicized interpretations. Two different types of changes were recorded, elaboration and transformation, and each teaching practice was tracked as it was publicized over the course of the semester. I created criteria to determine whether or not the discourse around a particular teaching practice was conventionalized within a community. Results from this study give insight into what teaching practices were challenging to understand, as well as the interpretations taken up and conventionalized by the GTAs. Approximately 20% of the practices showed evidence of some form of conventionalization; some of the conventionalized practices were transformations of the original version. The lead TAs may have influence over GTAs' instructional practice, but they did not have much influence over the interpretations publicized. These results yield insights useful to faculty involved in the professional development of GTAs.

Chapter 1: The Problem

Professional Development and a Game of Telephone

Do you remember playing the game of "telephone" as a child? One person comes up with a phrase and whispers it to the next person, who then whispers what they heard to the person after them, and so on. The great fun in the game is finding out how the phrase has been transformed at the end of the line. A phrase that could have started the game as "my favorite animal is a rabbit" might end the sequence of whisperings and people as "Fred likes ramen."

In many ways, professional development can feel like a complex game of telephone. The leaders and creators of the professional development have certain ideas that they are working to convey to the teachers or the facilitators with whom they are working. However, the teachers are going to interpret it in their own way based on their needs and experiences and use their adapted understandings in their classrooms. Furthermore, those same teachers might then express their altered ideas to other teachers, who will then interpret it once again in light of their own experiences and needs. As this goes on, what the professional development leaders originally thought they were conveying can be changed to some form the professional development leaders no longer recognize.

This particular phenomenon has been well documented in the K-12 literature. Research on the Standards movement reform of the 1980's and 1990's documented only a modest impact of the initiative on teachers' practice. What the research did document was that teachers selectively took up reform ideas and adopted only the surface-level features (Spillane & Zeuli, 1999). Researchers explained the adaptation in terms of teachers' learning processes and suggested that implementation varied because teachers drew on prior knowledge and practices when interpreting the message about the new standards and instructional practices (Coburn, Hill,

& Spillane, 2016; Coburn, 2001; Cohen & Ball, 1990). Additionally, the interpretation created by the teachers sometimes did not align with the interpretation of the providers of professional development and messages from school districts and school administrators, and so resulted in inconsistent instructional guidance (Coburn, 2001).

Though the K-12 research focuses on how standards are adopted or polices are implemented at the state level and then interpreted by district and local administrators (and, in some cases, content coaches), the context is still similar to the process of changing teaching at the university level. I argue that when faculty and graduate students undertake reform teaching, all of those involved, including the department chair, course coordinators, faculty who take on the professional development of graduate teaching assistants (GTAs), and the GTAs themselves, co-construct the message of the reform. It begins with a small group of faculty with the common goal to promote high-quality instruction and its success ultimately, in large part, depends upon the teaching of the GTAs who interact with the undergraduate students most frequently. Exactly how these reform ideas are co-constructed is important in understanding what is happening in the college classroom.

Turning back to the game of telephone, one of the most interesting parts of playing a game of telephone (besides finding out the end message) is figuring out where particular alterations happened and why. It can be greatly entertaining to find out that someone along the line could have sworn they heard one thing when the original person insists on saying something different. In fact, it is the various social interactions amongst those in the game and perhaps their own personal experiences that ultimately influence the changes we observe to the original message. In the K-12 literature, focus has been placed on the ways in which the teachers themselves are interpreting instructional policy and the ways in which their communities affect their interpretations (Coburn, 2001; Stein & Coburn, 2008). Through these studies, researchers have been able to record the significant impact on understanding that discussion with other teachers has on an individual teacher's learning of the instructional policy. I was interested in studying something similar at the undergraduate level to better understand how GTAs make sense of and interpret what they learn about how to lead a student-centered classroom.

This interest came about because at San Diego State University (SDSU) several significant changes were made to the Calculus I and II courses with professional development on teaching for GTAs who lead the break-out sections taking a central role. The professional development for the GTAs focuses on supporting the enactment of student-centered instruction. The GTAs are being asked to lead the Calculus homework and problem-solving sessions in a manner different than the instruction they likely experienced. Some have never taught before and among those who have, the paradigm is likely new to them. How do GTAs learn to teach with such a different instructional format? How do GTAs develop their own unique understanding of the professional development activities on teaching? How is this understanding transformed and publicized throughout the professional development events? Simply knowing what the end message is in the game of telephone is rarely satisfying; it is the actual transformations to the final message that happen along the way that hold some of the most interesting information. In education reform, it's critical to understand this since it can inform future professional development.

Before we can consider these questions, however, it would be beneficial to understand the background of the changes happening to Calculus instruction across the nation. I focus on Calculus instruction because of its critical importance in STEM (science, technology, education, and mathematics) majors and because of the recent national interest in understanding what is stemming the flow of students away from these majors (PCAST, 2012). In the next section I will give some history of the Calculus reform since the 1990's that brought us to where we are today.

Calculus Reform: The Catalyst

In the mid-1980's, there was a call for reform in College Calculus at the Tulane "Lean and Lively" calculus conference (Ganter, 1999; Schoenfeld, 1995) leading to widespread change in the ways in which calculus was taught. Specifically, there was a greater focus on examining what was being taught in calculus courses and in designing a new curriculum. As a result, the mathematicians teaching the calculus courses had the difficult task of interpreting and implementing the newly suggested curricula while still keeping in mind the aspects of the curriculum they believed their students would most benefit from (Ferrini-Mundy & Graham, 1991).

In an effort to understand the national impact of the reform efforts in the 1990's, a meta-analysis of 127 studies on the reform efforts from 1988 to 1994 was conducted (Ganter, 2001). The analysis suggested that the results were mixed on student achievement and attitudes toward calculus. While most instructors of calculus agreed that some change needed to occur within the teaching of calculus, there was debate as to whether or not the reform was contributing to improved student understanding. A seminal study by Seymour and Hewitt (1997) found that the most common complaint of students who switched out of STEM majors was their poor learning experiences in calculus.

While some progress does seem to have come from the reform efforts in the 1990's and there are many reasons why students move away from STEM degrees, studies completed in recent years have found that students were continuing to cite their experiences in calculus as a top reason for switching out of the STEM majors (President's Council of Advisors on Science and Technology (PCAST), 2012; Rasmussen, Ellis, & Bressoud, 2015). A study done by Chen and Weko (2009) found that approximately 47.3% of STEM intending students did not complete their STEM degree, either because they switched to a non-STEM major or they did not complete a college degree. It is for these reasons that the experience of the students in Calculus should be significant to undergraduate instructors.

Researchers in a recent national NSF study, conducted under the auspices of the Mathematical Association of America (MAA), *Characteristics of Successful Programs in College Calculus* (CSPCC) (Bressoud, Mesa, & Rasmussen, 2015), undertook a national investigation of Calculus I instruction at a broad spectrum of institutions to identify the factors that contributed to student success. As part of the study, students at 521 colleges and universities were surveyed on Calculus I in their institutions. Students were asked at the beginning and at the end of their calculus course whether or not they intended on taking Calculus II in the next term, which was used as a proxy for STEM intending majors. Those who started the term intending to take Calculus II but ended the term stating that they were no longer going to take Calculus II were named switchers, whereas those that continued with Calculus were referred to as persisters. (Rasmussen & Ellis, 2013). The researchers found that of the 7260 students who were surveyed both at the beginning and end of Calculus I, 671 (or 12.5%) were classified as switchers with 31.4% of switchers citing their experience in Calculus I as their main reason for switching away from a STEM major. The situation was even worse for women. In the same study, the researchers found from the students who reported their gender that at the beginning of their Calculus I course approximately 41.5% (1317) of STEM intending students were female and 48.5% (1856) were male. However, only 11% of the 1856 males were identified as switchers in comparison to the 20% of the 1317 females who were identified as switchers (Ellis, Fosdick, & Rasmussen, 2016). In other words, not all students are impacted equally.

In the report from the study on the state of calculus across the nation, researchers identified some institutions as having successful programs. Specifically, they used the characteristics of successful programs to provide seven recommendations for change:

1. Attention to effectiveness of placement procedures.
2. Proactive student support services, including the fostering of student academic and social integration.
3. Construction of challenging and engaging courses.
4. Use of student-centered pedagogies and active-learning strategies.
5. Coordination of instruction, including the building of communities of practice.
6. Effective training of graduate teaching assistants.
7. Regular use of local data to guide curricular and structural modifications. (Bressoud et al, 2015, p. viii)

The sixth recommendation, the professional development of GTAs, was of particular interest in this study as I was interested in learning how GTAs appropriate and transform the professional development on student-centered instruction. GTAs have become increasingly significant in teaching undergraduate mathematics, as they are beginning to be placed within several different aspects of the teaching of calculus (Belnap & Allred, 2009). In the grant that is an extension of CSPCC, known as *Progress through Calculus* (Rasmussen et al., 2016) researchers found that 81% of PhD granting institutions and 45% of Masters granting institutions in recognition of this importance now have some kind of department-run professional development for GTAs.

However, will simply providing professional development to GTAs necessarily improve the experience for undergraduates in calculus? As was seen in the K-12 literature (Coburn, 2001), there is no guarantee that GTAs will interpret the teaching practices from the professional development in the way it was expected by the developers or the leaders of the professional development. Hence, gaining a better understanding of how particular teaching practices within the professional development are taken up and potentially transformed by the GTAs over time will greatly add to our understanding of how to better support GTAs in improving their teaching over all.

Within the various studies done on the range of professional development programs available for GTAs, most studies can be described by three main themes: temporal, structural, and topical. In temporal studies, researchers describe the duration of the professional development and how it varies across the nation (e.g., Belnap & Allred, 2009). In structural studies, the focus is on the various ways the programs for professional development of GTAs are structured (e.g., Ellis, 2015; Palmer, 2011). In topical studies, there is an effort to create a list of standard topics and teaching practices on which the professional development programs are focused (e.g., McDaniels, 2010). Finally, outside of the three topics described above, there are a group of studies on the efficacy of particular professional development programs (e.g., Griffith, O'Loughlin, Kearns, Braun, & Heacock, 2010).

As we will see in Chapter 2 in the survey of the studies conducted nationally on the state of professional development of GTAs, the research base is still relatively small. There have been only a handful of studies done exclusively on the state of professional development of GTAs across the nation (Belnap & Allred, 2009; Kalish et al., 2011; Palmer, 2011; Robinson, 2011). Additionally, there have been a few meta-studies conducted over the years on the state of research in the teaching of undergraduate mathematics (Speer, Gutmann, & Murphy, 2005; Speer, Smith, & Horvath, 2010). Outside of the national studies, there are also a handful of articles on particular programs at specific institutions, with a focus on the structure of the program or the efficacy of the program (e.g., Griffith et al., 2010; Marbach-Ad, Shields, Kent, Higgins, & Thompson, 2010). So, while there have been studies that describe the various forms of professional development or that give an idea of what GTAs have learned from their experiences in professional development, little to no work hds been done on the ways in which the GTAs are actually taking up and implementing the insights into teaching practice from the professional development. In other words, the focus has been on the product and not the process.

The mathematics department at SDSU recently joined the group of institutions implementing a professional development program for GTAs. I collected data in the Fall 2016 semester at SDSU with two groups of GTAs, one for Calculus I and the other for Calculus II. The program at SDSU involves several opportunities for professional development of GTAs, including a three-day seminar before the Fall term begins, regular meetings with a mathematics education researcher on leading a student-centered classroom, weekly meetings with a course coordinator, and observations with debriefs from a fellow GTA. The fellow GTA who performs these observations and debriefs is known as the lead TA and has more experience with student-centered instruction than the other GTAs. I observed the GTAs in the various formal professional development settings in which they were involved and observed some of their teaching in their classrooms. From these observations and an analysis of their discussions in formal settings, I report on how over time the GTAs appropriated and transformed the professional development of teaching to address their own needs.

As I stated earlier, the professional development program for GTAs at SDSU has recently gone through several changes. In the next section I will go into more detail about how the program is currently structured. For a more detailed description of the changes in the program, see Chapter 3.

The Setting

The professional development program in my study is located at SDSU, which is a Masters-granting institution by the characterization by the Conference Board of the Mathematical Sciences (CBMS, 2012). Starting in the 2015 Fall semester, the mathematics department at SDSU decided to implement a large number of changes to the Calculus program based on the recommendations from the CSPCC study (Bressoud et al., 2015). The two recommendations I am particularly interested in are the fourth and sixth: use of student-centered pedagogies and active-learning strategies, and effective training of graduate teaching assistants. I will describe the ways in which the program at SDSU changed based in part on these recommendations. The four main changes made to the program as related to GTAs were: an increase in the number of hours each GTA spends with students, the addition of the GTA professional development meetings, the coordination of the Calculus program, and the designation of a lead TA.

Break-Out Sections

The Calculus I and II courses are taught in large lectures (150 or more students) with break-out sections led by GTAs. Before the changes were implemented, the GTAs met with the students in classes (break-out sections) of 40 or more students once a week for 50 minutes to talk about homework or any questions from the class and to give quizzes. Each GTA had 5 to 6 sections of this size, giving them responsibility for over 200 students at a time. The department believed that the GTAs typically were stretched thin and did not have much of an opportunity to engage with their students in a meaningful way (O'Sullivan, 2016).

The more traditional structure described above was changed in the Fall of 2015 to include two, 50-minute break-out sections a week, instead of one, doubling the amount of face time the students had with their GTA. The committee believed that having more contact hours with fewer students would provide the GTAs an opportunity to engage with students in a meaningful way. One of the break-out sections still involved discussions about the homework and topics from the class but the GTAs were encouraged to engage their students more in the discussion (in other words, to make them student-centered). The second break-out section became an “activity” day in which the students were put into groups to work on challenging problems based on the topics discussed in class that week.

The GTAs are encouraged to get the students working together and to facilitate whole-class discussions that involve pushing students to think conceptually about the topics from class. Since this was a way of teaching with which many of the GTAs had little to no experience, strategies for being successful in running an active learning classroom became one of the foci in the professional development of the GTAs, so as to provide the GTAs with the background and experience to help them implement pedagogical strategies that were likely new to them.

Professional Development

Before the changes were instigated in the department at SDSU, the mathematics department had no required, department-specific teaching preparation program. One of the first changes that was made to the GTA preparation program was the creation of a three-day summer seminar offered to all GTAs for Calculus I and II as well as the instructional student assistants (ISAs) for Precalculus before the 2015-16 academic year began. The GTAs and ISAs were primarily led by three experienced mathematics education researchers in order to learn about various ways they could successfully lead a student-centered classroom. This included ways to facilitate group work and ways to lead whole class discussions.

Additionally, during each term, the GTAs met regularly with a mathematics education researcher for an hour at a time. The topics at these meetings varied but were focused on particular aspects of being successful with an active learning classroom such as how to guide productive whole class discussions or how to alter the given tasks to be more cognitively demanding.

This format of professional development is one of the more common temporal forms of professional development seen across the nation. In a study by Belnap and Allred (2009), focusing on PhD granting institutions, the researchers identified the various types of professional development programs offered across the nation based on their temporal structure. Programs were categorized as an initial program or a recurring program, with some systems involving a combination of both. The program at SDSU would be categorized as a sustained professional development system. It involves both a seminar before the term begins (also known as an orientation program) and a course on professional development throughout the term (also known as an establishment program). According to the survey done by Belnap and Allred (2009), the sustained professional development system was the most common professional development system for PhD-granting institutions.

Coordination of Calculus

Before the Fall of 2015, Calculus instructors operated independently from one another and each taught the course with his or her own materials and exams. There was no aspect to the calculus sequence that was intentionally common amongst the instructors. Starting in the Fall of 2015, the Calculus sequence became more coordinated. A common textbook was selected for all sections of Calculus I and II and each took the same midterms and final exam at the same time in the same place. Furthermore, both Calculus I and II were assigned a coordinator who wrote the exams, selected activities, and worked with the GTAs for the courses.

The GTAs met weekly with their respective course coordinator to discuss aspects of the course, including administrative aspects (such as midterms and grading) and to discuss the activity for the following week. During the discussions about the activity for the following week, the coordinator, with input from the GTAs, would decide how it would be best implemented and what particular aspects of the activity should be the focus. They would also discuss how the activity of the previous week had gone so as to help make changes for future iterations of the activity.

Lead TA Structure

The mathematics department also incorporated a new structure to the GTA program known as the lead TA structure. In this structure, the lead TA position is filled by a more experienced GTA who provides support to his or her fellow GTAs with a professional development aspect that occurs both before the term begins and throughout the term (Ellis, 2015). In a national study done by Palmer (2011), it was found that approximately 22.8% of PhD-granting institutions utilized the lead TA format for their professional development program, making it the seventh most common program structure out of the 12 different types of programs identified. Palmer (2011) characterized the lead TA program as broad scope/high commitment, seeing it as a program focused on GTA development. The consequence of this is that lead TA programs cover a broad number of topics within teaching, but they also require a high level of commitment from those involved, especially those who serve in the lead TA position. In contrast, a one-time workshop would be considered to be a GTA development program with narrow scope/low commitment.

At SDSU, the lead TAs for Calculus I and II were chosen based on their prior experience with teaching or participating in an active learning classroom. Throughout the Fall 2016 semester, the lead TA visited the activity day sections of his fellow GTAs to observe the class and met with the GTAs after to debrief about how the class went. The lead TA attempted to make these visits about three times a semester for all of the GTAs that he was able to observe. Sometimes the schedule of the lead TA conflicted with a section taught by another GTA, preventing the lead TA from visiting. Finally, the lead TA served as a liaison for the other GTAs to the coordinator of the course, the mathematics education researchers involved in the professional development, and occasionally to the head of the department.

Since the lead TAs have additional responsibilities, they are compensated by a reduction in other aspects of their job. As part of their contract, the GTAs are required to work at the math learning center (MLC) for five additional hours a week. The MLC is a tutoring center on campus for math courses ranging from PreCalculus to Statistics, and the GTAs are expected to assist students who come into the center. The lead TA does not have this obligation, freeing part of his week to complete his additional duties as the lead TA. However, the lead TA in this program does still have his own two sections to teach a week, for four hours of teaching.

With the lead TA holding such a centralized position within the program at SDSU, I was particularly interested in capturing the ways they may or may not have had influence over how the professional development on leading a student-centered classroom was appropriated and transformed. What role did the lead TA play in shaping the information provided through the various professional development meetings? To answer this important question along with others about how the changes in the discourse around various teaching practices occurred within the program overall during the academic year, I conducted a pilot study that informed the design of my dissertation study. I needed a theoretical framework that incorporates both the social and individual aspects of learning. In the next section I will discuss the theoretical framework I used. Because of the increased use of GTAs in the teaching of Calculus (Luo, Grady, & Bellows, 2001), it is important that we study how the understanding of teaching practices were appropriated and transformed by those involved. To do so, we needed a framework and a method of analysis that will provide us with the answers to our many questions.

Theoretical Framework

In my dissertation study, I was interested in understanding how the discussions around various teaching practices in the professional development on leading a student-centered classroom were transformed and shaped over time by the GTAs who were engaged with the professional development and each other. Because of this, my theoretical framework would benefit from a social bent so as to capture how the community as a whole affects the observed changes. However, a cognitive aspect is also necessary as the transformation of the discussions around professional development over time may be a reflection of individual learning, so the framework should encompass individual learning within the community. These two needs led me toward the use of Vygotsky's socio-cultural learning theory because the basis of this theory is on the ways in which the social and individual planes are reflexively related: "changes in one constitute resources and conditions for changes in the other" (Peck, Gallucci, Sloan, & Lippincott, 2009, p. 17). In other words, when social processes are internalized by individuals, it necessitates a change to the social plane as it will affect the way the individual interacts in the social space. Furthermore, the social plane instigates a change in the individual and the individual makes sense of the change as it occurs. The framework known as the Vygotsky Space (Harré, 1983) works to explain these reflexive changes through considering different aspects of the change over time, where learning and change are thought of as the internalization and transformation of cultural tools as individuals participate in a social practice.

Within the Vygotsky Space framework, there are two main dimensions: the individual-social and the public-private (Harré, 1983). The superposition of these dimensions creates a two-dimensional space in which to describe how new ideas about a practice are taken up, discussed, and perhaps transformed. The two dimensions create four quadrants[1] and it is the movement between these quadrants that describes transitions in development (Gavelek & Raphael, 1996).

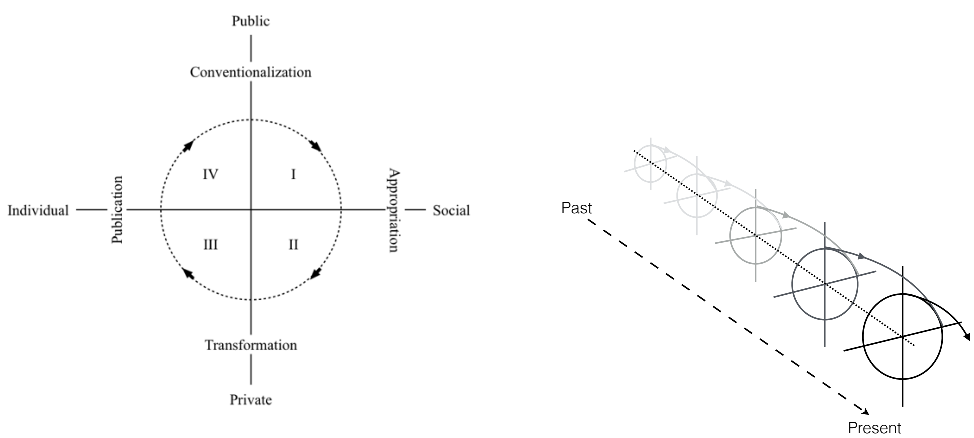


Figure 1.1: On the left is a diagram of the Vygotsky Space framework; on the right is a representation of how the changes in discussions move through time.

The movement from the first quadrant to the second is described as appropriation. In this transition, the individual is taking up and interpreting the concepts that have been introduced and used in the public-social setting of the first quadrant. The usage of the word *appropriation* seen here is different from the standard usage in the socio-cultural literature. Within much of the socio-cultural literature, appropriation involves both the taking-in of information and the transformation of that information by the individual. In contrast, the Vygotsky Space framework

[1] The numbering of the quadrants reflects the socio-cultural literature and does not follow the standard form within mathematics.

teases these two aspects apart so as to have appropriation mean simply the taking-in and interpretation of ideas. As reflected in moving from the second to the third quadrant, transformation is when the individual is taking the concept he or she has appropriated and is modifying it to make it at least partially their own. When moving from the third quadrant to the fourth, the individual is engaged in publication, which is when that individual has made their meanings and strategies public for others to comment on, either through verbal language, written language, or actions. Finally, the movement from the fourth quadrant to the first is known as conventionalization. In this, the "individuals' public manifestations of thinking (i.e., their actions and their ideas) are incorporated as part of the community of discourse in which they participate" (Gavelek & Raphael, 1996, p. 188). Furthermore, this cycle happens over time, continually changing as the individual and community develop. Images of the cycle and the time aspect are found in Figure 1.1.

In my dissertation, the Vygotsky Space framework provided a way to understand how the various teaching practices discussed in the professional development were appropriated and transformed as evidenced by how they were publicized within the social domain of the professional development meetings, the debriefings with the lead TA, and through the weekly meetings with their course coordinator. The results from this work have the potential to provide tools with which to better understand how professional development is transformed over time within a group of novice GTAs.

Another possible construct that may provide further insight into the transformations is known as mutual appropriation. In general, "when appropriation is reciprocal or multidirectional, the term mutual appropriation can be used to describe how teachers and learners together participate in the teaching/learning process" (Ash & Levitt, 2003, p. 6). Something to note here is that the use of *appropriation* within this construct involves the meaning used within the broader socio-cultural literature. The idea of mutual appropriation has been used at several different levels, such as at the level of teacher-student interactions or new teacher-expert teacher interactions (Ash & Levitt, 2003), and at the level of "the interactions between organizations representing those who are doing the intervening and the partner organization" (Downing-Wilson, Lecusay, & Cole, 2011, p. 658) in which the participants are working together to attend to each other's ideas.

While mutual appropriation does consider the changes made to particular ideas over time, it is much more focused on the interactions and relationships between those involved in the changes. For instance, in one particular study that utilized the framework of mutual appropriation, the focus was on the ways in which two communities worked together to create activities for their respective programs (Downing-Wilson et al., 2011). In contrast, my use of the Vygotsky Space was focused more on the changes to the practices or the discourse around the practices as a community interacts with one another. So, mutual appropriation has the potential to provide a way to look deeply into the ways in which particular relationships shape ideas and thoughts over time in a way the Vygotsky Space may not provide. While the Vygotsky Space is the theoretical framework I use to understand the ways in which GTAs learn to teach a student-centered classroom, mutual appropriation could be a useful additional tool for future analysis.

Research Questions

Thus far I have discussed the problem, the situation, and the theoretical framework I will use to add to the growing literature base on professional development of GTAs', the literature will be discussed in greater detail in Chapter 2. I now give the two main research questions that underpin the dissertation. The first question focuses on the ways various teaching practices within the professional development are transformed over time and by what means these transformations occurred. The second question looks more deeply into the "by what means" of the first question by asking how the lead TAs and others shape these various teaching practices in professional development on leading a student-centered classroom over time.

RQ1: How do the GTAs' publicized understandings of various teaching practices change (through elaboration or transformation) over the course of a term? How do these publications highlight which teaching practices are most salient to their needs?

RQ2: How do the lead TAs and others influence the shaping of the various teaching practices discussed in the professional development on leading a student-centered classroom?

Pilot Study: What We Learned

So as to create a method of analysis to use with the Vygotsky Space framework, I conducted a pilot study during the 2015-16 academic year. Earlier in this chapter, I gave a brief overview of the structure of the program both before and after the changes were instigated to the Calculus program. Using that overview, I will briefly map out the data collected during the pilot study and why each data choice was made. I will go through the analysis based on the data collected, ending with a section on what was learned about the method of analysis from the pilot study. The ways in which the data were collected and analyzed for my dissertation study are discussed in greater detail in Chapter 3.

The Data

With so many various times the GTAs meet together to talk about teaching both formally and informally, there are many different places for rich data collection. I wanted a record of what was publicized so I had recordings of various events. Each event in which data was collected and analyzed for my dissertation study is discussed in greater detail in Chapter 3.

Professional Development Seminar. Before the term begins, faculty hold a three-day professional development seminar for all of the GTAs. During this seminar, many of the GTAs are introduced to active learning for the first time and are given the chance to practice teaching before the semester begins. It is led by several mathematics education researchers and the topics covered change slightly from year to year, so as to keep it relevant for both new and returning GTAs. However, attendance is optional for returning GTAs.

Professional Development Meetings All meetings between the mathematics educators who serve as the professional development leaders and the GTAs are important to capture as they are opportunities in which the GTAs, including the lead TA, are able to practice and discuss various teaching practices of leading a student-centered classroom directly with the experts.

Weekly Meetings with Coordinator The weekly meetings are when the GTAs discuss the activities for the following week and so it is a time when they can talk about teaching with other GTAs and the course coordinator. These meetings also provide a space away from the mathematics education faculty for the GTAs to reveal their interpretations of the teaching practices they are learning about leading a student-centered classroom through the ways they plan to enact the activity in the following week.

Break-out Sections For both the pilot study and the dissertation data collection, I only visited the activity day break-out sections as that was when there was greater opportunity for GTAs to publicize what they had learned in the professional development meetings on leading a student-centered classroom. Also, in an effort to reduce the number of sections I was visiting, I only visited the sections the lead TAs were observing. This enabled me to know what had happened in the class during the debriefs conducted by the lead TA and it lowered the number of times the GTAs were observed since I went with the lead TA instead of coming at a separate time. Furthermore, on days when the lead TA visited, the GTAs were likely to enact practices that they thought the lead TA expected to see. As a consequence, I obtained a better picture of what their interpretation of what a student-centered activity looks like.

Debriefings. Audio recordings were made by the lead TA during all debriefings he had with the other GTAs. These interactions were quite important to capture because it was a time in which the lead TA provided more direct advice to the other GTAs through his observations and suggestions. The debriefings provide insight into the ways the lead TA and the GTAs interpreted the professional development of leading a student-centered classroom, giving information about how the teaching practices may be co-constructed and possibly changed over time. I did not attend these meetings between the lead TA and the GTA who was observed as they tended to be evaluative, so the audio recording served as my data of that interaction.

The Analysis

The pilot data collection provided me with a large and rich data set to investigate an appropriate analysis for my dissertation. I began the analysis of the data with a grounded theory approach with open-coding (Strauss & Corbin, 1994), which is described in more detail in Chapter 3. As I was interested in tracking the changes in the discourse around various teaching practices discussed during the professional development meetings over time, the analysis of the data happened in stages. I will first go through the analysis procedure I did for the pilot study and then describe how it helped to inform the analysis methods for my dissertation study.

In the first stage, each event was transcribed as needed and the topic of each utterance (Bakhtin, Emerson, & Holquist, 1986) was recorded, starting with the debriefings between the lead TA and the other GTAs because it was a place where the lead TA would make it known what teaching practices he thought were most important. For instance, some of the teaching practices included items such as how to discourage student use of cell phones, how to form small groups randomly rather than self-selected groups, and time management. Through the discourse around these teaching practices, initial codes were created on the general professional development idea being discussed in each utterance and notes were written as needed. The transcripts were for each the event such as the debriefings, weekly meetings, classroom observations, and professional development meetings.

In the second stage, the various events were collected together around common codes from the previous stage. Those teaching practices that were discussed in the various events in a formal professional development setting form the corpus of data for Phase 2 of the analysis. In the pilot study, the two teaching practices I focused on were *how to ask questions to the whole class* and *how to facilitate group work within the individual small group*s. This phase also included the beginning of coding around the various aspects of the theoretical framework, described earlier in the chapter. For instance, the professional development meetings on leading a student-centered classroom with the mathematics educators were an area of collective participation with the GTAs and so they provided an opportunity for the GTAs to appropriate new teaching practices.

Finally, in the third phase, each teaching practice discussed through professional development was analyzed through the use of the theoretical framework, showing the way in which it was transformed over time and who publicized those transformations. Each change was recorded based on its placement within the framework and its temporal relation to the rest of the changes.

Through the experiences of collecting the data and analyzing it in the pilot study, changes were made for the dissertation study. Data was still collected from the same events in the professional development program, and a detailed explanation of the data collected is given in Chapter 3. The main changes occurred within the analysis portion of the pilot study. For instance, since there was data from the entire term for a total of 16 GTAs, the preparation of the data for analysis happened in temporal order. Furthermore, the data was separated into three chunks, with each chunk being open coded after it was transcribed. This enabled a coding scheme to be built while the data was still fresh in my mind. Finally, after the general coding for teaching practices was completed, a second round of coding was done to further separate the practices into sub-parts of some equal size, which were then coded using the Vygotsky Space framework. As with the data collection, a detailed explanation of the methods of analysis is given in Chapter 3.

Summary

Through the use of the pilot study, I was able to gain a better understanding of how the Vygotsky Space framework might provide insight into how understanding of various teaching practices develops within a community of GTAs. The GTAs have several formal opportunities to publicize their understanding of various teaching practices around leading a student-centered classroom. Furthermore, the lead TAs are in the unique position of being both a provider of and involved in the professional development, and so their experiences and contributions have the potential to greatly affect the transformation of the ideas over time. It is for these reasons that I studied not only the community of GTAs as a whole but also the ways the lead TAs shaped the transformations both within the GTA community as a whole and within their local community of Calculus I or Calculus II GTAs.

Significance

In this chapter, I have shown why it is important to give more attention to how the GTAs are appropriating and transforming the professional development on teaching they are receiving. It has only been in recent years that the educational research field has begun to focus on the importance of GTAs in the experience of undergraduates. As has been seen in past studies, graduate students are starting to play a significant role in the experiences undergraduates have with mathematics (Belnap & Allred, 2009). As such, a focus on how we are supporting GTAs in their role has become an increasingly important topic. While this is an important aspect of undergraduate education to focus on, the specific topic of Calculus holds a deeply important role in undergraduate education because of its influence on the continuation into STEM degrees. Hence, while change should be focused on the overall experience, much of the change in recent years has begun within Calculus programs and therefore, focus is needed within that particular topic.

My dissertation adds to the growing research base on the overall professional development of GTAs. This particular research field is still relatively small and there is much to learn. More specifically, this dissertation utilized a method for collecting data and analyzing it to learn more about the ways in which professional development of teaching is shaped by the GTAs who are using it in their classrooms. Having a better understanding of how these changes are occurring will give important insight into how to shape future iterations of a professional development program as a whole. Furthermore, my dissertation provides more information on the ways the lead TA program structure affects the collective understanding of the teaching practices discussed during the professional development, which is important in a time when this particular structure and shift in teaching is becoming more popular across the nation. Finally, this dissertation provides a cursory understanding of how changes in the discourse around teaching practices can occur within a mathematics department over time.

In the next chapter, I provide a deeper analysis of the background literature, including a discussion of the socio-cultural learning theory, the theoretical framework used in this study, the professional development offered to GTAs across the nation, and the specific case of the lead TA structure. In Chapter 3, I describe the methods I used in collecting the data for the dissertation study and how it was analyzed to answer the research questions provided earlier. Chapters 4 and 5 include analyses that can collectively answer research questions 1 and 2. Finally, Chapter 6 gives an overall picture of the results from this dissertation, their contributions and significance, and a look into future work around this topic and data.

Chapter 2: Literature Review

Research into graduate student professional development at the undergraduate level is still in its infancy. The little work that has been done within graduate teaching assistant professional development has involved national studies on the variation of professional development programs across the nation or studies on the structure of one particular program and its efficacy. In contrast, studies on professional development in K through 12 are abundant and could be used to inform studies done at the undergraduate level. In this chapter, I give an overview of the research that has been done regarding professional development of graduate teaching assistants (GTAs) along with informative research in the K through 12 professional development literature. I will also give an overview of the specific program structure, the lead TA or mentoring program, that is the basis of the program at San Diego State University (SDSU). But first I will give an overview of the theoretical perspective and the framework known as the Vygotsky Space so as to provide a theoretical basis to the rest of the chapter and the dissertation as a whole.

Socio-cultural Approach to Learning

During the early twentieth century, Lev Vygotsky was engaged in revolutionary work in which knowledge and learning were thought of as involving the social plane in an integral way while the rest of the world was still using behaviorism as the main theory of learning. His theories were publicized in the West in the 1930's, but it was not until many years later after his death that his theories became well known and, subsequently, helped to lead in the "social revolution" (Lerman, 2000).

When Vygotsky's theories became more widely known in the West in the 1970's, there was another popular theory known as constructivism, which was based largely on the ideas of

Jean Piaget (1947). He posited that the individual is constantly taking in particular aspects of the environment they are in and reacting in such a way as to maintain equilibrium (i.e. what the individual expects to happen does happen) with their environment, making the individual an active participant in their own learning (Piaget, 1977). Constructivists thought of the brain as being organized in specific ways based on the experiences the individual has had (Amarin & Ghishan, 2013). Furthermore, the way in which the mind organizes the world is based on the way it has organized itself. Vygotsky, in contrast to constructivism, focused more on the ways in which the individual affects the social environment as well as make sense of it. While Vygotsky's theories of learning do consider the ways in which the environment affects the individual (Forman, 2003), they also consider the ways in which the individual affects the environment.

Forman (2003) summarized the three key themes from Vygotsky's work, which form the basis for the socio-cultural (or socio-historical) learning theory. The first key theme is known as genetic analysis, which involves studying a phenomenon as it changes. Vygotsky believed that the way to understand psychological functions such as learning is to study the phenomenon as it changes. A second major theme is that all activity, including thought, is mediated through signs, such as the spoken and written language. Finally, the third major theme is the idea that knowledge is reflexively related between the individual and social planes, with each affecting the other. This way of thinking about knowledge and learning naturally creates connections between thought and language, both in how language (written and verbal) mediates thought and how individuals appropriate language through social contexts. Each of these three themes will be expanded upon throughout this section.

Genetic Analysis

As stated above, Vygotsky believed that for one to understand a psychological phenomenon, one must observe it in a change process. From this perspective, a researcher may work to create materials that are meant to disrupt or capture the changes as they occur. Vygotsky did not view learning as a process with an end state. Instead, he thought of learning as constantly changing through the reflexive interaction between the individual and the environment (John-Steiner & Mahn, 1996). For this reason, he called for a focus on how the psychological phenomenon, such as learning, changed.

For instance, a well-known concept from the socio-cultural perspective is the zone of proximal development (ZPD). The ZPD is the difference between one's actual development level (as determined by what an individual can do unassisted) and one's proximal (or potential) level (as determined by what one can do with the help of a more capable other) (Bunce, 2003; Forman, 2003; Moll, 1990; Vygotsky, 1987). The guidance through one's proximal level can be done by the teacher or by another, more capable peer. Figure 2.1 below provides a pictorial representation of the area between one's actual developmental level and one's level of potential development, which represents the ZPD.

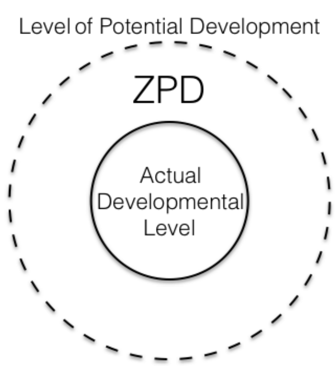


Figure 2.1: Pictorial representation of the ZPD.

The ZPD is continually changing as one learns and develops over time through a process known as internalization or appropriation. Appropriation is a gradual process that involves the teacher (or a more capable peer) guiding the individual towards independent competence (Ash & Levitt, 2003; Confrey, 1995; John-Steiner & Mahn, 1996). Gradually, the individual begins to take on more roles, sharing in the teaching/learning process with whomever is helping them along. Eventually, the individual is able to complete the given task independently and the more capable other becomes the supportive audience (Ash & Levitt, 2003; Brown & Ferrerea, 1985 as cited in Confrey, 1995). It is important to note that the process of appropriation does not add to any preexisting internal structure (John-Steiner & Mahn, 1996), as one might think of within constructivism; instead, the process creates a new plane with which a new ZPD is formed.

The appropriation process is not limited to the learner. There exists a co-constructed ZPD in which there are ongoing and changing interpretations of the ideas and actions of both the learner and the more capable other (Ash & Levitt, 2003). What is different between the appropriation process of the learner and the more capable other is how they use the co-constructed ZPD. The more capable other will take in what the learner is doing and respond to the learner using his or her expert understanding of the situation. Moreover, the more capable other will be increasing the level of his or her skills through helping another. In contrast, the learner is appropriating the skills and knowledge imparted by the more capable other and making sense of it through their own context so as to move towards upper levels of competence and development.

The co-constructed ZPD forms the basis for a theoretical framework known as mutual appropriation. In general, "when appropriation is reciprocal or multidirectional, the term mutual appropriation can be used to describe how teachers and learners together participate in the teaching/learning process" (Ash & Levitt, 2003, p. 6). As was explained in Chapter 1, mutual appropriation has the potential to add more detailed information into how the relationships between the GTAs affect their learning of teaching over time. However, this study is focused on the ways in which the discourse changes around various teaching practices as the individual interacts with the community rather than the changes ijn individuals as they interact with one another, with teaching practices being defined here and throughout as "what teachers do and think daily, in class and out, as they perform their teaching work" (Speer et al., 2010, p. 99). For example, asking students to justify their answer or anticipating student questions on a task would both be characterized as teaching practices with this definition. In contrast, a framework for breaking down teaching practices, such as the Five Practices for Orchestrating Productive Mathematical Discussions (Smith & Stein, 2011), would not be characterized as a teaching practice within this definition as the framework itself is not used which performing their teaching work. A deep analysis of the relationships between the GTAs and how this affected the changes observed in the discourse is a direction to consider for future work.

A common example of appropriation and transformation is the ways in which the language of a particular community is learned. Within the specific case of professional development, new graduate teaching assistants (GTAs) begin to appropriate the language of particular communities (such as the community of mathematics teachers) through the guidance of a more capable other, such as a professional development leader or a lead TA. In particular, the professional development leader may recast "the teachers' utterances into ways that may be more acceptable to the teaching community as a whole" (Forman, 2003). For instance, during the summer seminar an instructional student assistant (ISA) publicized an example of a practice that she had noticed in the example lesson they had just participated in in which the PD leader had moved forward with a suggestion from another student. Dr. S then went on to restate the teaching practice as "building and extending students' ideas," providing a more commonly used phrasing for the teaching practice for the GTAs to use in the future. Hence, through the guidance of the professional development leader recasting the new GTAs' utterances into forms accepted by the broader mathematics teaching community, the new GTAs are able to appropriate the formal language of the community.

Mediation

Language also serves as a way to transmit thoughts and ideas to others, either through spoken or written words. In this way, language serves as a type of mediation of our thinking. Mediation is the regulation of cognitive and social processes through tools including words, gestures, drawings, and models (Forman, 2003). Mediation also defines and shapes inner processes as well as connects the external world with internal human mental processes (Berger, 2005). The tools that mediate action help construct knowledge and hence, change as knowledge changes (Confrey, 1995). Much like a physical tool, such as a plow, works on the environment, culturally created signs are psychological tools that work on the mind (Frieson, 2012). Essentially, "agents without cultural tools are incapable of acting, on the one hand, and cultural tools do not mechanistically determine agents' actions, on the other" (Herrenkohl & Wertsch, 1999, p. 417).

As mathematics is a highly symbolic subject many times students are dependent upon the symbols given to them to mediate their thinking. For example, imagine a student has been asked to solve the following multiplication problem: 25×48. Many students would then proceed to solve the problem using the standard algorithm of multiplying the terms out using place value. As a researcher, one may have attributed the student as having a place value understanding when he or she used the standard algorithm and was able to clearly explain the various steps, but this understanding is also attributable partly to the meditational system.

Now, what if instead the student was handed the problem (XXV)×(XLVIII) and asked to solve it. Symbolically, it represents the same problem of 25 times 48. However, as most students are not taught to work with Roman numerals, the student may use a different method to solve the problem, such as repeating XLVIII 25 times and gathering the symbols together. For the researcher, it may be harder to attribute specific understanding to the student apart from their understanding that multiplication involves repetition. Hence, the knowledge researchers can attribute to the students they are observing is partly possible through culturally mediated tools, such as the Arabic number system.

For Vygotsky (1987), thought was not only mediated through physical entities, such as gesture and written language, but also through previously learned concepts. He specified two types of concepts or thinking: scientific and spontaneous. Spontaneous, or everyday, concepts involve everyday language and are not introduced in a systematic fashion. They are developed from bottom-to-top, starting with experiences and becoming generalized and abstracted. Furthermore, spontaneous concepts provide a basis for the development of scientific concepts. Scientific concepts are mastered through systematic instruction of basic knowledge and are presented as a system of interrelated ideas. Unlike spontaneous concepts, scientific concepts are developed top-to-bottom, starting with verbal explanation and becoming a more concrete phenomenon over time.

The development of counting is considered to be a spontaneous process whereas the development of the operations used on the natural numbers is considered to be a scientific process. The learning of counting takes place over time in a non-systematic fashion. Children learn counting through observing the ways in which the number of objects changes and slowly begin to appropriate the idea of numbers into their own psychological plane through the use of abstracting the numbers from concrete objects (Almoammer et al., 2013). In contrast, the development of the various operations performed on the natural numbers is systematic and typically is mediated through the use of concrete objects in the same fashion as learning to count. For instance, one might learn the concept of addition through the mediation of combining two groups of concrete objects. In other, more general terms: "The acquisition of scientific concepts is carried out with the mediation provided by already acquired concepts" (Vygotsky, 1987, p. 161).

In the case of professional development, the GTAs are coming in with their own everyday concept of what teaching is based on their past experiences as a student or possibly as a teacher in another position. Through professional development, the GTAs are creating scientific concepts by building on what the leaders are talking about and from their past experiences. It is through the mediation provided by their previous experiences that they begin to learn new methods of teaching and running a classroom. But this does not happen in a vacuum; instead, there is inherently a social to individual aspect to this learning.

Social to Individual

The main basis of the socio-cultural theory is that everything exists on the social plane before being appropriated or internalized by the individual and once the individual makes his or her thinking public, the social space is affected in turn. In this sense, the relationship between individual learning and the learning of the community the individual interacts with can be seen as transactional and co-evolutionary: "changes in one constitute resources and conditions for changes in the other" (Peck et al., 2009, p. 17). This idea can be seen in all aspects of the socio-cultural learning theory.

The main idea of genetic analysis, as it was stated above, is that to understand a psychological process, one must study it as it changes. In the case of learning, socio-cultural theory calls for the researcher to study the ways in which learning changes over time as well as how the reflexive relationship of the social and individual planes (Forman, 2003) affects learning. This is embodied within the idea of the zone of proximal development (ZPD). As was stated earlier, an individual's ZPD is continually changing as the individual interacts with a more capable other. At the same time, the ZPD of the more capable other is also continually changing as they interact with the learner (Ash & Levitt, 2003). Hence, the ZPD is an example of how learning can be seen as co-evolutionary between the individual and the more capable other.

Mediation is considered to be the regulation of cognitive and social processes through tools including language. In this sense, our thinking is mediated through our ability to describe our thinking through language, either verbal or written. In the same way, our ability to understand one another's thinking is mediated through language as well (Forman, 2003). The movement of thoughts and ideas from the social to the individual and back is mediated through language and would not be possible without mediation. Hence, mediation is also fundamentally related to the main theme of the socio-cultural learning theory of the reflexive relationship between the social and individual planes.

The reflexive relationship between the social and individual planes is essential to the Vygotsky Space framework as it describes the process by which individuals transform knowledge and how that knowledge becomes conventionalized (Peck et al., 2009). In the next section, the Vygotsky Space will be described in detail as well as how it has been used in other studies and how it is used in my dissertation study.

Vygotsky Space

Harré (1983), a social psychologist, is largely credited with the creation of the framework known as the Vygotsky Space. The framework was designed to explain development in general but it is also well suited to investigate the ways in which the individual creates their own psychological world under particular "conversational forms and strategies from that discourse" (Harré et al., 1985, as cited in McVee, Gavelek, & Dunsmore, 2007, p. 245). In this framework, Harré identified two dimensions: the individual-social and the public-private. The superposition of these dimensions creates a two-dimensional space in which to describe the development of an individual or an individual's learning over time, as seen in Figure 2.2.

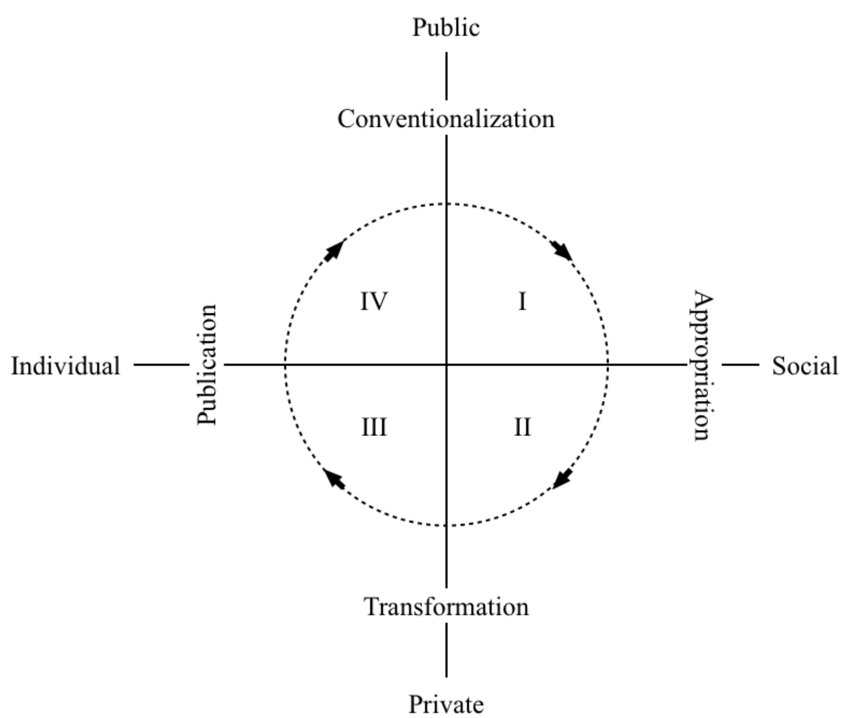


Figure 2.2: The Vygotsky Space diagram as described by Harré (1985).

The two dimensions create four quadrants, and it is the movement between these quadrants that describe transitions in development (Gavelek & Raphael, 1996). For instance, the movement from the first quadrant to the second is known as appropriation. In this, the person is taking up the concepts that have been introduced and used in the public-social setting of the first quadrant. This usage of the word appropriation is different from the standard usage in the socio-cultural literature described earlier. Within the standard literature, appropriation involves both the taking-in of the information and the transformation of that information. In contrast, the Vygotsky Space framework teases these two aspects apart so as to have appropriation mean simply the taking-in of the ideas, with the transformation coming in through the movement from the second quadrant to the third quadrant. In transformation, the individual is taking the concept he or she has appropriated and is modifying it to make it at least partially their own. When moving from the third quadrant to the fourth, the individual is engaged in publication, which is when that individual has made their meanings and strategies public for others to comment on, either through verbal or written language. Finally, the movement from the fourth quadrant to the first is known as conventionalization. In this, the "individuals' public manifestations of thinking (i.e., their actions and their ideas) are incorporated as part of the community of discourse in which they participate" (Gavelek & Raphael, 1996, p. 188).

In one particular study, a group of researchers used the Vygotsky Space to study language use within the classroom as well as its implications in the ways in which teachers and students discuss text. Through the use of observations of teacher-student interactions and book club meetings amongst the students, the researchers found that: "By examining students' publications, teachers can infer the process by which students transform meanings and strategies appropriated within the social domain, making those strategies their own" (Gavelek & Raphael, 1996, p. 188). What was important about this is that the researchers were able to show, using the Vygotsky Space framework, how talk changes amongst teachers and students through their interactions with one another.

In another study, using the Vygotsky Space framework, Gallucci and colleagues (2010) researched the ways in which an instructional coach learned both to teach and to coach other teachers. By studying an instructional coach both in his own classroom and in his interactions with the other teachers, the researchers found that "coaches are not unproblematic conduits of reform ideas but are also learners of new content and pedagogy" (p. 119). Furthermore, the researchers found that as the instructional coach's conceptual understanding of instruction grew, so did his capacity to coach others, and so they suggest that a professional development program for coaches would be best served if it focused on workplace pedagogy that addresses the learning needs of the coaches as well as the teachers. It was through the use of the Vygotsky Space that the researchers were able to make sense of how the learning took place for the instructional coach over time and how the community he interacted with affected his interpretation of the reform. The Vygotsky Space directed a focus on interactions rather than on particular individuals or communities, which helped illuminate the relationship between coach and teacher learning.

My use of the Vygotsky Space in this study is different from previous studies because the focus is on how the discourse around a teaching practice changes revealing how an individual's understanding of a practice changes through their interactions with others. This necessitated a change to the way the framework was used, which led to a modified version of the framework that was used in the analysis of the data in this study. A diagram of the modified version is given below in Figure 2.3. The modifications to the framework include a different way of defining transformation. Since the unit of analysis changed from a person to the discourse around a practice, and I wanted to attend to the meanings and whether the meanings had changed, I made a distinction between an elaboration of the practice and a transformed meaning of the practice. A complete explanation of elaborations and transformations is given in Chapter 4. Furthermore, the definition of conventionalization stays the same, but it may or may not occur, especially in the timeframe of the study. In other words, the meaning or motivation behind a practice may become normalized within the community or there may not be enough evidence to state that it has. An explanation of the qualifications for conventionalization is given in Chapter 5.

Much like the studies described above, the results from this work provide deeper insight into how GTAs learn to teach and what we can do to support this process. It is with this better understanding of how GTAs discuss, appropriate and transform the ideas that are the foci in the professional development that we can better support them in their teaching. Using the framework of the Vygotsky Space, we can better understand the development the GTAs go through in learning to teach as they engage with one another and with professional development, much as they do at the program at SDSU.

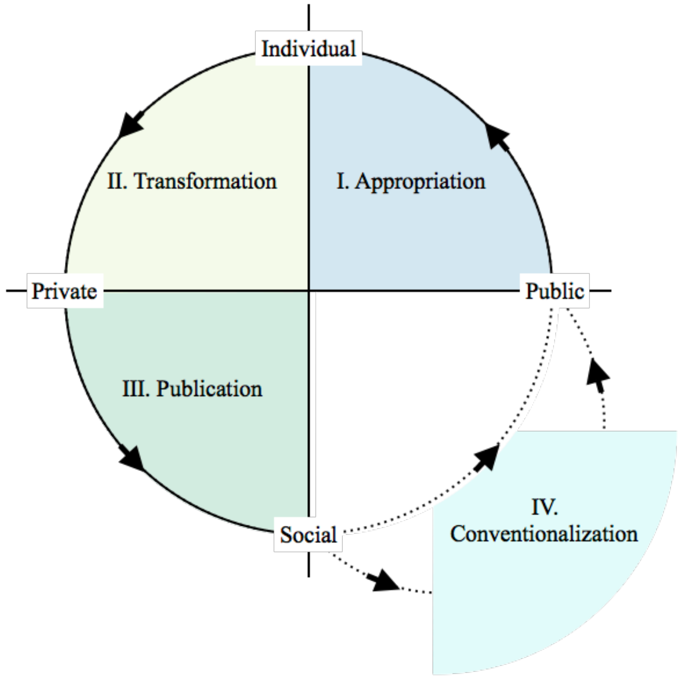


Figure 2.3: The modified Vygotsky Space.

In the program at SDSU, several changes were instigated to the Calculus program within the past year. Because of this, not only are the GTAs learning how to teach in a manner different than what they have experienced, the professors involved in teaching Calculus courses were working to change the way they think about the instruction of Calculus. The Vygotsky Space framework is able to capture at a new level the conceptions of the practices that are the focus in the professional development and help to develop future iterations of the program to make it stronger for years to come. In the next section, I focus more directly on this idea of professional development within Calculus programs and in undergraduate mathematics, in general.

Professional Development

There was a call for reform in College Calculus in the early 1990's (Ferrini-Mundy & Graham, 1991; Tucker & Leitzel, 1995) for more of a focus on depth rather than breadth of material covered. Curriculum materials for Calculus were developed with this focus in mind with the idea that it would be adopted across the nation as the new standard. However, professional development to support the adoption of these new standards was not part of the reform efforts and the new materials yielded mixed results (Ganter, 2001). In 1997, a seminar study examined why students leave STEM (science, technology, engineering, and mathematics) majors (Seymour & Hewitt, 1997). In this and subsequent studies, students cited their experience in Calculus as a top reason for switching out of STEM majors (Chen & Weko, 2009; PCAST, 2012; Seymour, 2006), the focus returned to the teaching of college calculus. As a result of the growing population of students attending college, universities have increased the number of large sections (150+ students) and employ graduate students as teaching assistants, increasing the impact the graduate students have on the experiences of undergraduate students (Luo et al., 2001). Furthermore, Speer, Murphy, and Gutmann (2009) estimated that more than a third of undergraduates will have a TA as a mathematics instructor. Even with this increased impact that GTAs have on the experiences of undergraduates in college calculus, the research base on how graduate students are being trained and supported in their new teaching roles is still small, but it is growing.

In a study done by Belnap and Allred (2009), universities across the US were surveyed about their use of TAs, the demographics of those TAs, and the teaching preparation provided the TAs. From the information gathered, they found that 97.8% of doctoral institutions and 62.5% of masters institutions utilized GTAs in some way. The different levels of teaching assignments ranged greatly, and included being the sole instructor of the course, team-teaching the course with a faculty member, leading a discussion or lab section, and “other” which included duties such as acting as the grader for a course. Researchers in a national study known as the *Progress Through Calculus* (PtC), which looks beyond Calculus I to include the sequence of courses from Precalculus to Calculus II, surveyed departments across the nation asking whether they had some form of professional development for their GTAs. The initial results of the study have shown that approximately 81% of PhD granting institutions and 45% of Masters granting institutions offer professional development of some form to their GTAs (Ellis, Deshler, & Speer, 2016).

Within the various studies done on the range of professional development programs available for GTAs, the data descriptions fall into one of three categories: temporal, structural, and topical. Temporal studies describe the duration of the professional development and how they vary across the nation. In structural studies, the researchers provide an analysis on the various ways the professional development of GTAs is structured in programs across the nation. Finally, a list of the topics focused on within each of the professional development programs is given within the studies with a topical focus. Each of these will be discussed further below, with a final discussion on efficacy studies.

Temporal

The study done by Belnap and Allred (2009) identified several different types of preparation programs among those who had such programs for GTAs. These included *initial programs*, *recurring programs*, *orientation systems*, *transitional systems*, and *sustained professional development systems* (see Figure 2.4 for a visual of how these programs are related). Within the *initial programs*, there are *orientation programs*, which only occur at the beginning of the term, and *transitional programs*, which take place partly before and partly during the term to provide a transition into the course the GTA was assigned to teach. These programs tended to be one-time events varying from a few hours to a few days in length. Within *recurring programs* there are *refresher programs*, which are usually short, much like transitional programs, but happen repeatedly at the beginning of each term, and *establishment programs*, which last throughout the term and GTAs are expected to participate in them each time they teach a course. These programs have repeated participation, whether yearly, by term, or when teaching a new course. *Orientation systems* are a combination of initial-refresher programs that recur each term that a GTA teaches. *Transitional systems* are a combination of initial-refresher programs, as well, but only occur when the GTA is teaching a new course. Finally, *sustained professional development systems* are a combination of initial programs or refreshment programs and involve an establishment program.

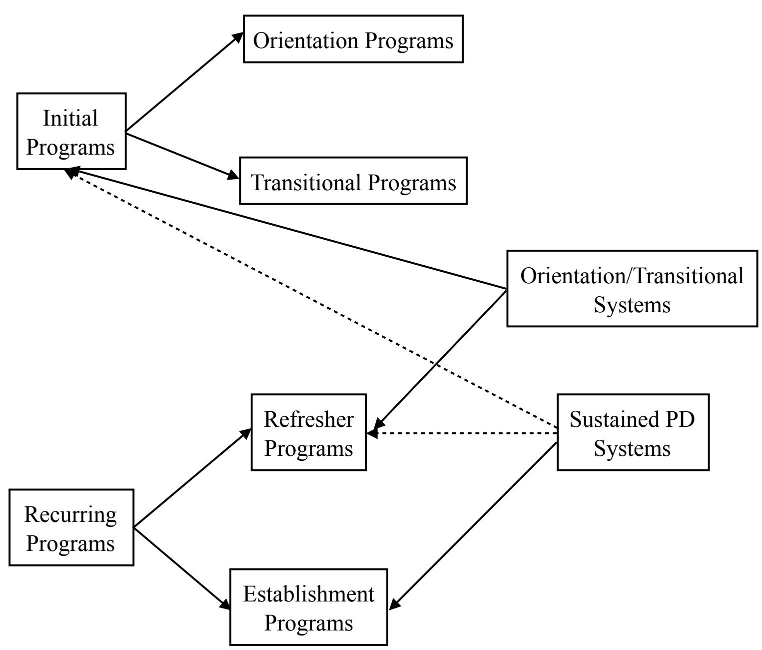


Figure 2.4: The relationships between the various types of professional development programs, with the arrows indicating types of those programs and systems.

The program at SDSU is considered an example of a sustained professional development program. At SDSU, all of the GTAs participate in a three-day seminar before the academic year begins, which is known as an initial program. Additionally, any GTAs who are new to the course during the second semester of the academic year participate in a shortened version of this seminar, so they also have some kind of initial program before beginning to run their own class. Furthermore, the GTAs for Calculus I and II at SDSU participate in sustained professional development throughout the academic year. During the 2016-17 academic year, this was the form of a course with a mathematics education researcher taking the role of the professional development leader.

Structural

Palmer (2011) focused more broadly on the structure of preparation programs. During the summer and fall of 2009, existing GTA professional development programs at 283 different PhD granting institutions were studied for commonalities of their structures. Through the use of email contact with the institutions and internet searches on the variations of preparation programs offered to GTAs, the researchers found six major themes: 1) teaching assistant preparation programs, 2) lead TA/mentor programs, 3) higher education pedagogy courses, 4) teaching certificate programs, 5) preparing future faculty (PFF) and PFF-like programs, and 6) higher education teaching minors. Of those universities in the study, 22.8% of them used a lead TA/mentor style program, similar to the program of this current study and will be described in greater detail in a later section.

Robinson (2011) focused directly on the structure of GTA orientations by contacting mathematics departments at 20 universities and asking faculty to fill out a short email survey. Of those 20 contacted, 17 responded and he used their responses to find similarities and differences between their professional development programs. All of the departments offered an orientation of some sort to their TAs but only eight made it a required activity. Furthermore, it was most common for the orientation to last only one day, with eight stating that was their average length. The topics covered in orientation varied greatly amongst the 17 institutions, ranging from professional development to policies. However, Palmer did state that the variation may be a product of the sample size.

Apart from reporting on the results of surveys, various taxonomies have been created to describe the different professional development programs seen across the nation. However, it is the one created by Palmer (2011) that is used the most often in the literature. He distinguishes between three main domains of professional development programming: Teaching Assistant Development, Overall Teaching Development, and Broad Professional Development. Furthermore, he breaks up each of these into the scope of the PD and the commitment required of those participating in the PD. Figure 2.5 below shows this taxonomy and Table 2.1 gives various examples of programs within each of the different areas of the taxonomy suggested by Palmer (2011).

Lead TA programs, which is format of the program at SDSU, are considered to be a teaching assistant development program with broad scope/high commitment (Palmer, 2011). What this means in part is that the lead TA program is focused on GTA development specifically instead of more broadly on professional development for their future job overall. Furthermore, it means that lead TA programs cover a broad number of topics within teaching and require a high level of commitment from those involved, especially those who serve in the lead TA position. In comparison, a one-off workshop would be considered to be a GTA development program with narrow scope/low commitment.

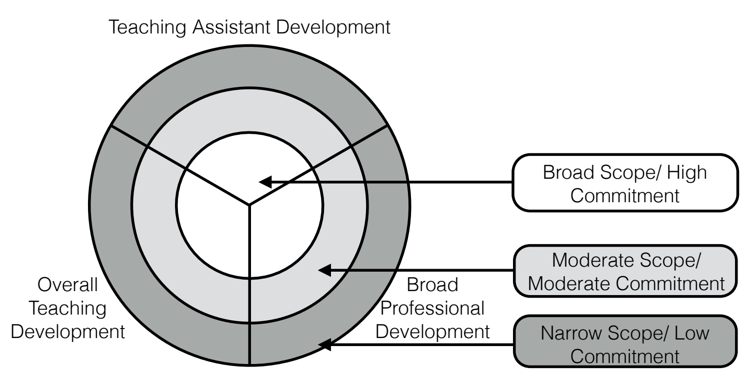


Figure 2.5: Pictorial representation of a taxonomy of professional development programs.

Table 2.1: Taxonomy of professional development programs by Palmer (2011).

	Broad Scope/ High Commitment	*Moderate Scope/ Moderate Commitment*	*Narrow Scope/ Low Commitment*
Teaching Assistant Development	Lead TA/mentor programs	TA orientations	Ad hoc, one-off workshops
Overall Teaching Development	Teaching minors	Teaching certificates	One-time consultation
Broad Professional Development	PFF/PFF-like programs	Workshop series	Print or web-based informational resources

A second taxonomy of GTA programs was created by Ellis (2014) for her dissertation work on GTA professional development programs across the nation. This study also explicitly utilized a theoretical framework in the analysis of the data. Ellis utilized situated learning (Lave & Wenger, 1991) as a way to explain the variations in the types of professional development programs. In her framework, there are six main aspects of GTA programs: 1) institutional and departmental context, 2) institutional and departmental culture, 3) structure, 4) development of knowledge and practices, 5) evaluation, and 6) implementation. A pictorial representation of the framework and the connections between the six aspects can be seen below in Figure 2.6.

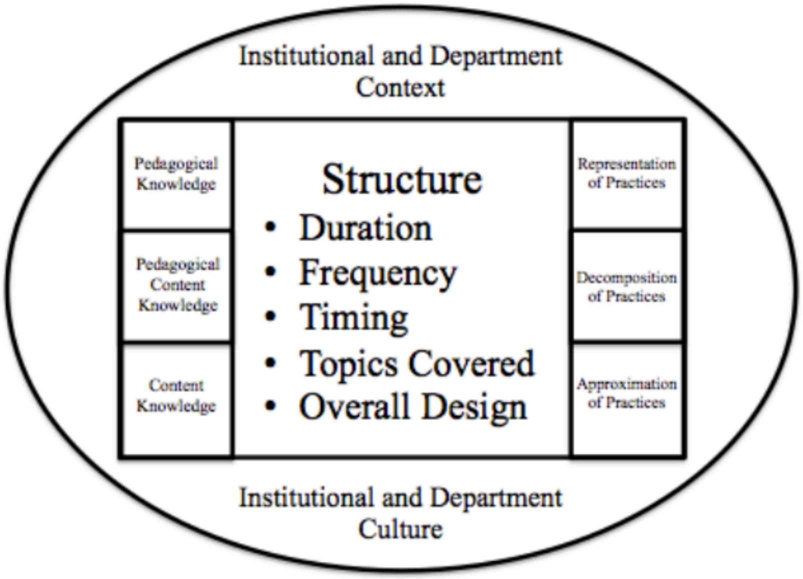


Figure 2.6: Ellis (2014) framework of the main aspects influencing a GTA program.

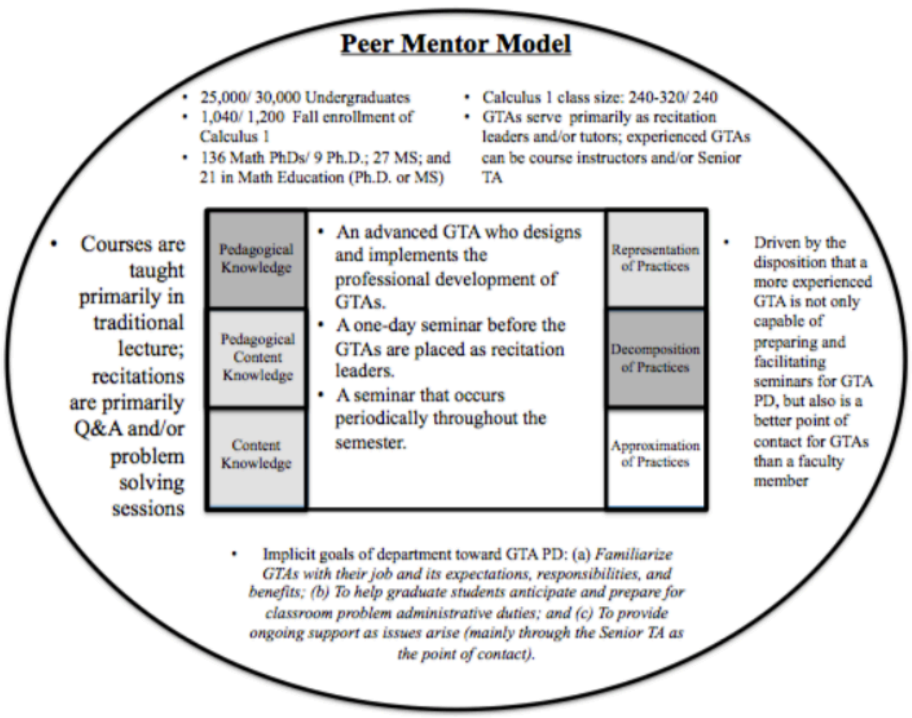


Figure 2.7: A representation of a peer-mentor program using the Ellis (2014) framework.

As an example of this framework used for a different peer-mentor, or lead TA, program than the one at SDSU, consider Figure 2.7 above. The information surrounding the inner area is the context in which the GTA program is situated. It includes the institutional context and the departmental culture that affect the program both implicitly and explicitly. On either side are different aspects of knowledge and practice needed to lead a classroom and the darkness of the grey represents the amount of focus provided those aspects. Inside the inner area is a description of the GTA program itself. Altogether, the framework gives a comprehensive overview of a GTA program, providing a condensed way of learning about many aspects of varying programs.

Recently, this framework has been used to help inform a new taxonomy of various GTA professional development programs. In a study done by Bragdon, Ellis, and Gehrtz (2017), they found nine distinct models of GTA programs within 120 different mathematics departments. These different models were distinguished from one another based on the level of interaction involved in the program and the amount of activities involved in the professional development. Table 2.2 below gives a basic overview of the various different models and the number of programs within each category. The interaction level was determined by the institution’s answers to questions 1 and 2, which focused on the amount of time GTAs participate in a PD program. The activities level was based on the number of opportunities provided to the GTAs to obtain feedback on their teaching from peers, PD leaders, and faculty.

Based on their categorization, the program at SDSU would be characterized as a Model 8, with a high level of interaction (seminar before the academic year and a course throughout the first two terms of teaching) and a medium level of activities (reading research on student thinking, practice teaching, and observations from a more experienced GTA). As can be seen in Table 2.2, 11 programs were categorized as Model 8, making it the fourth most common type of professional development program, along with Model 3.

Table 2.2: Nine models of GTA professional development programs, recreated from a study done by Bragdon, Ellis, and Gehrtz (2017).

Model Name	Interaction Level	Activities	Number of Programs
Model 1	Low	Low (0-1)	9
Model 2	Low	Medium (2)	13
Model 3	Low	Medium (3)	11
Model 4	Medium-Mixed	Low (0-1)	15
Model 5	Medium-One Semester	Low (0-1)	27
Model 6	Medium	Low (1-2)	15
Model 7	Medium	High (4-5)	9
Model 8	High	Medium (2-3)	11
Model 9	High	High (4-5)	10

Topical

Researchers have collaborated to create curriculums for GTA professional development through the use of key components of the socialization process of GTAs into the profession of teaching. For instance, through a meta-analysis of previous studies, McDaniels (2010) created a list of four major categories of topics that would best serve GTAs: conceptual understandings, knowledge and skills in the core areas of faculty work, interpersonal skills, and professional attitudes and habits. While there was no theoretical framework explicitly stated, there was mention of the interactions between the social and individual planes, which references the socio-cultural perspective used in this dissertation. Many of these refer to the profession of professor as a whole and overlap with the list of seven competencies developed by Kalish and colleagues (2011):

1. Graduate and professional students will gain knowledge of how people learn and how to teach consistently with these principles of learning, using a variety of techniques appropriate for the discipline, level, and learning context.
2. Graduate and professional students will learn how to consistently set and communicate learning goals and expectations, both for individual class sessions and the overall course, that are appropriate for the discipline, level, learning context, and the institutional curriculum.

3. Graduate and professional students will learn how to assess student learning responsibly, equitably, and in alignment with learning goals and use the results to enhance student learning.
4. Graduate and professional students will learn to assess and improve their teaching performance through inquiry-based practice informed by a community of scholarly teachers.
5. Graduate and professional students will situate their practice and potential career choices within the contexts and culture of postsecondary disciplines and institutions.
6. Graduate and professional students' teaching practice will be guided by an understanding of ethical issues and codes in postsecondary environments.
7. Graduate and professional students will learn how to teach with attention to diversity and inclusion of multiple perspectives so that every student has the opportunity to learn. (Kalish et al., 2011, pp. 165–166)

The seven topics outlined above will not necessarily come from a single source of professional development. For instance, within the context of SDSU, the GTAs discuss grading with their coordinators during the weekly meetings, and thus learn the third topic from the interactions that GTAs have with each other and the course coordinator rather than in the formal professional development offered prior to the semester. Additionally, the instructor for the professional development course at SDSU included various opportunities for the GTAs to reflect on their teaching and the teaching of others through the use of peer observations and videotaping their teaching. Finally, the pilot data analysis revealed that the lead TA tended to focus on ways to keep the focus on the goals of the class and the activity in his debriefings with the GTAs, which addresses topic number two above. So, the GTAs can learn from not only the professional development leaders during the three-day summer seminar but also from fellow teaching assistants, course coordinators, and professors within the program.

Efficacy

The last commonly seen type of study within the professional development of GTAs are efficacy studies. However, very limited work has been conducted on what is learned from various professional development programs. In a study done by Griffith and colleagues (2010), students were interviewed six months after they completed a pedagogy course to capture what information was retained by the GTAs in the course. The researchers believed that six months provided enough separation from the course so as to observe the influence it had on their teaching but not such a long separation so as to have other, more substantial influences over take the course. The course was optional and so one could argue the students were already motivated to become better teachers, making them more invested in continuing to work on their practice. The researchers did find that the graduate students seemed to have become more reflective on their practice through participating in the class. However, the course involved 10 students and only 6 agreed to participate in the interviews and so the results can at best be taken as a possible example.

Marbach-Ad and colleagues (2010) published their findings of the usefulness of a course for TAs teaching for the first time. Through the use of pre- and post-surveys, the researchers found that the students felt that the course had exceeded all expectations. The researchers gathered data about the efficacy of the program by asking the GTAs what topics they felt were the most and least useful. The three topics that were described by the GTAs as the most useful were "war stories" coming from returning GTAs, academic dishonesty, and time management. On the other side of the spectrum, the three topics the GTAs labeled as the least useful were quiz writing, elements of a syllabus, and grading using rubrics. In addition, an educational researcher conducted a review of the course and noted the openness of the instructors, which allowed for a safe environment for the new GTAs, and the way in which the course seemed to build a community between the students.

In recent years, more studies have been conducted on the efficacy of various professional development programs by focusing on what GTAs learned through programs that emphasized particular frameworks or research-based strategies. During the Research in Undergraduate Mathematics Education (RUME) conference in 2017, there were five different studies presented that involved examining what GTAs learned from a particular professional development program. The study done by Pascoe and Stockero (2017) focused on the results of an intervention in which the GTAs learn about a noticing framework and how to use it while watching videos of teaching. Reinholz (2017) and Wakefield and colleagues (2017) focused on the use of reflections in the development of teaching in GTAs, with Reinholz also looking into the role of peer feedback. Each of these studies focused on a cognitive approach to learning. My study differs from these because it was an in-depth study into how the changes in understanding about various teaching practices occurred over the course of the semester rather than focusing on the overall changes.

Furthermore, Speer, Deshler, and Ellis (2017) presented results from a study done on the ways departments are evaluating the undergraduate student outcomes from their GTA professional development programs. With this greater focus on GTA professional development programs, ways to evaluate their efficacy is an important aspect that has not been widely studied. Their results showed that many departments are relying on student evaluations to evaluate the teaching of their GTA's, which has been shown to be an ineffective measure of teaching (Krautmann & Sander, 1999).

Finally, during the same conference, results were presented from an ongoing study that is similar to what is being investigated in this dissertation. Beisiegel (2017) presented her preliminary results of the ways in which GTAs develop as teachers over the course of their graduate program. Through the use of surveys and interviews with GTAs spanning first through fifth years, there were results that suggested GTAs "have more advanced thoughts about teaching in their third and fourth years" (p. 1137), which are linked to their use of active learning strategies. GTAs in their first year were more likely to talk about "surviving" their first year of teaching rather than about ways they incorporated active learning strategies they had learned in the professional development seminar. The data presented were based on a single year of surveys and interviews, with the goal to continue to collect data on the same GTAs as they continue through their program.

My study differs from those described above because it is not an efficacy study. I did not evaluate the teaching of the GTAs in my study nor did I place an evaluation on the PD program as a whole. The focus in this study was on how the GTAs interpret and transform their understanding of teaching practices introduced in professional development as evidenced by their discourse about the teaching practices.

Lead TA Structure

As mentioned earlier, the lead TA structure is in greater use in mathematics departments across the United States. This is not only true at the collegiate level; more and more districts across the nation have begun to implement versions of the lead TA structure, called peer mentoring, to help implement various reform efforts. In this section, I will discuss the lead TA/peer mentoring structure in more detail, pulling from both the K-12 literature and the more current work done at the undergraduate level.

In the K-12 literature, the lead TA structure is known as "coaching" or peer mentoring and is common amongst several disciplines, including science, mathematics, and literacy. In a 2012 national study of the state of mathematics and science education, it was found that approximately one-fourth of schools offer coaching in mathematics and approximately one-fifth of schools offer coaching in science (Banilower et al., 2013). Both teachers and administrators typically provide the one-on-one coaching, but it is more likely that a teacher serves as the role of mentor. In mathematics education, the common structure is peer coaching in which two teachers are paired up and coach one another. They visit each others' classes and provide each other with feedback. There is evidence that peer coaching can support reform goals, however the research into the effect peer coaching has on various reform efforts has yet to be conducted (Gallucci et al., 2010).

Coaching has been used to represent many different aspects of instructional leadership. Taylor (2008) discussed the various dimensions of instructional leadership (or an instructional coach as he refers to it), showing the variety of ways instructional coaching can be implemented. There are many aspects that go into being an instructional coach but overall, research has shown that instructional coaches can make a significant positive impact on both teachers and students alike (Bruce & Ross, 2008; Busher, 1994; Licklider, 1995). In Table 2.3 below, I show certain aspects of the dimensions of instructional coaching as they relate to the temporal and structural elements of instructional coaching.

Table 2.3: Temporal and structural dimensions of instructional coaching.

Dimension	Classification
Temporal Dimensions	
Frequency	Continuous ↔ Regular or periodic ↔ Rare
Span	Multiyear ↔ One year ↔ Less than a year
Structural Dimensions	
Type of coachee	Novice ↔ Learner ↔ Expert
Orientation	Active ↔ Passive
Style	Directive ↔ Facilitative
Form	Technical ↔ Collaborative ↔ Problem-solving ↔ Simple support

This table can be used to quickly see the overview of a lead TA program within the temporal and structural aspects of the program. For instance, Table 2.4 shows how the program at SDSU would fit within these dimensions through highlighting the various aspects of the format of the program. The program at SDSU is only one example of how a lead TA program could be structured. Just as with K-12, the format of coaching can vary greatly within undergraduate education. Within the temporal dimensions, coaching (or lead TA) programs vary on the frequency with which the TAs meet and the span of the program. In some programs, such as the one at SDSU, the GTAs have regular access to the lead TA. The lead TA makes regular visits to the other GTAs classes and is present at all weekly meetings. In other programs, the lead TA may only be seen at the beginning of the term. They may be accessible for the rest of the term to the other GTAs but not typically in a formal setting.

Table 2.4: Temporal and structural dimensions of the lead TA program at SDSU.

Dimension	Classification
Temporal Dimensions	
Frequency	Continuous ↔ Regular or periodic ↔ Rare
Span	Multiyear ↔ One year ↔ Less than a year
Structural Dimensions	
Type of coachee	Novice ↔ Learner ↔ Expert
Orientation	Active ↔ Passive
Style	Directive ↔ Facilitative
Form	Technical ↔ Collaborative ↔ Problem-solving ↔ Simple support

Furthermore, at SDSU the lead TA holds their position for as many years as they are a graduate student at the university. Since SDSU is a Masters granting institution, many of the GTAs are only available to run a section for at most two years. However, generally they only hold the position for a semester or two before they are working only on research or they graduate. Having the lead TA hold the position for as long as they are a graduate student at SDSU gives a form of stability to the program since there is at least one graduate student who has been involved in the professional development and the teaching of Calculus I or II for approximately two years. In other programs, the lead TA holds their position for a year but may have spent the prior year being trained for the position by the previous lead TA (Ellis, 2015).

Structurally, a common theme can be found amongst the lead TA programs: a GTA (or faculty member) serves as a mentor for others within various aspects of teaching. There are programs in which there is one lead TA for all of the GTAs teaching a particular course (as is the case for the program at SDSU), one lead TA for all GTAs teaching with a junior GTA in training to take over the lead TA position (Ellis, 2015), a mentoring program between faculty and GTAs (Schram & Wright, 2011), and others.

Taylor (2008) studied a variety of coaching programs with similar structures to that of lead TA programs. The main element of instructional coaching that Taylor focused on was that of observation. With that in mind, he classified any leadership position with an element of observation to be (sometimes loosely) a type of instructional coaching. However, he does provide a more detailed definition that more closely resembles the format of the lead TA program at SDSU, and it is given below in the summary.

Summary

As the structure of lead TA programs are similar in their variety as the programs studied by Taylor (2008), I adapted the definition of instructional coaching he put forth:

> *Instructional coaching* – one form of instructional leadership – is characterized by nonsupervisory/nonevaluative individualized guidance and support that takes place directly within the instructional setting. This support is intended to promote

> teachers' learning and application of instructional expertise. (p. 12, original italics)

Based on this definition of instructional coaching, I define a lead TA as the following:

> The lead TA position is characterized by nonsupervisory/nonevaluative individualized guidance and support that takes place directly within the instructional setting. This support is intended to promote GTAs' learning and application of instructional professional development.

To be clear, nonsupervisory/nonevaluative means the lead TA does not hold "power" over the other GTAs and they do not provide evaluation of the GTAs teaching. Instead, they provide suggestions and support for improvement.

The lead TA structure involves a large amount of social interaction between the GTAs, the course coordinators, and the professional development leaders. Together they are co-constructing the content and format of their professional development program. Through the coordination of their past experiences and their social interactions, they appropriate understanding of teaching practices and transform the discourse around various teaching practices within an active learning classroom to fit their own unique situations and the situation of the local community. As learning is mediated through language, others in the community hear individuals' publications of their understandings, which in turn affect the social plane.

In the next chapter, I will provide a detailed account of how I studied the ways in which the professional development on teaching practices in an active learning classroom transformed over time through the various interactions the GTAs had with each other and others involved in the Calculus I and II courses at SDSU. I give a description of the various methods that were used to collect and analyze the data as well as how that analysis helped to answer the research questions introduced in Chapter 1.

Chapter 3: Methods

In Chapter 1, I began the discussion of my methods by going through the methods used in the pilot study and how that informed my dissertation. In this chapter, I begin by discussing what the situation was at San Diego State University (SDSU) during the semester I collected data along with how the program changed from its structure before the reform efforts began. I then discuss the various data collection sources and the data collection time line as it occurred throughout the semester. After, I give an overview of the way the data was analyzed to answer each research question and discuss how the methodology helped to address the research questions.

The Situation: A Program in Flux

In Chapter 1, I gave a brief description of the situation within the Calculus program during the study and how it had changed from previous years. In this section, I will be going into more detail about the way in which the Calculus program at San Diego State University (SDSU) evolved. I begin with an outline of the way Calculus I and II was organized before the 2015-16 academic year. I then discuss the impetus for the changes that began in the 2015-16 academic year and end with how the program was organized in the 2016-17 academic year when data collection took place.

The Before Picture

Before the 2015-16 academic year, Calculus I and II at SDSU were taught in large lectures of 150 students or more, with separate break-out sections that occurred once a week and were run by a graduate teaching assistant (GTA). These sections had approximately 40 students with each GTA supporting 4 to 6 sections, resulting in each GTA responsible for more than 200 students (Apkarian, Bowers, O'Sullivan, & Rasmussen, in press).

There was no formal professional development at SDSU for the GTAs in the mathematics department. Instead the decisions on how to support the GTAs in their teaching was up to the instructor of the course (O'Sullivan, 2016). Furthermore, the Calculus program was not coordinated and so there was no faculty with whom the GTAs met weekly. Instead, the GTAs met with the instructor of the course they were assisting if the instructor chose to have a meeting. Generally, according to the GTAs, they only met occasionally with their instructor and the discussions tended to be about administrative issues, such as grading the exams.

The Impetus for the Changes

Before the 2015-16 academic year, the mathematics department at SDSU began looking into the results of the data collected on grade distributions and teaching evaluations in Calculus. It was generally known that there was a low passing rate within the Calculus sequence (Apkarian et al., under review). Consequently, the department decided to implement a large number of changes to the Calculus program based on the results from the *Characteristics of Successful Programs in College Calculus* (CSPCC) (Bressoud, Mesa, & Rasmussen, 2015) study done over the previous five years. In this national study, programs that were determined to be successful through analysis of a national survey were further visited by researchers for classroom observations and interviews so as to better understand what made them particularly successful. Researchers deemed a program to be successful in part based on the rate of students passing Calculus I and whether or not students who started the semester with the plan of taking Calculus II still had that plan after the semester was over, also known as the rate of persisters (Rasmussen & Ellis, 2013).

The recommendations from the study were as follows:

1. Attention to effectiveness of placement procedures.

2. Proactive student support services, including the fostering of student academic and social integration.
3. Construction of challenging and engaging courses.
4. Use of student-centered pedagogies and active-learning strategies.
5. Coordination of instruction, including the building of communities of practice.
6. Effective training of graduate teaching assistants.
7. Regular use of local data to guide curricular and structural modifications. (Bressoud et al., 2015, p. viii)

Of particular interest to this study are the fourth, fifth, and sixth recommendations as they are the ones directly affecting the GTA program in this study[2]. However, some of the recommendations may have had an effect on the GTA program, albeit less directly. For instance, the mathematics department has begun using ALEKS (Falmagne, 2018) as a way of placing the students into a course best suited to their mathematics preparation. Based on the results from ALEKS, the students in the sections the GTAs are leading have been deemed ready for Calculus. However, until more analysis has been done by the mathematics department, its effect is uncertain.

After: A Picture of the 2016-2017 Academic Year

In the 2016-17 academic year, Calculus I and II still met in large lectures of approximately 150 students. The lectures were taught by tenured faculty and experienced instructors. Each of the courses had a tenured faculty as a Calculus coordinator to work with the GTAs and to create common exams with the other instructors. The coordination can be described as *coordinated independence* (Rasmussen & Ellis, 2015) because aspects of the Calculus program were coordinated (e.g. common textbook, common exams, etc.) but other aspects were independent (e.g. instructors chose what to emphasize, what homework to assign, etc.). The

[2] While the department is working to incorporate other recommendations into their program, I will not be focusing on them here.

researchers from the CSPCC found that changes to the department came easier with this type of system in place because of the feeling of independence (Rasmussen & Ellis, 2015).

Each week Calculus students went to two break-out sections instead of one. The first section resembled the break-out sections described in the "before" picture: the GTA was to discuss the homework and go over topics from the lecture as needed. The second break-out section involved GTAs engaging students in active-learning, which was related to the fourth recommendation from the CSPCC (Bressoud et al., 2015). In this second section, the students were given challenging, group-worthy tasks (Lotan, 2003) and were asked to work in groups to solve the problems. The problems were related to the lectures in their class but were meant to challenge the students and, at times, give them a more conceptual view of the material. It was also intended to be a place where the students could explore difficult topics from the course more deeply with their classmates than they could in the large lectures.

The GTAs also functioned with coordinated independence (Rasmussen & Ellis, 2015). The coordinators for Calculus I and II met with their GTAs once a week to discuss administrative topics and the activity for the coming week. The meetings typically lasted for 30 minutes to an hour and all GTAs who were available attended the meeting. They all implemented the same activities in their class each week. However, they also had some autonomy in the ways they presented the activity and what they emphasized in their sections.

Many of the GTAs that were expected to lead active-learning classrooms had little to no experience teaching in a student-centered way nor had they had much, if any, opportunity to experience it themselves as students. The department realized the need for change in the professional development of the GTAs so they could be successful in these active classrooms (O'Sullivan, 2016). This shift to prepare them to lead student-centered classrooms meant a professional development program needed to be developed to support GTAs. Another change that was instigated was a change in the structure of the GTA program. The department appointed a lead TA each for Calculus I and II; they were expected to organize peer visits with their fellow GTAs and serve as a liaison between the GTAs and the coordinator of the calculus course or the department as a whole (O'Sullivan, 2016). The lead TA structure was one of the structures used by programs described by Ellis (2015) that were deemed successful by the CSPCC (Bressoud et al., 2015).

The lead TAs were chosen for Calculus I and II based on their prior experience with teaching an active learning section as well as experience in a course that was taught in a student-centered way. These lead TAs can hold their position as long as they are a graduate student at SDSU. As SDSU serves many more Masters students than PhD students, this generally means that it is likely they will hold the position for no longer than two years. Both lead TAs in the study were in their second year serving in this position.

Each lead TA visited his fellow GTAs twice during each semester. The sections they visited were the activity day sections since those were the times the GTAs most needed support with active learning strategies. During my dissertation data collection, the lead TA for Calculus I observed his fellow GTAs in chunks over two weeks, twice during the semester. During each observation, he would take detailed notes on his computer and after each observation, he would work to schedule a time to meet with the GTA to talk about what he had observed. In the first round of observations, he met with each GTA but in the second round of observations, he was only able to schedule a debriefing session with one GTA. The lead TA for Calculus II observed two of his fellow GTAs each week, with a week or two break between the first and second rounds. During each observation, he hand-wrote notes using an observation guide he had created based on a three-day seminar in which he participated in (Appendix C). Directly after each observation, he met with the GTA for approximately five minutes to talk about the section.

For the 2016-17 academic year, the GTAs for Calculus I and II were provided with support to develop their practice. Approximately half of the GTAs were new and half were continuing their job from last year, so the professional development reflected their diverse needs[3]. First, they met for a three-day seminar before the term began during which the GTAs discussed techniques for leading an active learning classroom with three mathematics education researchers who have been deeply involved with the creation of the professional development program for the GTAs. The seminar also provided opportunities for the GTAs to practice various techniques with each other and to prepare for their first couple of weeks of classes.

Second, during the semester, the same GTAs met with one of the mathematics education researchers for a course on successful teaching in a student-centered classroom. The class meetings gave the GTAs an opportunity to discuss various techniques with one another and reflect on how their classes had gone in previous weeks. The faculty who led the course also assigned readings on various active learning teaching techniques. A syllabus for the course can be found in Appendix B.

Third, in addition to the course, the GTAs met weekly with their course coordinator to discuss aspects of the course, including administrative aspects (such as midterms and grading), as well as to discuss the activity for the following week and how the activity from the previous week went. The meetings typically lasted for 30 to 45 minutes at a time for the Calculus I GTAs and 45 minutes to an hour at a time for the Calculus II GTAs. All GTAs who were available for

[3] The returning GTAs participated in a three-day seminar the summer before and two to three 2-hour seminars during the academic year.

the meetings attended, with only a couple of GTAs unable to make the meetings due to scheduling conflicts.

The coordinators for Calculus I and II taught at least one section of the course and so much of the planning with the activities was based on what was going on in their specific section of the course. Usually the other instructor or instructors covered the same topic at the same time but when there was a sufficient amount of difference, the GTAs during the weekly meetings worked out how to accommodate it in their own sections. Furthermore, the exams were all coordinated so every section of Calculus I and II took the same midterms and final exams at the same time.

With all of the changes that happened within this department and the GTA program, there were many different sources of rich data collection for my study. In the next section I will describe in detail the various places I collected data throughout the Fall 2016 semester along with a detailed timeline of when the data collection occurred during the term.

The Collection of Data

In Chapter 1, I introduced the research questions for this study. As a reminder, they have been repeated below:

RQ1: How do the GTAs' publicized understandings of various teaching practices change (through elaboration or transformation) over the course of a term? How do these publications highlight which teaching practices are most salient to their needs?

RQ2: How do the lead TAs and others influence the shaping of the various teaching practices discussed in the professional development on leading a student-centered classroom?

To be able to follow the changes in discourse among both the individual and the local community, the data was collected from several different sources over the period of one semester. In this section, I will give an overview of the participants in the study, the various places data was collected, and what data specifically was collected. I will conclude this particular section with an overall timeline for when the data collection took place and summarize the sources for data.

Participants

Sixteen of the eighteen GTAs agreed to be part of my study, including eight from Calculus I and eight from Calculus II. Table 3.1 provides an overview of the experience of each of the GTAs in my study before beginning the Fall 2016 term.

At three weeks into the semester, Leilani was offered a research assistantship and chose to no longer serve as a GTA for Calculus I. At this time, Nancy came in and took her place. As a result, there is only partial data available for both Nancy and Leilani but both GTAs did agree to be part of the study and so they have been included.

I collected data in the formal meetings in which the GTAs were involved. I describe each of the data sources (and who was in attendance) in more detail in what follows.

1) Video recordings and field notes of three-day professional development seminar prior to the semester (approximately 14.5 hours)
2) Video recordings and field notes of professional development follow-up course during the semester (9 1-hour meetings)
3) Audio recordings and field notes of weekly meetings with the Calculus 1 and Calculus 2 coordinators (19 meetings)
4) Video recordings and field notes of classes that were observed by Lead TAs (29 observed classes)
5) Audio recordings and written notes of Calculus I Lead TA debrief after observation (8 debriefings and 13 written notes)

6) Video recordings and written notes of Calculus II Lead TA debrief after observation (approximately 12)
7) Written observation notes from GTAs observing each other (10 written notes)

Table 3.1: Participants in the study, their pseudonyms, and their experience with teaching prior to the Fall 2016 semester.

Course	Pseudonym	Experience
Calculus I	Adam	Returning GTA for SDSU; tutoring experience.
	David	No formal training or experience; new GTA for SDSU.
	Edgar	Returning GTA for SDSU; tutoring at another institution.
	Justin	Lead TA; experience as a student in an active classroom and running a student-centered class.
	Leilani	6 years of tutoring at various institutions; new GTA for SDSU.
	Nancy	Returning GTA for SDSU, but moved from Calculus II to I.
	Sheri	Returning GTA for SDSU; instructional student assistant (ISA) for SDSU prior to serving as a GTA.
	Tina	Returning GTA for SDSU; served as teaching assistant for elementary school.
Calculus II	Charlie	10 years of tutoring; curriculum designer and instructor for math camps; new GTA for SDSU.
	Jack	Undergrad TA for another institution; new GTA for SDSU.
	Jeff	Lead TA; experience tutoring, grading, and TA-ing at SDSU.
	Joe	Attended tutoring training at another institution; new GTA for SDSU.
	John	TA for another institution; 1 year teaching High School; 6 years of tutoring; new GTA for SDSU.
	Megan	1 year of tutoring experience; new GTA for SDSU.
	Michael	Returning GTA for SDSU.
	Sally	Returning GTA for SDSU; experience tutoring and as undergraduate supplemental instructor.

Professional Development Seminar

Before the 2016 Fall semester began, there was a three-day seminar during which the GTAs for both Calculus I and II met with several mathematics education researchers, the course coordinators, and the chair of the mathematics department. All GTAs who were available came to the summer seminar, but not all were back in town for the seminar, including the lead TA for Calculus I. It was required for all new GTAs and so the seminar was the first place some of the GTAs learned about techniques for running an active learning classroom. During the seminar, I video recorded all sessions and took field notes on the topics discussed as a reference for the transcription later. As this was the first time I met with the GTAs, I obtained permission to collect data during both the seminar and throughout the semester from the GTAs who were able to attend the seminar. Those who were not in attendance at the seminar were asked permission during the first coordinator meeting they attended. There were two GTAs who declined to participate in the study.

The seminar covered a variety of topics to help the GTAs prepare for the first week of classes. There were GTAs from Calculus I, II, and III and graduate instructors for various mathematics for elementary school teachers courses, as well as instructional student assistants (ISAs) from PreCalculus. During the seminar, the GTAs had the opportunity to watch video examples, discuss a way of decomposing teaching, and to practice some aspects of teaching in front of their peers. They also participated in discussions about stereotype threat and on equity issues in the classroom. Finally, there was also an opportunity for the GTAs to meet with their course coordinators for the first time. A copy of the schedule for the seminar can be found in Appendix A.

Professional Development Meetings

The professional development course during the semester was for the GTAs of both Calculus I and II and was taught by Dr. D, a mathematics education researcher. I attended each meeting, video-recorded the course, and took field notes of the topics covered. The video-recordings allowed me to reference to what happened in the course and who was talking when.

The course met for the first five weeks of the semester and then met approximately every other week for the rest of the term. The syllabus for the course can be found in Appendix B. During the first five classes, Dr. D talked about what he called the ABC's of teaching: assessment, beliefs, community, discourse, and equity. Two class sessions were dedicated to sharing video recordings of their classrooms and debriefing with their peers. One class session was dedicated to discussing their experiences observing one another. Finally, the last class session was used as a focus group interview for another graduate student's dissertation data. While the plan for week 2 of the course was to talk about beliefs, much of the class discussion centered on administrative issues for the course itself and so little relevant data was collected on that topic in the course. Furthermore, there were some administrative issues with the course which caused attendance to fluctuate, however this was kept in consideration when keeping track of who were present for which publication.

Weekly Coordinator Meetings

The GTAs for Calculus I and II met with their respective coordinators approximately once a week. For Calculus I, the GTAs met on Fridays and for Calculus II, the GTAs met on Mondays. I attended each meeting and took field notes on the topics that they discussed. I also audio recorded the meetings for transcription purposes.

The structure of the meetings varied depending on the week, but they generally involved discussing how a previous activity went, what to expect for the upcoming activity, and general administrative issues. There was more variation within the Calculus I meetings.

Classroom Observations

Throughout the term, I visited each participating GTA's classroom twice, along with the lead TAs for Calculus I and II. Each of these classroom observations were video recorded with an individual mic placed on the GTA. The classroom observation videos were collected as a way to have a reference point for the debriefing sessions that occurred with the lead TAs after the observation. The video was used to help recall particular aspects of the class discussed by the GTA and the lead TA.

In general, the recitation sections for the Calculus I GTAs were on Tuesdays and Thursdays (with Nancy/Leilani and Justin as the exception) and the recitation sections for the Calculus II GTAs were on Mondays and Wednesdays. So, avoiding conflict in my observation schedule with the lead TAs was easily done.

Debriefings

After each observation, the lead TAs met with the GTA they observed to discuss what happened in class. This was a time for the GTAs to hear from a peer and get advice on their teaching. It was also an opportunity for the lead TA to provide professional development to their fellow GTAs as well as for the GTAs to talk through their class with a peer outside of the more formal situations like the professional development course or the weekly meetings.

The Calculus I lead TA scheduled these meetings to occur at another time after the observation. Since these meetings were only between the GTA and the lead TA, I was not present at these meetings. Instead, the lead TA audio recorded his meetings with the other GTAs. The Calculus II lead TA, in comparison, met with the GTA directly after the observation. So, since the GTA still had on a mic from the video recording of the observation, the debriefing was recorded using the same device. In an effort to not intrude onto the meeting, I stayed with the video camera, away from the lead TA and GTA during the meeting.

For Calculus I, each meeting was between 20 and 40 minutes long and occurred as soon after the observation of the classroom as possible. However, after the first round of observations, the Calculus I lead TA had difficultly scheduling the debriefing sessions and so only one debriefing was conducted during the second round of observations. For Calculus II, each meeting was approximately five minutes long. Each of the lead TAs took observation notes and gave those to the GTA after the observation. The lead TA for Calculus I had his electronically and would send them via email to the GTA. The lead TA for Calculus II had his written on a protocol he had developed after the summer seminar (see Appendix C) that was then given to the GTA. I was able to obtain copies of all of the observation notes from the Calculus I lead TA and the observation notes from the Calculus II lead TA for eight of the twelve observations.

Overall Timeline

The data collection occurred throughout the Fall term of the 2016-17 academic year as well as a few days before the academic year began during the three-day summer seminar. In this subsection is an overall timeline in Table 3.2 indicating when data was collected throughout the term. Essentially, I collected data every week during the term. Consequently, there was consistency within the data. While many studies on changes in professional development tend to be over a long period of time, given the amount of data collected, evidence of some change was observable during a single semester.

Table 3.2: Data that was collected through the semester. All grey cells represent data collected from that session in that week.

Week	PD Course	Calculus I Meeting	Calculus II Meeting	Calculus I Observation	Calculus II Observation
Per-Term					
Week 1					
Week 2					
Week 3					
Week 4					
Week 5					
Week 6					
Week 7					
Week 8					
Week 9					
Week 10					
Week 11					
Week 12					
Week 14					
Week 15					

The Analysis

The analysis for both Research Question 1 and Research Question 2 proceeded concurrently. I give an overview of the specific details of analysis for each research question. As I was particularly interested in tracking how the understanding of instructional practices evolved, I began my analysis with the pre-term professional development seminar. Any time a new teaching practice was introduced, whether from a professional development leader or from a GTA, it was considered the publication of an understanding of that particular teaching practice. As the GTAs discussed and made sense of a newly introduced teaching practice, changes in the discourse around that practice could then be tracked throughout the semester.

The analysis of the data happened in three main phases: 1) open coding for teaching practices, 2) separating the teaching practices into sub-practices and coding for transformations and elaborations, and 3) the creation of a temporal representation of the Vygotsky Space for each sub-practice. I began the analysis by logging and transcribing the videotapes and audiotapes. In the logging process, I listened to or watched each recording from the summer PD seminar, the PD course meetings, the weekly course coordinator meetings, and the debriefing sessions between the lead TAs and their fellow GTAs. I made notes of what was discussed throughout the video or audio recording along with approximate time stamps for each topic that was discussed. Using these logs, I was able to determine which parts of the videos and audio recordings would need to be transcribed. Since I was interested in analyzing the times the GTAs talked about various teaching practices, I did not transcribe the periods in which there was discussions about administrative issues or the specific mathematics involved in a particular activity (e.g. how many points for problems on a quiz).

Phase 1: Open Coding and Axial Coding

The data was transcribed chronologically. After a part of the data had been logged and transcribed, I coded, using MAXQDA (VERBI, 2018), each utterance about teaching practices using descriptive coding (Bakhtin, Emerson, & Holquist, 1986; Miles, Huberman, & Saldaña, 2014). An utterance was determined to be a talk turn and it could be tagged with multiple codes. Within descriptive coding, one "assigns labels to data to summarize in a word or short phrase – most often a noun – the basic topic of a passage of qualitative data" (Miles et al., 2014, p. 74). I chose to code as I created logs of the data, so I could create the list of descriptive codes iteratively while I went through each event. After coding each of the transcripts as well as the written observation notes provided by each of the lead TAs, I had a second coder code 15% of my data with the coding scheme created through my iterative process. We began by coding two different transcripts separately and then discussed our coding to ensure shared understanding the coding scheme in the same way. We had 82% agreement or higher on all of the different transcripts we both coded and discussed any discrepancies until we had full agreement.

Phase 2: Coding with Reference to the Meaning Behind the Practice

The next round of analysis had a focus on when particular teaching practices were discussed, by whom, and what understanding was evidenced. I utilized MAXQDA (VERBI, 2018) to see frequency of a code and when the code appeared temporally in the list of codes. Recall from Chapter 2 that within my framework of analysis, there is an important temporal aspect that must be traced, and this type of analysis allowed for that. Once I organized who talked about various teaching practices and when they talked about them, it became easy to see how individuals may have influenced various understandings.

Once the various instances of discourse about a particular teaching practice were organized temporally, the discourse was analyzed for differences in the way the teaching practice was discussed and any differences in the main reason for its use. I developed criteria for determining it was a transformation and developed the construct of an elaboration. I used these revised codes to label various utterances around a teaching practice as an elaboration, transformation, or publication (indicating the discourse around the practice had the same meaning or motivation as those previous to it and its discussed use was within a similar context as those previous to it). In past education studies that have used this framework, a particular person's understandings were tracked as they interacted with others (Gallucci et al., 2010). I modified the framework from the version given in earlier studies because the focus was no longer on the development of a single person as they interacted with a community but instead on the development of the discourse around teaching practices as it was publicized to a community from individuals. I focus on publications because of the insight they provide into the learning of an individual: “It’s an imperfect murky window to be sure, but it’s the best we’ve got” (Lindfors 1999, 16, as cited in Alrø & Skovsmose, 2004).

Each time a teaching practice was discussed, it was considered a publication. Each time there was a publication, there was the opportunity for those present to appropriate the meaning of what was just said. The publications could also be verbal representations of an elaboration or a transformation from a single person. An utterance was labeled elaboration if it only added to or extended the teaching practice without changing the meaning behind the practice. In contrast, an utterance was labeled a transformation if the meaning or motivation behind the practice changed from an earlier version. What is important to note is that the publications are what provide evidence of the appropriation and transformation, since both of those processes are invisible to the observer.

Using the type of analysis described here, in Phase 3 I used the modified Vygotsky Space to temporally trace the discussions around the various teaching practices as they developed through the semester and then created a representation of the way the discourse around a teaching practice changed over the course of the semester.

Phase 3: Vygotsky Space Representation

Once each utterance was coded within a particular teaching practice, I applied criteria to determine whether or not there was sufficient evidence of a transformation or an elaboration in the discourse around a teaching practice. The codes from the Vygotsky Space framework were used to create a representation of the transformation and elaboration of the discourse around a teaching practice through time. Through the use of the modified version of the Vygotsky Space framework, I created a full representation of the different changes each teaching practice went through throughout the term and where and when those changes occurred. An example of the temporal representation created for each teaching practice and sub-practice is given below in Figure 3.1. Utilizing these temporal diagrams, criteria were created to determine whether or not a practice became conventionalized within the community or a sub-community. A particular understanding of a teaching practice is considered conventionalized if a version of a practice has become normalized within the community (Gallucci et al., 2010). Within the data for this study, the evidence for conventionalization would be when a particular understanding of a teaching practice becomes something that is used by multiple GTAs in multiple different events, such as within the PD course meetings, the coordinator meetings, and in debriefing sessions. Only utterances tagged as a transformation are considered to be a change to the original understanding of a teaching practice, and so an elaborated version would still be considered equivalent to the original. More detail about this will be given in Chapter 5.

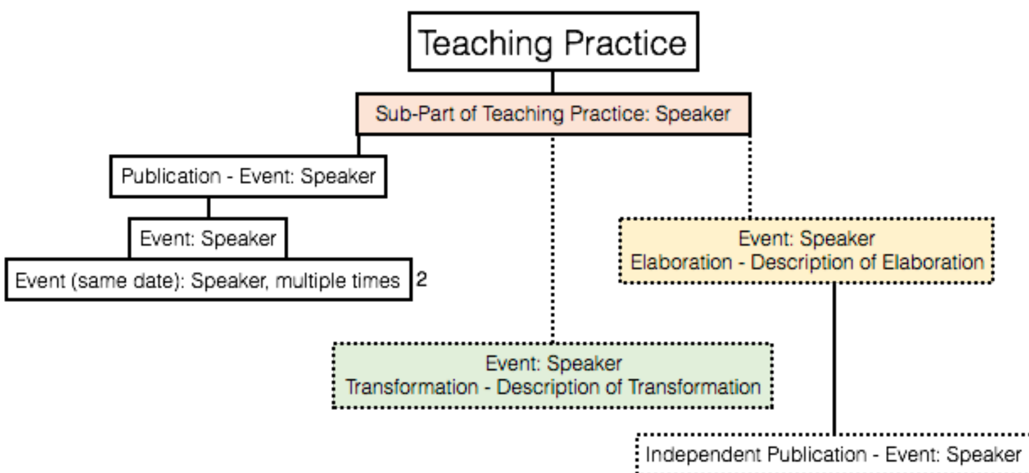


Figure 3.1: An example of the structure of the charts created for analysis.

The period of a single semester does not provide enough evidence to say with complete certainty that the discourse around a teaching practice was conventionalized within the community. However, there were times in which there was evidence to state that it may be conventionalized, or it was beginning to be conventionalized. A deeper explanation for how this was determined with the data collected in this study is given in Chapter 5. The analysis was inspired by the construct of something being *functions as if shared* in the community (Rasmussen & Stephan, 2008). Within this construct, researchers have used Toulmin's analysis of argumentation (1969) to provide evidence that the community has a shared understanding of particular ideas in a classroom. The main idea of this type of analysis is to look for evidence of students no longer providing warrants and backings to their claims because they no longer feel the need to do so. In my analysis, I looked for evidence of GTAs no longer publicizing different meanings or understandings of a practice. When the GTAs did not offer a different meaning or motivation in the discourse around a practice (i.e., a rebuttal), there is evidence of a commonly held understanding. Within the context of this study, a community is defined as a group of people with a common goal, such as the teaching of Calculus I and II. Sub-communities are communities within a larger community, such as the GTAs for Calculus I. Specific criteria are discussed more thoroughly in Chapter 5.

Since each research question has a slightly different focus on the data, the analysis methods for Phase 3 are described individually below.

Research Question 1

As a reminder, my first Research Question is the following: How do the GTAs' publicized understandings of various teaching practices change (through elaboration or transformation) over the course of a term? How do these publications highlight which teaching practices are most salient to their needs? To be able to answer this, I needed to be able to track a particular teaching practice from when it was first introduced and through various events that involve the particular teaching practice.

For every teaching practice and sub-practice discussed throughout the semester, charts like the one shown in Figure 3.1 were created to track transformations and elaborations of the discourse around a particular teaching practice, who was speaking, and when in the semester it occurred. This created a temporal representation of aspects of the modified Vygotsky Space and the changes that occurred within the discourse through the semester.

With the information from the chart created in Phase 3, I conducted a meta-analysis of the various practices and sub-practices. I took the criteria of conventionalization, the number of transformations, and what the transformations conveyed about the GTAs' understanding of the teaching practice to provide evidence for answering Research Question 1. I looked for patterns among them to help determine the types of practices discussed by the GTAs, such as whether or not the practices involved "traditional" teaching practices or "active learning" teaching practices. Furthermore, based on the changes in the discourse I analyzed the practices for ones that had evidence of being challenging for the GTAs to make sense of and for practices individuals believed to be important to discuss in formal settings but not because they were working to make sense of them.

Research Question 2

As a reminder, Research Question 2 is the following: How do the lead TAs and others influence the shaping of the various teaching practices discussed in the professional development on leading a student-centered classroom? The lead TAs were in the unique position of providing support to their fellow GTAs in much the same way as the mathematics education researchers but were also part of the local community of GTAs. So, what they said and did had the potential to shape the discourse and understanding on leading student-centered classrooms in a direct way.

The analysis for Research Question 2 was very similar to that of Research Question 1. As I stated earlier, charts in Phase 2 enabled me to track how particular individuals contributed to changes in the discourse around various teaching practices over the course the semester. So, the analysis for Research Question 2 occurred in much the same way as Research Question 1 but the narratives were focused on who publicized and elaborated or transformed the various teaching practices along with whether they were carried forward throughout the semester.

Validity and Reliability

While as researchers we work to keep our studies as free of potential problems as possible, there are always validity and reliability threats that must be acknowledged. In this section, I discuss the various possible threats to validity and the ways in which I worked to guard against them to the best of my abilities.

According to Maxwell (2013), there are two broad types of threats to validity: researcher bias and reactivity. While it is not possible to completely eliminate researcher bias, I do acknowledge that I may have inherent biases. For instance, I am interested in finding change over time to the various topics within the professional development and had to guard against seeing a bigger change when there was none.

Reactivity is defined as the response of the researcher and the research participants to each other during the research process (Maxwell, 2013). In the design of my study, and the collection of the data, I made sure to not engage in discussions with the GTAs about their teaching. Furthermore, I positioned myself in the various professional development events at the back of the room so as to provide the least amount of distraction. I do acknowledge that my presence may have affected what the GTAs talked about or brought up in the various professional development events, but the design was such that I did not directly contribute to this effect.

Other ways in which I worked to reduce the threats to validity was conducting the study over a long period of time, collecting data from all formal situations of professional development, comparing the two Calculus programs to look for differences and similarities between the local sub-communities, and involving outside researchers in the coding process. I chose to collect data over one semester because it was a set period of time in which the same GTAs were involved throughout. Some of the GTAs did not continue to teach into the next semester and there were three new GTAs, so a semester was the longest amount of time in which the community of GTAs were consistent. Furthermore, as was discussed above, the data was collected from any formal event in which the GTAs discussed or used their professional development, which lead to a rich data source.

Summary

For my dissertation, I collected observational data on the teaching and learning of GTAs for Calculus I and II. There are two main research questions that guided my study:

RQ1: How do the GTAs' publicized understandings of various teaching practices change (through elaboration or transformation) over the course of a term? How do these publications highlight which teaching practices are most salient to their needs?

RQ2: How do the lead TAs and others influence the shaping of the various teaching practices discussed in the professional development on leading a student-centered classroom?

I collected data in all formal learning environments the GTAs were involved in for their professional development on leading a student-centered classroom. This included all professional development meetings (both before the semester and during), all weekly meetings between the GTAs and their respective coordinator, various classroom observations, and the debriefings associated with the classroom visits.

The theoretical framework I used to track the changes in their discourse over time is Vygotskian in nature. The framework is known as the Vygotsky Space (Harré, 1983) and it works to provide an explanation of how development occurs over time through the interactions between the social and individual spaces. The GTAs were negotiating between the professional development meetings they were involved in with their fellow GTAs and their own understanding of how they can be successful in leading a student-centered classroom. It is because of this negotiation that utilizing a theory that incorporates both the social and individual aspects of learning provided the best understanding of their development.

My analysis of the data incorporated grounded theory. In the first phase, the various events and utterances were open coded using descriptive coding (Miles et al., 2014; Strauss & Corbin, 1994) to create lists of teaching practices discussed by the GTAs. From there, in phase 2, all events and utterances around a particular teaching practice were further analyzed in terms of meaning, coded as elaboration or transformation, and labeled using the Vygotsky Space framework (Harré, 1983). Within phase 3, the coding and the time line were used simultaneously to create charts showing who spoke when and what changes occurred around the discourse on a particular teaching practice. It was through the use of the charts and the corresponding narratives that conclusions were drawn about the changes made to various teaching practices throughout the semester and who facilitated those changes. Chapters 4 and 5 provide a deep analysis of the various transformations and elaborations, and of which practices showed evidence of conventionalization and which did not, respectively. Chapter 5 has a focus on the speakers. With the analyses from Chapters 4 and 5, the findings for the two research questions are described in detail in Chapter 6.

Chapter 4: The Discourse Around Teaching Practices

This chapter will focus on the transformations and elaborations that the various practices and sub-practices underwent throughout the course of the semester. Each of the teaching practices discussed by the GTAs, and their various sub-practices, were analyzed for how they were elaborated or transformed over the course of the term. The focus of this analysis was on the changes themselves and how those changes occurred, with a brief discussion on who publicized the changes and when at the end of the chapter, so as to provide a basis for the overall results discussed in Chapter 6. In Figure 4.1 below, each of the 33 teaching practices are given within a category based on the number of transformations that occurred within their various sub-practices. A full description of the 33 teaching practices can be found in Appendix D.

Equal
Exploration
Practicing Procedures
Anticipation - Student Questions
Anticipation - Student Thinking
Checking In - Whole Class
Selecting
Visible Work

More Elaborations than Transformations
Connecting
Cognitive Demand - Whole Class
Scaffolding
Motivation
Participation - Carrot/Stick
Participation - Norms
Monitoring
Moving Forward
Establishing Norms
Body Position
Attention

More Transformations than Elaborations
Lecturing
Questioning
Group Creation
Using Representations

Elaboration Only
Elaboration
Precision
Participation - Atmosphere
Think-Pair-Share
Answering
Goals
Checking In - Group Work

Transformations Only
Synthesizing
Cognitive Demand - Planning
Wait Time
Anticipation - Additional Problems

Figure 4.1: List of teaching practices describing what was discussed by the GTAs and the PD leaders throughout the semester.

As a reminder, an elaboration is defined to be a publication in which the motivation or meaning behind the teaching practice was not substantively changed but was instead added on to (e.g., placed into a new context). In contrast, a transformation is defined to be a publication that indicated a different understanding or motivation for the practice. Examples of both of these will be given throughout the chapter. In terms of the Vygotsky Space, whenever there is an elaboration or a transformation publicized, a new cycle based on that version is created. As we will see in this chapter, within a teaching practice there may be several publications that are elaborated or transformed, or there may only be one or two elaborated/transformed versions that are publicized. Either way, it still creates a new cycle to which the proceeding publications may or may not contribute. A general version of this can be found in Figure 4.2 below.

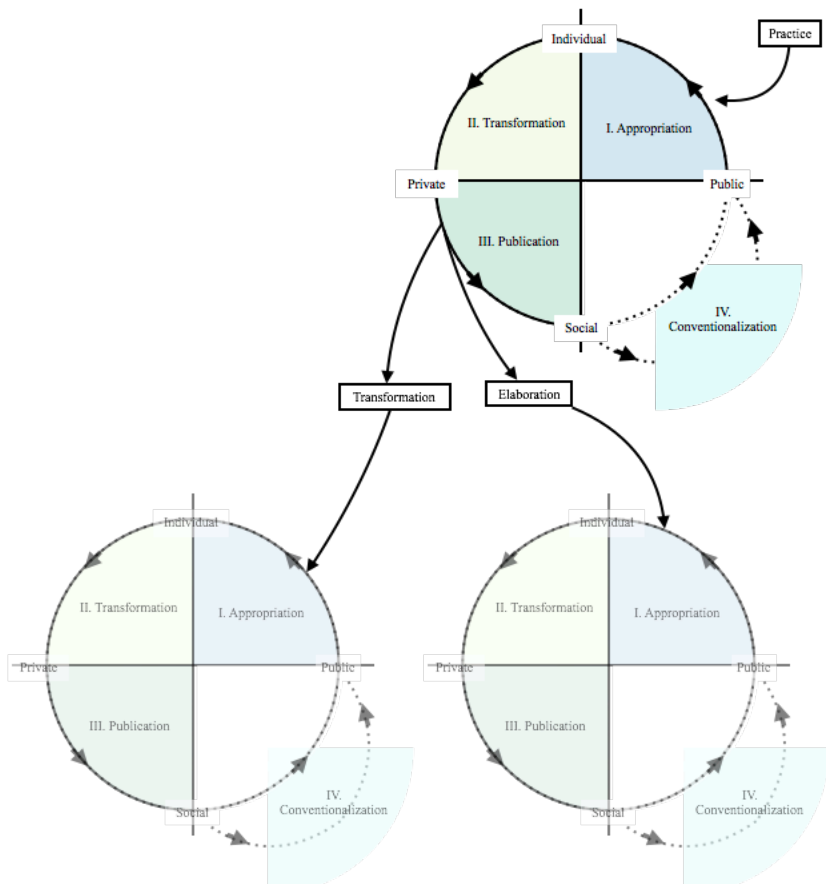


Figure 4.2: General diagram of the creation of new cycles based on elaborations and transformations.

The remainder of this chapter will be broken into two main sections. The first section broadly discusses what general teaching topics were discussed throughout the semester. The second section focuses on the ways in which the discourse around the teaching practices was changed over the course of the semester. Using the modified version of the Vygotsky Space, I provide an analysis of how the discourse around various teaching practices changed through the semester, separating them into categories based on how they were elaborated or transformed.

The General Teaching Topics

For this study, teaching practices were defined as "what teachers do and think daily, in class and out, as they perform their teaching work" (Speer et al., 2010, p. 99). Not everything discussed in the discourse around teaching fit within this definition and so those topics that did not fit were designated as general teaching topics. However, knowing which general teaching topics were discussed does provide insight into the meaning behind the discourse around the teaching practices. Those discussions that are considered to be general topics are highlighted in Figure 4.3 below. Within this figure, the general topics are separated into two categories: Frameworks and General Discussions. Each of these types, and examples of them, are elaborated on along with the reasons for why it was considered a general teaching topic rather than a teaching practice, based on the definition given above.

Frameworks
Five Practices
Three Pillars
General Discussions
Instructor Student Relation
Students Establish Norms

Figure 4.3: Categories of general topics.

Frameworks

There were two teaching topics within the category of Frameworks: *Five Practices* and *Three Pillars*. Both of these topics were used to mark discussions about frameworks that were useful in understanding and discussing teaching in an active learning classroom. These are not considered teaching practices because it is a way of describing practices rather than a practice itself. Both are used to better understand what teachers do and think in the classroom on a daily basis but would not be considered what a teacher is doing or thinking in the classroom.

Neither one of these teaching topics were discussed much outside of the summer seminar. Each were introduced during the summer seminar as a structure for discussing components of the practice of teaching in an active learning classroom. It also allowed the PD leaders to have a common language to talk with the GTAs about various aspects of teaching in an active learning classroom. So, even though it was not brought up explicitly throughout the semester, each of these topics were discussed indirectly by GTAs and PD leaders alike while talking about teaching.

The framework of the Five Practices for Orchestrating Productive Mathematics Discussions (Smith & Stein, 2011) was first introduced by Dr. D during the summer seminar. The five practices are: anticipating, monitoring, sequencing, selecting, and connecting. These each contain an aspect of facilitating a student-centered classroom and Dr. D used it as a way to discuss various teaching practices the GTAs should focus on. The framework of the three pillars was introduced by Dr. C during the introduction of the summer seminar as a way to introduce active learning. This framework on its own is not a publicized construct but instead is a combination of two other constructs: the two pillars of inquiry-based learning and the two pillars of active learning. Between the two constructs, they share a similar "pillar," which combined creates the three pillars described by Dr. C.

General Discussions

There were two codes within the category of General Discussions: *instructor-student relation* and *students establish norms*. Both of these indicated general discussions around those two topics with no direct reference to a teaching practice. For instance, in *instructor-student relation*, discussions involved stories about times the GTAs felt like they had done a good job in fostering a relationship with their students, but it did not involve how they fostered those relationships. Therefore, it was not considered a teaching practice based on the definition above.

Within the topic of *students establish norms*, the discussions were around the importance of allowing the students to explicitly, rather than just implicitly, constructing the norms of the classroom, so they felt agency over them. This was a commonly discussed topic during the first couple weeks of the semester but not after, as it was something that they wanted to do at the beginning of the term. While this could be seen as a teaching practice, the discussions were more around the reasons behind having students explicitly establish the norms in the classroom, and how the practice went when they tried it, rather than the practice itself.

Teaching Practices

Perhaps unsurprisingly, not every teaching practice that was brought up over the course of the semester underwent a significant transformation. In fact, some were not take up by the GTAs at all, but others became important practices for the GTAs to discuss. In this section, I provide an analysis of the various teaching practices based on how many of their sub-practices were elaborated or transformed. Even though there was a thorough analysis of all teaching practices, not all 33 teaching practices that were discussed over the semester will be described in detail here. Instead, illustrative examples will be given within each category in Chapter 5 so as to provide a strong base for the analysis presented. With an idea of how teaching practices were transformed or elaborated, we can get a better idea of ways to better support GTAs in the future.

Before an analysis of the teaching practices themselves is given, I begin with a quantitative overview of the various teaching practices, including which underwent transformation and which underwent elaboration. For a practice to undergo a transformation, the motivation or understanding behind the teaching practice must have changed in some way. If, instead, the understanding of a practice was simply added to, it was considered to have been only elaborated. Each teaching practice was broken down into sub-practices, as was described in Chapter 3. As long as at least one of those sub-practices were transformed, the teaching practice was considered to be transformed at some point throughout the semester. However, this does not necessarily mean that the transformed version was taken up by the GTAs. An analysis of this aspect is given in Chapter 5.

Within the 33 main teaching practices, seven contained only elaborations and four contained only transformations (e.g., every sub-practice was transformed). Four of the teaching practices contained more transformed sub-practices than elaborated sub-practices; ten contained more elaborated sub-practices than transformed sub-practices, and eight had the same number of sub-practices that were elaborated or transformed. The number of sub-practices within any given teaching practice varied from none to eleven. Of the total of 137 sub-practices analyzed, 52 (38%) showed evidence of transformation and 86 (62%) showed either evidence of elaboration or no evidence of any changes. Overall, it was much more common for a teaching practice or sub-practice to be elaborated, rather than transformed. This is not surprising as other constructs of learning have described the tendency to apply new ideas within one's personal situation (Brown, Collins, & Duguid, 1989). The breakdown of the percentage of teaching practices that were elaborated or transformed is given below in Table 4.1.

Table 4.1: Percentages of teaching practices that underwent various amounts of transformations and elaborations over the course of the semester.

	Number	**Percentage**
At least one transformed publication in each sub-practice	4	12%
At least one transformed publication in more than half of the sub-practices	4	12%
At least one transformed publication in exactly half of the sub-practices	7	21%
At least one transformed publication in less than half of the sub-practices	11	34%
At least one transformed publication in none of the sub-practices	7	21%

The remainder of this section will be organized based on the ways in which the sub-practices were elaborated or transformed over the course of the semester. I begin with an analysis of those teaching practices that contained an equal number of practices whose meanings were transformed and elaborated. I then discuss the teaching practices that had more elaborations than transformations, followed by the teaching practices that had more transformations than elaborations. I conclude with a section on the teaching practices that only had elaborations within the discourse and finally the teaching practices that were publicized only with transformations. Figure 4.1 above gives the breakdown of which teaching practices are within which section. An analysis of who facilitated these elaborations and transformations will be discussed in Chapter 5.

Equal Parts Transformed and Elaborated

As was stated above, there were eight teaching practices in which the sub-practices contained an equal number of transformations and elaborations. A breakdown of each of these teaching practices into their sub-practices and which were transformed versus elaborated is given below in Table 4.2.

Table 4.2: A breakdown of the teaching practices that had an equal number of sub-practices whose meanings were transformed or elaborated.

Teaching Practice	Elaboration	Transformation
Anticipation – Student	Layout	Avoid Confusion
Questions	Previous Experiences	Awareness
Anticipation – Student	Like a Student	Past Experiences
Thinking	Future	Activity Layout
Checking In – Whole Class	Common Problem	Check Understanding
	Scaffolding	Discussion
Exploration	Exploration	Productive Struggle
	Role of TA	Critical Assessment
	Get Hands Dirty	Agency
Practicing Procedures	Procedure w/no Connection	Procedure as a Guide
Selecting	Comparison	Asking
	Multiple Strategies	Partially Completed
	Incorrect	Completed – Pacing
	Completed – Example	Completed – Selecting
Visible Work	Student Written	Instructor Written

For teaching practices that have an equal number of sub-practices elaborated and transformed, it could be an indication of the GTAs trying to make sense of the teaching practices. There were some in which they offered a transformation and others where they offered elaborations, in each case they were making sense of it based on their own experiences and needs. However, nearly two-thirds of the sub-practices within this category did not have evidence of being taken up by the GTAs through their discourse, as will be seen in Chapter 5. So, a concrete conclusion on the GTAs' thinking around this set of practices is not viable.

There are two illustrative examples that will be described in greater detail: *exploration – agency* and *selecting – asking*. For each of these, the types of elaborations and transformations will be described in detail along with the context in which they were publicized. These two sub-practices were chosen because they were publicized often and in several different events, providing a large number of publications from which to draw.

Exploration – Agency. During the summer seminar, the professional development leaders emphasized the importance of exploration during the activities. Exploration is a way for students to take ownership over their thinking and give them a chance to work as a mathematician or a scientist would. The teaching practice of *exploration* was used to indicate any and all discussions around the use of exploration during the implementation of an activity. There are six different sub-practices within this overall teaching practice: *productive struggle*, *exploration*, *critical assessment*, *agency*, *role of TA*, and *get hands dirty*. As seen in Table 4.2 above, the sub-practices of *exploration, role of TA,* and *get hands dirty* did not undergo any transformations. Instead, each of these sub-practices were only elaborated in some way during the semester. In contrast, the sub-practice of *agency* did undergo a transformation and an elaboration, making it a good first illustration of the difference between the types of publications.

The sub-practice of *agency* had discussions centered on ways in which the students had the chance to take ownership over the mathematical ideas in the classroom. It was first publicized by Dr. J during a summer session focused on an observation protocol, *Mathematics Classroom Observation Protocol for Practices* (MCOPP) (Gleason, Livers, & Zelkowski, 2015), created for observing active learning classrooms. While discussing an aspect of the protocol that involved students critically assessing mathematical statements, she publicized a simple, short version of agency: “Because it’s about the students doing the assessing.” While she does not name this as agency, it is the first time the idea of students having ownership over exploration in their work is brought up.

Later in the summer seminar, during a practice session, a new Calculus I GTA, Leilani, publicized an elaboration of the original sub-practice while discussing important aspects of the implementation of an activity so students were getting the chance to understand the steps required for the solution. Within this, she talked about the balance of allowing students to figure it out for themselves, but still helping them when they get stuck:

> "I think maybe for that exercise it might be helpful to, um, like specifically say the student, if they, um, there was a lot of confusion on if all the transformations are in the end graph or if they're in steps or if, like, that type of thing. Or maybe, it's good for them to like, see how they do it themselves."

The original version did not discuss this tension between helping students to move forward and allowing them to figure it out for themselves. Leilani's elaboration includes this tension while still acknowledging the benefit of allowing students to do the task on their own.

Another change to this sub-practice was seen during an early Calculus II meeting in which Jeff publicized a transformation where he suggested allowing the students to pick which method they want to use in an activity that asks students to use both methods: "Yeah, I think we ran out of time. But uh, we might let them pick which way they want to use." While this is still giving the ownership to the students by allowing them to choose the method they prefer, the purpose of the practice has changed from the original and elaborated versions. The intention put forth by Jeff is from a time management stance where allowing students to pick a single method could help save time during the activity sessions.

Within this teaching practice, the difference between the elaboration and the transformation may seem subtle. In the elaboration, the motivation behind the use of the practice was still to give students a chance to solve the task on their own while still acknowledging the difficulty of finding the balance between helping them and allowing them to own their thinking. In contrast, the transformation Jeff shared involved a change in the purpose for letting students choose. The motivation was now to manage the time in the classroom rather than giving students ownership over their thinking. Students were being given the choice between different methods, but they were still being designated two different methods to use instead of generating their own.

Selecting – Asking. The second example focuses on the overall teaching practice of selecting students to present their work. Selecting is an aspect of the five practices for productive discussion (Smith & Stein, 2011) that the GTAs were introduced to by Dr. D during the summer seminar and something he focused on throughout the semester. In the analysis of discourse, within *Selecting* there were six sub-practices discussed: *asking*, *comparison*, *multiple strategies*, *completed*, *partially completed*, and *incorrect*. The sub-practice of *completed* was further broken down: *pacing*, *example*, and *selecting*. The sub-practices of *comparison*, *multiple strategies*, and *incorrect* did not include any transformations. Furthermore, the sub-practice of *completed-example* also did not include any transformations.

A major aspect of *selecting* is the process of actually asking students to present. So, the practice of *asking* was used for any discussions centered around asking students to share their work in front of the class. There is nothing specific to the type of solution being shared (e.g. completed, incomplete) and is more focused on the shift of having the student present their work. It was first publicized by the Calculus II coordinator in which he suggests simply calling on students to present: "If there are no volunteers you just pick people and say 'okay, go solve that on the board.' Um, that is the ideal scenario." While this may not directly ask a student to present, he does start by suggesting the GTAs ask for volunteers and then simply tell students to present if there are no volunteers. The main motivation expressed for this practice is to simply have someone speak during whole class discussions. During the same session, Jeff publicized a transformed version in which he suggests asking students to present instead of telling them to present. This marked a transformation because while the motivation was still to have someone present in front of the class, the motivation behind was to create a comfortable environment for which a student could present their thinking.

During the same summer session, three elaborations were publicized in response to the transformed version publicized by Jeff. The first was publicized in a conversation between Leilani and Dr. D in which she talks about liking the option he had given them during his demo lesson of bringing a buddy up for presentations:

> Leilani: I think it was kind of cool that, I'm wondering because there was only two people in each group but they both went up together. Since some students get scared but if one representative from the group wants to…
>
> Dr. D: Yeah, I really like partners. They're easy to manage and usually it keeps everybody involved. Not easy to manage. Easier than four people.

This publicized version still held the same motivation of creating a comfortable environment for students to present but adds on the idea of allowing students to bring a classmate up with them as another way to create a comfortable environment for students to present.

Dr. D went on to publicize a second elaboration later in the summer seminar in which he suggested that if a student is unsure about presenting when first asked, the GTA should give them a few minutes and then ask them again. The final elaboration was publicized during the final session in the seminar by Charlie in which he suggested asking the entire group if there was anything else they wanted to add before their groupmate went up to present, making it clear it is a group effort and not just on a single student.

What is interesting about this example is the fact that there were two different versions the GTAs continued to talk about throughout the semester, each with different motivations. In the original version, the motivation was simply to have a student present, whether or not they were willing. In the transformed version, and the subsequent elaborations on that version, the motivation was to create an environment in which students felt comfortable to present their thinking. The fact that it was the transformed version that had subsequent elaborations, rather than the original version, is unique. Very few other teaching practices had this situation.

More Elaborations than Transformations

There were 11 teaching practices in which the sub-practices contained more elaborations than transformations, but still contained sub-practices of both, making it the largest collection of teaching practices within the five categories. A breakdown of each of these teaching practices into their sub-practices and which were transformed versus elaborated is given below in Table 4.3. Since each of these teaching practices contained more sub-practices that were simply elaborated on rather than transformed, there is evidence of greater general agreement with the original versions as they were first publicized. However, over two-thirds of the sub-practices within this category did not have evidence of being taken up by the GTAs through their discourse with one another, as will be seen in Chapter 5. Furthermore, over 75% of the sub-practices with no evidence of a transformation were not taken up, whereas only 50% of the sub-practices with evidence of a transformation were not taken up.

Table 4.3: A breakdown of the teaching practices that had more sub-practices elaborated than transformed.

Teaching Practice	Elaboration	Transformation
Attention	Aggressive	Draw Attention
	Confidence	Elementary
	Focus	
	Prepare	
Body Position	TA Gaze	Position in Class
	Group Engagement	
	Attention	
Cognitive Demand – Whole Class	Raise through Questions	Lower through Guiding
	Lower through Procedures	Raise through Less Scaffolding
	Maintaining	
Connecting	Conventions	Course Material
	Across Students	Real Life
	Within Activity	
Establishing Norms	Notes	Peer-to-Peer
	Relationships	
	Physical Space	

Table 4.3: A breakdown of the teaching practices that had more sub-practices elaborated than transformed, continued.

Monitoring	Making Progress Enforce Norms Student Presentations	Student Struggles
Motivation	Real Life Class Material Challenge Peer-to-Peer	Energy Grading
Moving Forward	When to Move Students Present Student Ideas Attention	Telling
Participation – Carrot/Stick	Using Names Sign-In Active Engagement	Points Cold Calling
Participation – Norms	Sharing Ideas Setting Expectations How to Participate	Student Engagement
Scaffolding	Decrease Scaffolding Within Activity Under Scaffolding	Add Scaffolding

The reasons why these practices were not taken up in the discourse are not clear, but it is not surprising that it was more likely for a transformed sub-practice to be taken up rather than an elaborated one because the fact a transformation was publicized shows that the GTAs were still making sense of the practice in a formal setting. So, it may still be the case that the GTAs felt more confident in their understandings of these practices even though they did not publicize those understandings because they may have not felt the need to discuss their thinking with others.

There will be four illustrative examples given from this category: *cognitive demand – lower through guiding, connecting – course material*, *establishing norms – peer-to-peer*, and *scaffolding – add scaffolding*. All four of these sub-practices provide different views of those practices within the category of more elaboration than transformation.

Cognitive Demand – Lower through Guiding. There were two different teaching practices related to *cognitive demand*; one was within the context of whole class discussions and the other was within the context of planning for the activity. In this case, the teaching practice of *cognitive demand* was used to mark discussions about raising or lowering the cognitive demand of a task during the class itself. There were five practices identified within this teaching practice: *lower through guiding*, *raise through questions*, *lower through procedures*, *raise through less scaffolding*, and *maintaining*. Only the practices of *lower through guiding* and *raise through less scaffolding* had evidence of a transformed publication.

The practice of *raise through questions* did not undergo any elaborations or transformations. Both *lower through procedures* and *maintaining* contained elaborations but no transformations. For the practice of *lower through procedures*, the discussions were centered around how procedures could be used to lower the cognitive demand of a task and the practice of *maintaining* had discussions centered around ways to maintain the cognitive demand of a problem. The practice of *raise through less scaffolding* involved raising the cognitive demand of a task by decreasing the amount of scaffolding given to the students and it contained a single publicized transformation. All but *lowering through guiding* were not commonly discussed over the course of the semester.

The practice of *lowering through guiding* underwent three elaborations and one transformation. Within this practice, discussions were centered on ways a task was made easier for students by adding additional guidance to the task. It was first publicized by Dr. J during the summer session where she talked about providing so much guidance that class becomes a game of "guess what is in my head" instead of one that encourages student thinking. Later during the same session, Dr. J then elaborated on this idea by adding a specific name, "over scaffolding", to the idea of giving too much information to the students: "You over-scaffold means like you're putting, you know, you're, you just tell them every single step so that there's no initiative on the student's part to see what I should do next."

Another PD leader, Dr. D, publicized the next elaboration during the first PD course meeting of the academic year: "And so that's one of the things I want to get out here is, like, the way we ask questions, we can either sort of elevate the level of demand or we can diminish it." In this, he adds on that even questions can lower the cognitive demand by guiding the students too much. One of the new Calculus II GTAs, John, then went on to publicize yet another version where he states that even class notes can give the students too much information on the problems. So, by the end of the first week of the semester, the original version of the practice put forth by Dr. J was elaborated to include the title of "over-scaffolding" and how it could occur through the types of questions asked and even student notes from class.

The transformation of this sub-practice was first publicized during a Calculus II meeting by a returning GTA, Michael, while he was explaining how he had finished a particularly long activity in the allotted time:

> But I mean I think, I was actually really surprised that both my sections finished. But maybe I, well I don't know if I helped them too much. I, because about, I gave them some time to work on it and then they kind of just brought them back and gave them that picture. I was like kinda making sure everyone was on the same page.

In his publication, he talks about how he gave the students additional guidance so as to save time in the activity. This marks a transformation because his motivation for guiding students was no longer to help them without lowering the difficulty of the task and instead was simply to save time, without a focus on whether or not it would make the task easier for the students. The coordinator then went on to say that there were times where additional guidance was necessary or the students would get confused.

Much of the publications of this sub-practice for the remainder of the semester came from the lead TA for Calculus I, Justin. During an early observation with Edgar and a later observation with Sheri, Justin pointed out times when the GTA may have given their students too much information before allowing their students to figure it out themselves. Near the end of the semester, Charlie talked during a Calculus II meeting about guiding students through a problem that seemed to be very difficult for his students, publicizing a similar motivation to the transformed version put forth by Michael earlier in the semester: “I think only one, maybe one student got it on his own and everyone else was just copying down what I eventually put on the board in the end.” Overall, this sub-practice was not publicized much after the beginning of the semester. However, during the Calculus II meetings, there seemed to be evidence of a shift toward guidance being a necessary tool to get through the activities.

Connecting – Real Life. The *connecting* teaching practice marked all times the idea of connecting various ideas and topics within mathematics was publicized throughout the semester. This included connecting to the material being covered in class, connecting to past material, and even connecting between different aspects of a single activity. Each of these different types of connecting led to five different practices: *conventions*, *course material*, *across students*, *real life*, and *within activity*. Only the practices of *course material* and *real life* had evidence of a publicized transformation; the rest contained either no changes or only elaborations.

The sub-practices of *conventions* and *across students* were each only brought up once in the semester, and so they underwent no elaborations or transformations. The discussion about the practice of *within activity* did undergo a single elaboration. The discussions centered around making connections between ideas that were covered within the activity. It was first brought up by a returning Calculus I GTA, Tina, while giving an example of when a new Calculus II GTA, John, had used connecting during his practice session in which she points out the way John made a connection between methods used within the activity itself, which helped the students make connections for themselves. Later during the same session, the Calculus II Coordinator publicized an elaborated version of Tina's original by adding on that GTAs themselves can explicitly make these connections as well. These two interpretations, one where the students are guided to the connection and one where the GTAs explicitly make the connections, were the two that carried on throughout the semester, with the original version being the more dominant version.

The lead TA for Calculus I, Justin, also independently publicized both versions. During a Calculus I meeting, he talked about how it was important for the GTAs to help the students make the connection between the slope of the secant line and the limit definition of the derivative, which were two topics covered within one activity. Then, during a debriefing session with a new GTA, David, Justin talked about how he could have made that same connection clearer for students.

As was said earlier, both *course material* and *real life* contained evidence of transformations. However, when considering both of those sub-practices, none of the transformed versions were taken up. So, since both underwent a similar progression, I focus on the practice of *real life*. The discussions were centered on making connections to real life problems or examples. This practice was first publicized by the course coordinator for Calculus II during the practice session in the summer seminar.

> Um, going in the direction of [Dr. C], about motivation and challenge, I think to start with a little bit of introduction of why we're going to be using this hyperbolic function… A little bit connection to real life would be nice.

Essentially, the course coordinator believed that making connections to real life examples would help motivate students for working on the activities.

However, later during the same session, the PD course instructor, Dr. D, pushed against this idea by stating that if there is going to be a connection to a real-life application, it needs to be meaningful or students may disregard it.

> Because one of the things that was a struggle was like you can make the connections like there's this great application, but still it's like okay. People have been telling me my whole life that math applies to everything and I don't believe them anymore.

This represents a transformation from what was originally stated by the course coordinator because Dr. D is stating that making connections to real life may not actually motivate students at all. In contrast, the course coordinator believes the use of real life connections would be motivating for students. The PD course instructor, Dr. D, went on to push back once again, suggesting instead that David focus on deep mathematical connections instead of real life connections, once again publicizing a transformed version of the original but still conveying his skepticism in using real life examples as a motivator for students. Overall, skepticism did mark a transformation because it questioned the motivation behind the use of a practice. However, evidence of skepticism in the discourse was not common.

Establishing Norms – Peer-to-Peer. An important aspect of leading an active learning classroom is the establishment of norms that support the type of environment where everyone feels safe to share their thinking with one another. This could be something done in a whole class setting or a small group setting. The teaching practice of *establishing norms* was used within the interactions of small groups and involved discussions about establishing group work norms in an active learning classroom. There were four practices within this overall teaching practice: *notes*, *peer-to-peer*, *relationships*, and *physical space*. Only the practice of *peer-to-peer* had any transformations throughout the semester and so it will be the one focused on here. The other three practices were not commonly discussed throughout the semester.

The practice of *peer-to-peer* involved discussions centered around how to establish norms where groups work together to solve problems rather than leaning on the instructor. It was first publicized by Sally during the summer seminar:

> Um, so, I noticed since I'm sitting in the groups, as you walked around most of you, I don't remember exactly, but, um, when someone asked a question in the group you would answer directly to that person instead of like branching out and asking 'does anyone else in the group have an idea about that' or like just have more of that peer to peer interaction and like have them talk to each other rather than just a one on one conversation with you and the student. So that's something you can, like, work on as you get started.

In this, she suggested the use of the members of the group as a resource to answer student questions instead relying on the GTA to answer. Right after the publication by Sally, Dr. C went on to publicize an elaboration to this, adding that the GTAs should be careful to talk to everyone in the group and not just the student who asked the initial question. Later, during the same session, John (a new Calculus II GTA) publicized a transformation to the original in which he suggested that asking a student to help their group mates could be a way to deal with troublesome students:

> I thought it was good, I wouldn't know how to deal with it either, but I thought it was good how you like dealt with the troublesome students. How you said, um, 'oh well if maybe if you understand it really well, you can help the people around you.' And that might be a good way to, like, get them, if they have a big head about them anyway, they might try to help others.

This publication is no longer about creating norms of working together but is about a way of managing "troublesome" students who are not working with their peers. However, this is the only time this transformed version was publicized throughout the semester.

A second transformation was publicized by Dr. D during a Calculus I meeting:

> Whereas like, another thing is I don't know exactly how to grade it but for instance, if you were collecting one paper from a group. It's like I'm not gonna tell you who to give me your paper, I'm just gonna take one of them from you. It's building group accountability but it's, it's also like, you know, then if they're in it together in a group, you can also say like okay, your group is not working.

His suggestion of using grading to build group accountability and encourage working together could be taken as a negative or positive approach. The assumption could be made that it was meant as a positive approach but for GTAs new to the practice of teaching, it could have been interpreted in a way not expected by the PD leader because the meaning was ambiguous.

There were two additional elaborations publicized, but each only occurred one time. The first was publicized by Dr. D where he recommended the GTAs elevate the status of students who do not seem engaged, so they feel valued in the class:

> Um, I don't know if we've talked about this at all or maybe we did but there's this idea of elevating status… but sometimes like during group work, you know, you notice that person never talks. And they said something and maybe it's not that best thing but it's, it contributes. Like, highlighting that, either publically in the group or publically in the class, can be a really helpful way, so like, you know, stepping back.

By highlighting a student’s voice within a group, the instructor is giving the student a way to engage with their peers. Furthermore, it allows for the other students in the group to hear from everyone, which in turn encourages peer-to-peer engagement.

The second was publicized by Joe (a new Calculus II GTA) in which he brought up the idea of assigning roles to students in their groups to help encourage them to work with one another. Overall, it was the original version publicized by the returning Calculus II GTA, Sally, that was taken up by the GTAs. More about how this was determined can be found in Chapter 5.

Scaffolding – Add Scaffolding. The final teaching practice that will be given as an example for this category is that of *adding scaffolding.* Once the idea of scaffolding was introduced to the GTAs, it became something the GTAs worked to make sense of throughout the semester. The *scaffolding* practice was discussed in all publications about adding or taking away scaffolding in the tasks. It was broken down into four sub-practices: *add scaffolding*, *decrease scaffolding*, *within activity*, and *under scaffolding*. Only the sub-practice of *add scaffolding* had evidence of a transformed version being publicized, and so it is the one focused on here. The sub-practice of *under scaffolding* was publicized only once throughout the semester. The sub-practice of *decrease scaffolding* was elaborated once throughout the semester, but it also was only publicized four times throughout the semester. Finally, the sub-practice of *within activity* was commonly discussed throughout the semester, but mostly within Calculus II meetings. The discussions were centered around specific discussions about the scaffolding within the activity itself. For this particular sub-practice, the discussions are more about the structure of the entire activity itself rather than parts of the activity. It was first publicized by the Calculus II coordinator through a specific example. The coordinator talked about how the activity was designed to build toward a specific goal. He continued to talk about this in several different Calculus II meetings with various Calculus II GTAs.

The sub-practice of *adding scaffolding* had discussions centered around giving students additional support to move forward in a given task. It was first publicized by Dr. J during the summer seminar while she was discussing ways to either maintain or raise the cognitive demand of a task, depending on where the students are with the material:

> Something like that where you just change the questions so that you keep people involved because not everybody's at the same place. We all know that. So, when you're planning your questions, if you can put in the back of your pocket, um, ‘oh I know what I could do. I could make this higher cognitive demand.’ Or ‘if I have to I could scaffold it more.’

In this, she is making a simple comment that they can add scaffolding if they feel the need, without decreasing the cognitive demand. This conversation was continued during the final session of the summer seminar by Dr. D and Dr. B. While discussing a task with a "high floor" (i.e. a challenging problem to begin working on), Dr. D voiced his concern of access for the students if there is no additional scaffolding to help them begin and Dr. B gave some thoughts on how they could provide scaffolding for students.

The first transformation was publicized by a new Calculus II GTA, Charlie, during the first Calculus II meeting: "Maybe ask them, you know, like, so what's the first thing we're gonna do? And what's the second thing…" In this, he suggests a way of adding support that would decrease the cognitive demand rather than maintaining it so as to help students move forward on a difficult task. This marks a change in the meaning behind the practice as originally, the goal was to maintain the cognitive demand rather than decrease it. While there is no evidence to state that it was Charlie's goal to reduce the cognitive demand of the task, his suggestion would accomplish that. So, evidence of a transformation does not need to include a change in the motivation of the practice; rather, it could include a change in the meaning or result of the practice itself. In this case, the motivation did not change as Charlie was discussing the practice as a way to help students move forward, but the result of his version of the practice would include reducing the cognitive demand of the task which was not the original intent of the practice from the PD leaders.

There was a second transformation publicized by Justin where he suggested that even if you make the problem easier for them they still will not be able to or be willing to engage with it:

> Um, I know from helping create the Calc I activities this summer, like, some of the things, like, Charlie was talking about with proof for that identity, like, I thought about that as well. Like that would be interesting. But at the same time, from someone who had to build some of these activities for Calc I that is, um, it's hard to fit stuff in there that's deep and meaningful in fifty minutes when most of the students, like, even if we just did what you said, the lift out [inaud] the tables, we just let them explore the differences, half of them would just sit there and go

> 'well, I don't know how to do that.' You could give them as much scaffolding as you want, and they would still sit there and go 'I don't know how to explore that.'

In this, he may not be directly speaking about the cognitive demand of the task, but he is suggesting that no matter how easy one makes the task, there will still be students unwilling to engage with the activity. However, this is the only time during the semester this view came up.

Two elaborations were also publicized during the semester. The first was during a PD course meeting where David, a new Calculus I GTA, added the suggestion of using student presentations as a way to support students moving forward. Soon after, during a Calculus II meeting, the coordinator publicized another elaboration where he suggested rewording the activity to help students make sense of what the task is asking them to do instead of changing the problems. In both of these, the speaker is taking the sub-practice of *adding scaffolding* and suggesting specific ways it could be done without decreasing the cognitive demand of the task.

Throughout the remainder of the semester, the predominant version of this sub-practice was the transformed version publicized by Charlie. While there were a couple of instances in which the Calculus I GTAs publicized a similar version, it was overwhelmingly discussed within the Calculus II meetings. This particular sub-practice is an example of a transformed version becoming conventionalized within a sub-community, which is described in more detail in Chapter 5.

While the majority of the overall teaching practices did fall within the category of containing more practices that were elaborated only rather than transformed, there were a handful of teaching practices with the opposite composition. Examples from this category are described in more detail below.

More Transformations than Elaborations

There were only four teaching practices which contained more transformations than elaborations. A breakdown of each of these teaching practices into sub-practices, and which were transformed versus elaborated, is given below in Table 4.4.

Table 4.4: A breakdown of the teaching practices that had more sub-practices transformed than elaborated.

Teaching Practice	Elaboration	Transformation
Lecturing	Forward Movement	Felt Need
		Struggling Students
		Shared Understanding
		Lecturing
Questioning	Alternative Methods	Asking Student Questions
	Conceptual	Check Understanding
	Respond to Student Strategies	Evaluating
		Forward Movement
	Yes/No Questions	Justification
		Rephrasing
Group Creation	Number	How to Group
	When to Change	When to Group
		Physical Space
Using Representations	Use by Students – Student Generated	Use by Instructor
		Use by Students – Instructor Generated

With a greater number of transformations than elaborations, there is evidence that the GTAs were still trying to make sense of the overall practice. However, within each sub-practice of the teaching practices, there may have been agreement. So, it may be unsurprising based on the results discussed earlier in this chapter that approximately 70% of the sub-practices within this category showed evidence of being taken-up in some way by the GTAs. This is the largest percentage of sub-practices with evidence of being taken-up of all of the five categories within this chapter. A possible explanation for this is that by publicizing transformations, the GTAs were making sense of the sub-practice within their own context, which continued the conversation over the course of the semester.

There are four illustrative examples for this category: *lecturing – felt need*, *lecturing - lecturing*, *questioning – justification*, and *questioning - rephrasing*. The teaching practice of *lecturing* contained many more sub-practices that were transformed rather than elaborated and the teaching practice of *questioning* was almost equal in the number of sub-practices that were transformed or elaborated. This difference between the two will give a good picture of how practices within this category were understood by the GTAs.

Lecturing. The teaching practice of *lecturing* included discussions on the use of lecture in the classroom. While lecturing is not traditionally associated with active learning, there were discussions around when it was useful in the classroom. There were five main sub-practices associated with this overall teaching practice: *forward movement*, *felt need*, *struggling students*, *shared understanding*, and *lecturing*. Only the sub-practice of *forward movement* had no evidence of transformation. The sub-practice of *struggling students* focused on ways to use lecture to help students when they are struggling with the task and included a single transformation. Discussions that focused on creating a shared understanding within the classroom were marked with the sub-practice of *shared understanding*, and it included two elaborations and a transformation.

The sub-practice of lecturing when there was a *felt need* involved discussions centered around the use of lecture when students showed a need for the information. It was first publicized by Dr. S:

> If they're struggling and it's not productive, if it's not, they're not making progress, it's okay to stop, call everybody back together again, and either clarify a term, have somebody share one of these ideas that isn't completely all worked out, but

> get them, find a way, either through other students' thinking or through your own scaffolding.

In this case, the decision to utilize lecture is specifically based on a felt need from the students rather than an assumed need. While Dr. S does give suggestions other than lecturing to accomplish the goal of helping students move forward, one of the teaching practices is to use lecture to "clarify a term" or scaffold without direct student input. This is separate from the sub-practice of *forward movement* because it is not based on a time constraint.

There were times, particularly within the sub-community of Calculus II GTAs, that there was discussion on how to make the "traditional" break-out sections more active for the students. One way the Calculus II GTAs worked to do this was the introduction of worksheets that were created based on what was going on in class that week. It was during the first Calculus II coordinator meeting during the academic year that Sally publicized a transformation of this sub-practice while discussing how to use the worksheets in class. She talked about how she made the decision to go over some information with her students before letting them work on the problems:

> So, what I did was like the properties slash identities, I went through those really quickly on the board with them and then I let them try the examples in groups and gave them like 10 minutes to do that.

This is a transformation because it is based on an assumed need for the students rather than a felt need, which is the opposite of what was originally discussed. By giving her students information before allowing them to decide what information they needed as they worked on the worksheet, she was assuming the information that her students would need.

Later in the semester, an elaboration to this transformation was publicized during a debriefing between Justin and Leilani:

> So, I liked that you actually did the launch like and showed them hey this really easy limit that you could do in your sleep is actually implicitly limit laws. Like that was good. It helps them, I think, to like refocus like okay, yeah, limit laws.

Justin talked about using lecture to help refocus students onto the topic under consideration, which is an elaboration because it is still based on a felt need from the students, but more of a need to be refocused onto the task rather than a need for more information. Justin brought this up a handful of times, but he was the only one to publicize this version. Overall, the publications were between the original and the transformed versions of this sub-practice. While a few GTAs did talk about this, it was mostly Justin who talked about this sub-practice.

For the final sub-practice of *lecturing*, the discussions were centered around the traditional lecture format and reasons for using it. This is different from the other practices within the overall practice of *lecturing* because it is more directly related to the traditional form, rather than an implicit reference to it. It includes discussions about the traditional format itself and moments when it is useful in an active learning classroom. It was first publicized by Dr. C as a definition of how traditional math classes are run: “They're usual taught by somebody like me standing in front of the room lecturing to you and you're there taking notes.” He acknowledged the fact that many of the GTAs have not had a course taught in a student-centered manner and so what was being asked of them may seem foreign. There was a single elaboration and two transformations in this discourse. The elaboration was also publicized by Dr. C where he elaborated on his original statement that they are asking the GTAs to move away from traditional lecture by adding on that there are times in which lecture is needed in an active learning classroom: “Conventional knowledge is things that people just have to tell you what that is. Right? It's a convention. No one's going to sort of figure it out just remember, or like invent it, or discover it. It's a convention.” Specifically, he was giving an example where lecture is a needed practice for telling students conventions within mathematics, which cannot be discovered on their own.

For the remainder of the semester, there were two transformations publicized from the original version. In one, David publicized the use of lecture as a way to review material and in the other, Jack publicized the use of lecture as a way to explain specific topics. These are both transformations from the original because Dr. C was originally discussing lecture as something that is not traditionally used in active learning classrooms except for something like explaining conventions. However, both David and Jack were talking about a more traditional use of lecture in their classrooms. Based on previous work (Marrongelle & Rasmussen, 2008), mathematics instructors do tend to struggle with working along the continuum of pure lecture to pure discovery. So, it is unsurprising that the GTAs were continuing to discuss the use of lecture in their student-centered classrooms at the end of the semester because it is something that is commonly difficult for instructors new to active learning.

Questioning. One of the more difficult aspects of facilitating a student-centered classroom is the practice of creating questions on the spot to engage students in the mathematics. There are several different types of questions that are used in a mathematics classroom, with some questions engaging the students on a deeper level than others. How to use different types of questions in the classroom was a very commonly discussed topic, with it coming up 280 times throughout the semester. The teaching practice of *questioning* involved discussions about the practice of asking questions overall, and so there were 11 sub-practices associated with this overall teaching practice: *alternate methods*, *asking student questions*, *check understanding*, *conceptual*, *evaluating*, *forward movement*, *justification*, *rephrasing*, *respond to student*, *strategies*, and *yes/no answers*. The sub-practices that did not show evidence of a transformation were *alternate methods*, *conceptual*, *respond to student*, *strategies*, and *yes/no answers*.

Of those sub-practices that did have evidence of a transformation, the sub-practices of *justification* and *rephrasing* were the most commonly discussed. The remaining sub-practices were not commonly discussed and so they will not be focused on here. The sub-practice of *justification* was first publicized by Dr. S as an example of a way the GTAs could encourage students to share their thinking, which was the first goal of active learning she was introducing to the GTAs: "So you could say 'could you say some more about that,' where you get a student to elaborate on their thinking." While her goal for sharing this particular teacher move was to provide the GTAs with a way to encourage students to share their thinking, it includes within it a request for a justification of their thinking by prompting the student to say more. By asking students to "elaborate" or say more about their thinking in a math classroom, the teacher is requesting additional explanation around their answer, which includes justification for their reasoning.

This particular sub-practice was elaborated on twice and transformed three times. Two of the transformations and one of the elaborations were not taken up by the GTAs over all. The first of these publicized changes was a transformation publicized by Tina in which she suggested the use of justification to make sure the student did the work instead of having copied from someone else, which changed the motivation behind the use of the practice. Justin then went on to publicize an elaboration in which he added the importance of pushing for precision within their justifications. The last transformation, which was not taken up by the GTAs, was publicized by David and involved the use of justification for grading purposes.

The elaborated version that did seem to be taken up by the GTAs was publicized by Dr. S during the introduction of the summer seminar. She added that a way to get students to deepen their reasoning through discourse was to explain how they know that their answer or method worked. This is another version of asking for justification within a whole class context. Jeff went on to publicize a transformation in which he seemed to suggest asking for an explanation simply to have students provide one without the additional goal of learning about their thinking during a conversation with a new Calculus II GTA, Charlie:

> Charlie: How would you prove, I didn't know how much or what degree of justification should be provided for finding the range. I found [inaud] it's difficult to find the range of an arbitrary function but in this case, would we ask the students to verify or prove that the range is the set of all real numbers or it's the interval from one to infinity.
>
> Jeff: Yeah, I mean you can ask them, right, you could ask them 'well, how'd you get that? How'd you get that range?' Make them explain it.

In this interchange, Charlie is unsure about the level of justification they should ask from their students and Jeff suggests a question in which the GTA could simply see whether or not the student could explain it. In other words, it was a request for justification so the GTA could evaluate if the student is understanding the material rather than as a way to help the student engage more deeply with the mathematics. While the transformation is attributed to Jeff, the evidence for it being a transformation is within the publication from Charlie because Jeff's publication is in response to Charlie's question. Charlie is trying to figure out how much justification they should ask from their students to satisfy the activity and Jeff is suggesting a particular practice to meet the goal of ensuring students do understand their answer.

The final sub-practice, *rephrasing*, was one of the more complex discussions about a sub-practice seen throughout the semester. The GTAs seemed to have several different ways to think about this sub-practice, which resulted in several different versions being publicized over the course of the semester. Figure 4.4 gives a simplified look of the changes the sub-practice underwent throughout the semester. In the figure, the colors represent similar changes that occurred but with a different motivation behind the use of the sub-practice. Examples of this will be given in the description below.

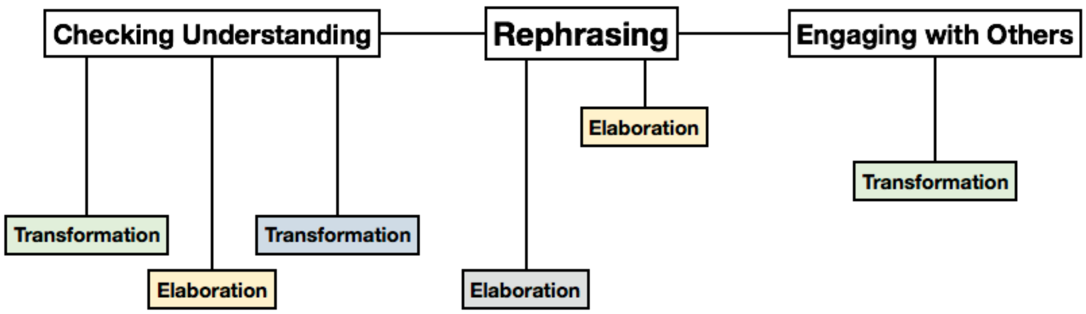


Figure 4.4: A simplified version of the changes the practice of rephrasing underwent over the course of the semester.

The initial publication of this sub-practice included two different motivations for the practice: to check student understanding and to encourage student engagement. During the summer seminar, a lecturer with a graduate degree in mathematics, with an emphasis on teaching, suggested the following:

> There was something that I wanted to add that I think is really productive and engaging your students in a task is to make sure that if someone gives an answer, say you ask a question and a student gives an answer or shares their thoughts and they're kind of going in the right direction, you want to make sure the rest of the class understands it as well so you can say 'can somebody revoice what Nick just said or revoice what Joe just said' or basically say what they said but in your own words to make sure that other students do understand and that a lot of times students don't want to share, they're scared to say it in front of the whole class so sometimes you can say 'in your groups can you discuss that Nick just said' and then they'll come back as a class and check in to make sure that everyone actually understood. Because sometimes when you say 'oh does everyone understand' sometimes the majority of the class might not understand but they...

In this, she talks about the sub-practice as something that can engage students and as a way to make sure students understand what has just been said. As can be seen in the figure above, there were publications that involved only one of those motivations or both of those motivations (the ones in the center of the figure), and so they were separated out from one another for further analysis. However, there were times when an elaboration or a transformation would be publicized of one motivation and then again another. In the figure, similar meanings are marked by the same color, with the first instance occurring higher in the figure. The various elaborations and transformations will be discussed independently, with descriptions of the similar ones occurring in different motivations of the sub-practice being given at the same time.

There was one transformation and one elaboration that occurred only within their corresponding motivation for the sub-practice. As an example of the motivation that included both types, I share the following elaboration that was publicized by a returning Calculus I GTA, Nancy:

> I think even asking [inaud] students to like revoice or talk about what just happened is good because it gives different perspectives than you teaching them and you make sure someone in some group out there understands and maybe when they say it, others will get it better. Maybe notice some patterns better.

In this, she still talks about the motivation of engaging students in discussion and making sure students are understanding the material, but she adds on the benefit of providing students with a different perspective.

The transformation to the version that considered the motivation of checking understanding occurred much earlier in the semester. It was publicized by lead TA Justin during a debriefing session and he suggested the sub-practice as a way to save time: “Yeah. If you want to save yourself some time, like, talking all the time, you can have one of the students explain what's going on instead of saying like, oh, let me make sure you're all familiar.” While there is no evidence to state that he did not have the motivation of checking students understanding in this publication, there is evidence that he at least felt this sub-practice could also be used to save time for the GTA. In fact, he publicized a different version during the same debriefing session that implied the sub-practice could also be used to get students to listen, providing evidence that he held different understandings of the same sub-practice.

That particular transformed version that was noted in the debriefing session was first publicized by the other lead TA, Jeff, independently of Justin, during a debriefing session. However, it was originally utilizing the motivation of student engagement instead: “One of them is if you see someone who's talking, you say ‘hey can you repeat what, repeat what Christian said.’ And put them on the spot a little.” In this, he is providing a suggestion to a new GTA to help her make sure the class is paying attention to whomever is presenting. While the base motivation is still student engagement, there is the added motivation of classroom management, representing a transformation to the original version of the sub-practice.

Finally, there was an elaboration to the sub-practice that involved both motivations publicized by Dr. D during the summer seminar:

> So, my favorite is to let the students do that and so sometimes you get someone who's really quiet and so that move, asking can someone else say what they said or can someone else explain that idea, very often that student will be like ‘oh, I didn't hear that.’ And so that's an opportunity to get a student to ask for clarification versus yourself and I find that tends to work without making anyone feel bad.

In this, he is suggesting the use of the sub-practice as a way to help encourage students to speak up and make their ideas heard without specifically telling the student to state it again. Justin went on to publicize a similar elaborated version later in the semester during a PD course meeting but within the motivation of checking student understanding:

> I think, um, one thing I do, 'cause I do the same thing. I ask them ‘do you understand that’ and then no one says anything so pick on someone you know, maybe not all the time, but occasionally pick someone you know usually struggles and see if they actually understand. Have them try and explain it. And then at that point they either do and they explain it, or they say ‘well, I don't actually get it.’ Okay well, take some time, talk about it with your groups and then we'll come back and then tell me what it means.

In this, he is suggesting a similar thing of asking a student to repeat something but instead of being concerned that the class did not hear what was said, the concern is that the class did not understand what was said. The goal behind the sub-practice is to not make the original student feel bad by directly telling them to say something again, which is similar to the goal in the suggestion by Dr. D.

Overall, the sub-practice of asking students to rephrase something that was shared to the class began with the motivations of student engagement and checking student understanding but underwent a handful of transformations over the course of the semester. While this sub-practice was separated into three parts, when they are taken together there is evidence that the original version, with some elaborations, was the predominant version publicized by the GTAs. What is interesting to note is that all of the transformations publicized about this sub-practice involved using the sub-practice as a way of managing the classroom, whether it was time management or scaring students into paying attention in class.

While some sub-practices involved both transformations and elaborations, there were others that only involved elaborations.

Elaborations Only

There were seven teaching practices in which the sub-practices contained either only elaborations or no changes from the original version. These two types of changes, or lack of changes, are grouped together because they both involve no fundamental change to the meaning or motivation behind the teaching practice. A breakdown of each of these teaching practices into their sub-practices and which were elaborated is given below in Table 4.5. Less than a third of the sub-practices within this category showed evidence of being taken up by the GTAs.

However, as was stated earlier, this could have been because the GTAs did not feel a need to discuss the practice with others because they felt confident in their own understanding.

Table 4.5: A breakdown of the teaching practices that had only elaborated sub-practices.

Teaching Practice	Elaboration
Elaboration	Extending Ideas
	Rephrasing with Precision
	Requested Information
	Add Clarification
	Repeating
Precision	Communication
	State Why
	Understand Why
Participation – Atmosphere	Word Use
	Question Use
	Social Structure
	Grading
	Presentations
Think-Pair-Share	
Answering	Take Away Agency
	Equal Playing Field
	Students Take Agency
Goals	Main Topics
	Structure
	Active Learning
	Coverage
Checking In – Group Work	Engagement
	Struggling Groups
	Walk Away
	Progress

Since this category does not contain any transformations, I will focus on a single example: *precision – communication*. Within mathematics, the use of precise language is important for many different reasons, including for communication purposes. The teaching practice of *precision* involved discussions about the importance of precision in the classroom and how to encourage it among the students. The difference between this teaching practice and the practice within the teaching practice of *elaboration* is that in the latter case, it was times in which someone talked about rephrasing something a student said with precise language. It was an elaboration on what the student had originally said. In this case, *precision* is marked by times in which the discussion was on the importance of precision and times when it was important for the GTA to use precise language.

There were three sub-practices within this overall teaching practice: *communication*, *state why*, and *understand why*. However, only the sub-practice of *communication* had any publicized elaborations. The discussions were centered on ways in which precision was important for communication within mathematics. It was first publicized by one of the PD leaders, Dr. J, during a discussion about an observation protocol, the MCOPP (Gleason et al., 2015). Within the MCOPP, there is an area for the observer to comment on the use of precise language in the classroom and Dr. J was asking the GTAs and ISAs why precision would be important in the classroom, which began the conversation on how precision and communication are combined:

> I don't know why I love this so much but it's so important to me, that idea of precision is that communication is, you know, either verbal or written should be precise. And, um, the teacher and the student should try to be precise. Why would that be?

While Dr. J does not explicitly state a motivation behind the use of precision in communication, one can be inferred through the use of the MCOPP as this was the context that guided the discussion. The MCOPP values precision in communication with the expectation that the teacher both uses precision and supports students using precision for better communication.

The conversation was continued during the same session in the summer seminar by returning GTA, Tina, and new GTA, Megan, along with Dr. J. Later during the same session, an ISA publicized an elaboration on the original version by observing that the instructor in the video they had watched "was on point with his terms." In this, she is adding on that the instructor should be modeling the use of precise language in his or her communication, as well as teaching students the importance of precise language. A few weeks into the semester, the lead TA for Calculus II, Jeff, publicized another elaboration during a meeting of the PD course: “But I really like having it. It sort of, it does reinforce that idea that we really want them to write very clear statements.” In this, he talked about how the use of complimenting student’s organization of their work could help to reinforce the idea that precision in their statements is important. So, it was not just about making sure that they, as GTAs, were using precise language and notation but that the students were as well.

Overall, teaching practices within this category had evidence of general consensus among the GTAs since they did not publicize any transformed version. Some of the practices did not have a large enough number of publications to provide evidence of agreement but the fact that no one publicized a transformation provides evidence that they may not have felt the need to change the motivation or meaning of the practice. In the next, and final, category, all of the practices were transformed in some way, which could provide evidence of inconclusive discussions.

Transformations Only

There were only four teaching practices in which every sub-practice within the overall teaching practice contained a transformation. Only one of these teaching practices, *cognitive demand – planning*, contained sub-practices; the remaining three teaching practices did not contain any other practices and so it was the teaching practice itself that contained a transformation. A breakdown of each of these teaching practices is given below in Table 4.6. Only two of the practices within this category did not show evidence of being taken up by the GTAs in their discourse.

Table 4.6: A breakdown of the teaching practices where every sub-practice contained a transformation.

Teaching Practice	Transformation
Synthesizing	
Cognitive Demand – Planning	High Ceiling Additional Problems Simplifying
Wait Time	
Anticipation – Additional Problems	

The idea of *cognitive demand* within planning involved discussions about the difficulty of the task and how to deal with it when implementing the activity. This is different from the *cognitive demand* teaching practice within whole class because those discussions were focused on the raising or lowering of the cognitive demand while enacted in class. There were three sub-practices within this overall teaching practice: *high ceiling*, *additional problems*, and *simplifying*. For each of these there was one elaboration and one transformation publicized.

For the sub-practice of *high ceiling*, the discussions were centered around planning activities that have plenty of room for the students to continue working on the problem. Generally, this is paired with the idea of a "low floor," which is the idea of creating activities that are easy to engage with. However, discussions tended to focus on making sure there was room for students to continue working rather than making sure they were accessible. It was first publicized by the chair of the mathematics department in which he talked about giving students problems that are easy to understand and start but have a large amount for them to explore:

> Low floor, high ceiling, what does that mean? … Yeah, kind of like Fermat's Last Theorem. You can explain it very easily, you can get into it, you can experiment with it, and maybe you can prove some of the results but there's plenty of room above to keep working.

The conversation about problems and tasks that follow this idea continued through the summer seminar, with several PD leaders and a few GTAs publicizing their understanding of the same idea.

Later during the practice session at the summer seminar, Dr. C went on to elaborate on the original idea by adding on that GTAs have the authority to change the tasks they are given to make them more challenging. In discussing one of the activities, he stated:

> So personally, I would have restructured, if I was teaching this, I would restructure this and, say, 'okay I'd blow out number one' because you're what that task is doing is laying out okay small bite, small bite, small bite, now do the big thing that I want you to do.

He went on to talk about this several more times throughout the practice sessions, publicizing this version three more times. During the first Calculus II meeting, Jeff publicized a transformation where he talked about an activity the GTAs would be implementing in their sections and mentioned that the interesting part didn't come until the end of the activity. This is distinctly different from what Dr. C and the chair of the department were talking about during the summer seminar. Both the chair and Dr. C talked about giving interesting problems with room to explore, with Dr. C encouraging the GTAs to change the activities so as to create more interesting tasks. Instead, Jeff noted that the interesting part of the task did not come until the end without any suggestions of bringing that question to the forefront. Additionally, the problem was written as a bonus question, and so it was thought of as something that was optional would be nice to get to, but not important.

The other lead TA, Justin, publicized a similar version independently of Jeff during a debriefing session with a new GTA: "We didn't have this extra graphing which was a lot harder than the first page. The first page was designed... they should be familiar, and it should be exactly how you presented the first problem…" In this, he talked about the two different pages of the activity. The first page was changed to be easier and to include problems the students were familiar with. The second page was the one that included the much more difficult task of creating a graph representing the various limits given. He goes on to say that getting to the second page of the activity is difficult to do in the time allotted. Instead, it is considered almost an extra problem.

For the sub-practice of *additional problems*, the discussions were centered around creating additional problems for students to work on if they finish the activity early. The goal was to continue to challenge the students by giving them more tasks to try and explore. There was a single elaboration and a single transformation publicized in reference to this sub-practice. However, overall this sub-practice was not taken up by the GTAs.

Finally, for the sub-practice of *simplifying*, the discussions were centered around ways to make a task easier for students. This could involve making an entire task easier for students or creating an easier entry point for students on more challenging problems. This sub-practice was first publicized in a conversation between Dr. D and Dr. B, two PD leaders, during the summer seminar:

> Dr. D: Yeah, I was just wondering about one other aspect of this problem. So, you really hit the language piece for me but computationally, this is also a very difficult problem. [Dr. B: yes} And this gives no, neither of these give any support to do the computation. I just didn't know what your thoughts were on that. That seems like that's another sort of access, equity dimension there.
>
> Dr. B: Yes. I think you're absolutely right. So, when you say computationally, are you saying like the setting up of the integral, the...
>
> Dr. D: Setting up the integrals, doing, it's like probably at least a page of computations to do it. Like getting the right variables. Like, we talked, I think earlier, if you guys remember the idea of the, like, low floor and high ceiling. This seems like they both have a pretty high floor.
>
> Dr. B: Yeah, this is like you're entering on the third floor, just like this building. [laughter] Right? I think I completely agree. yeah. And I don't think this would be

> a problem that I would give with no support by any sense or stretch of the imagination.

In this interchange between the two PD leaders, they discussed the need to add support for students to access a challenging problem, relating back to an earlier discussion about tasks with a low floor and a high ceiling. The leaders were not suggesting making the main task easier for students but instead to offer students additional support so as to access the challenging task.

During the first Calculus II meeting, the coordinator publicized a transformed version of this sub-practice in which the coordinator encouraged his GTAs to make the problem easier for students by telling them the parameters. This way the students did not struggle as much with the general form of the equation given in the task and were able to move forward. However, this is not so much as to provide students a way to access the problem but to make the problem easier overall.

During a later Calculus II meeting, the coordinator again talked about making a problem easier in general for students. But he did go on to offer an elaboration by suggesting that the ability for students to access the task was dependent on what they came into section already knowing. He went on to state that it is up to the GTAs to find out how much the students know before implementing the task so as to be prepared to help the students access the problem.

Throughout the rest of the semester, this sub-practice came up only during the Calculus II meetings, with them referencing all three versions throughout. It ends with Tina talking about how the tasks had been rewritten to be more accessible for students over the past year and how students seemed to have more “aha” moments than during the previous year. Overall, this sub-practice seemed to be an important topic within Calculus II but not as much for Calculus I.

Conclusions

In this chapter, I discussed the differences between an elaborated publication and a transformed publication along with several examples illustrating the differences. For a publication to be classified as an elaboration, the meaning and motivation behind the practice would not have changed. Instead, the publication would only add on to the practice by placing it within a new context or giving an additional way the practice could be used. For a publication to be classified as a transformation, the meaning or the motivation behind the practice would have been changed. In some cases, the change is obvious. For instance, in the practice of asking students to rephrase something that had just been said, there was the motivation of student engagement and the motivation of classroom management. However, there were cases in which the transformation was not as obvious because the motivation may have not changed for the speaker. An example of this was seen within the practice of adding scaffolding. In the case of Charlie’s publication, his goal was still to provide assistance to students, much like the original version of the practice. However, the meaning of his version involved the simplification of the task rather than the maintenance of the cognitive demand.

The importance of the differences between elaborations and transformations will be clearer after the analysis discussed in Chapter 5. If the practice showed evidence of being taken up, then two criteria were used to determine whether or not it was conventionalized. In Chapter 5, we will see whether it was the elaborated, transformed, or original version that was conventionalized. If it was taken-up but not conventionalized, then the discussion may have been inconclusive or dominated by a single person. If the practice was not taken-up, there are two possibilities for why. One possibility is that the GTAs are confident in their understanding of the practice and do not feel a need to discuss it with others in a formal setting. In contrast, another possibility is that the GTAs are not confident enough in their understanding of the practice to publicize it in a formal setting. Without additional data from what they implement in the classroom and their informal conversations, it cannot be concretely determined which type it is. Overall, it is the analysis done in this chapter that allows for a better understanding of how GTAs make sense of the various practices individually and within a community. Figure 4.5 below provides a simplified representation of the different possibilities for the development of a practice through discourse.

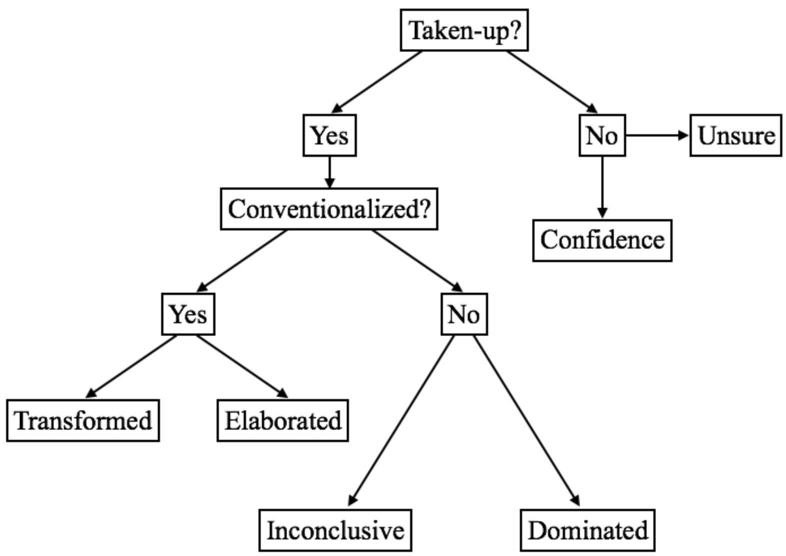


Figure 4.5: The possible outcomes for a publicized practice.

Furthermore, it was not only the original version that could be elaborated on. In some cases, it could be the transformed version that was subsequently elaborated on. For instance, within the sub-practice of *selecting - asking*, it was the transformed version publicized by Jeff that was then elaborated. Examples of the importance of this are described in Chapter 5 when there were times in which it was the transformed version that showed evidence of conventionalization. However, a transformation was always marked as one on the original version because if the meaning or motivation has changed, it would have changed from both the original and the transformed version, not just one or the other.

One concrete result that stands alone within this chapter is that some of the publicized changes involved classroom management, with classroom management referring to behavior-modification approaches that "prioritize behavioral learning, emphasize the contingencies that exist in the classroom and implicate reinforcement strategies, shaping, and response costs as key techniques" (Rimm-Kaufman, Storm, Sawyer, Pianta, & LaParo, 2006, p. 145). For example, the practice of body position contained a sub-practice in which it was suggested that the TA could stand near a disruptive group to help gain their attention:

> You just stand by them and continue talking and the fact that you are there, they're like 'okay, I guess I can't text my buddy on my cell phone right now 'cause Charlie is right here and it's obvious.' So I think that's one thing to do where that can help with that.

While not every publicized introduction, elaboration, and transformation involved a management approach to the teaching practice, there was evidence within some of the transformations and elaborations publicized by all of the GTAs, including the lead TAs, that did add a management approach to the practice. A count of the number of elaborations and transformations that involved a management approach is given below in Table 4.7.

Table 4.7: Number of publicized introductions, elaborations, and transformations that involved a management approach to the teaching practice compared to the total.

Speaker	Management	Total	Percentage
PD Leaders	9	127	7%
Calculus Coordinators	11	43	26%
Lead TAs	28	110	25.5%
Calculus GTAs	25	87	29%

What is particularly interesting to note is that the PD leaders only publicized elaborations and transformations with a management approach 7% of the time, compared to 25.5% of the time for the Calculus I and Calculus II lead TAs. Furthermore, the Calculus I and II GTAs publicized management based changes 29% of the time. So, the lead TAs are less likely to publicize a management change to a practice than their fellow GTAs but still more likely than the PD leaders.

A time in which the difference between a management and non-management approach was particularly evident was within the practice of asking students to rephrase what was just said. Both of the lead TAs publicized a transformation in which the practice could be used to manage the classroom and scare students into paying attention in class. While there is evidence of both of the lead TAs publicizing a version related to the original later in the semester, the fact that the lead TAs also worked to incorporate more advanced teaching practices into a classroom management practice is telling of the context the GTAs are working within.

Chapter 5: The Individual and the Collective Influence

Chapter 4 focused on the various teaching practices that were discussed over the course of the semester and the ways in which they were elaborated on or transformed by various individuals within the GTA program. The focus was on the use of the modified Vygotsky Space to document the ways in which various teaching practices were publicized, appropriated, and transformed without an emphasis on who was publicizing the various versions over the course of the semester. This chapter leverages the structure of the modified Vygotsky Space to focus on the interplay between the individual and the community.

The ways in which various teaching practices were discussed and transformed or elaborated over the course of the semester has a connection with the people publicizing those versions. This chapter goes into detail on the criteria for a practice to become conventionalized within a community. Chapter 4 and this chapter taken together answer both of the research questions, and Chapter 6 will summarize the overall results to those two research questions. However, the analysis of the themes of the practices and sub-practices discussed in this chapter will be given at the end.

An important note worth reiterating is that this study focused on the teaching practices *discussed* by those involved in the GTA PD program and not those practices enacted in the classroom. While there are data from the observations conducted by the lead TAs in the form of their written notes and their debriefings with the GTAs after, these were used as reference for analysis of the discussion, rather than as a representation of their overall use of teaching practices. The professional development, coordination, and debriefing spaces provide the opportunity for individuals to appropriate new motivations or meanings for instructional spaces. So, while there were several teaching practices that did not continue to be discussed in a formal setting by those involved in the PD, I am not suggesting those practices were not discussed in an informal setting or enacted in the classroom. Reasons for why these practices may not have been discussed in more depth are suggested later in this chapter and are based on when they were discussed, by whom, and the practice discussed itself.

Through an in-depth analysis of each of the teaching practices and their sub-practices, some of which are described in more detail in Chapter 4, there were four categories that characterize the interplay in the discussions between the community and the individual: Conventionalized Discussions, Dominated Discussions, Inconclusive Discussions, and Limited Discussions. This discussion of instructional practices gave evidence of various levels of conventionalization. Within the category of Dominated Discussions are discussions about various teaching practices that were dominated by one particular person or by a particular group of people (such as the lead TAs). These instances can provide insight into something important to a particular individual but not something broadly discussed by the community. The category of Inconclusive Discussions contained three different teaching practices that showed no evidence of agreement in the meanings. Finally, teaching practices rarely discussed by the community are within the category of Limited Discussions. This includes both practices that are discussed by a handful of people over a short period of time and practices only discussed by a single person. Reasons for why these particular practices were not taken up in discussions around teaching are proposed in this section.

Conventionalization

Within the modified Vygotsky Space framework (recreated below in Figure 5.1), there is the fourth quadrant of *conventionalization* that may or may not occur. As was defined in earlier chapters, conventionalization is when the “individuals’ public manifestations of thinking (i.e., their actions and their ideas) are incorporated as part of the community of discourse in which they participate" (Gavelek & Raphael, 1996, p. 188). As can be seen in this definition, conventionalization involves the reciprocal nature of the relationship between the individual and the community found within the socio-cultural learning theory on which this framework is based.

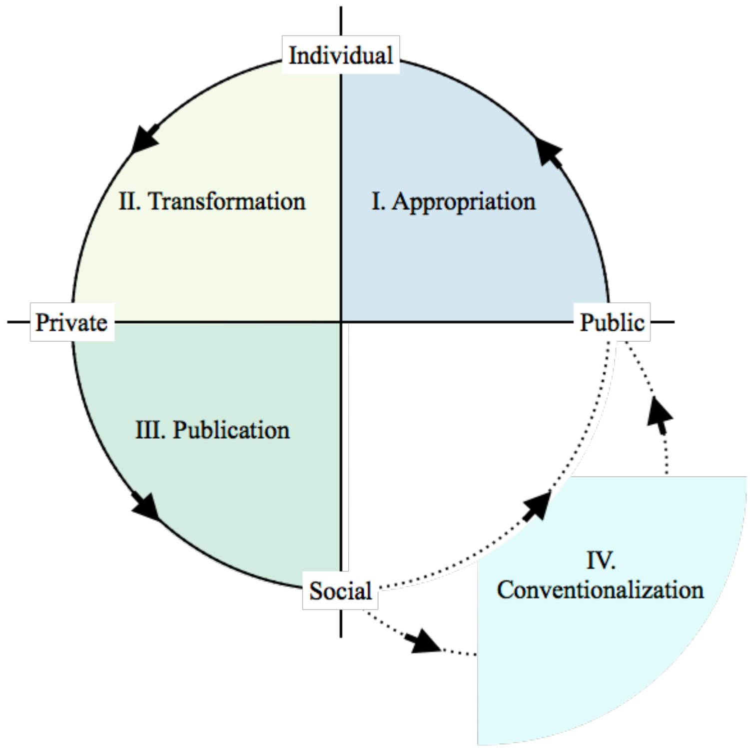


Figure 5.1: The modified Vygotsky Space.

The way that conventionalization was determined was influenced by the construct of *functions as if shared*. The construct of functions as if shared is defined to be an idea or topic that functions *as if* everyone in the community shares that way of reasoning (Rasmussen & Stephan, 2008). The way in which these forms of reasoning that were functions as if shared are determined is through the use of documenting collective activity, which utilizes Toulmin's model of argumentation as a tool for the methodology (Toulmin, 1969). Within the model of argumentation, there are four main aspects: data, warrant, claim, and backing. Through the use of the model of argumentation, researchers use three criteria for determining whether an idea has become a normative way of reasoning within the community:

1. When the backings and/or warrants for particular claim initially are present but then drop off or
2. When any of the four parts of an argument (the data, warrant, claim, or backing) shifts position within subsequent arguments or
3. When a particular idea is repeatedly used as either data or warrant for different claims across multiple days (Cole et al., 2011, pp. 199–200).

For the purposes of this study, there are two criteria for a particular understanding of a teaching practice to be considered conventionalized within the discourse of the community of GTAs. The first is based on the third criteria noted above and involves a variety of GTAs (e.g., Lead TA, Calculus I, returning) publicizing the practice, and the second is based on the first of the three criteria noted above, with changes made to how it is determined based on this particular case. The two criteria are:

1. The teaching practice has been publicized by numerous GTAs (more than 50% of the TAs within the entire community or within a sub-community), both new and returning, over the course of different events throughout the semester. In other words, numerous individuals contributed to and shaped the meaning of the teaching practices, which in turn was appropriated and publicized in a consistent manner.
2. When no member of the community or sub-community challenges the publicized understanding of a teaching practice, and/or if the publicized understanding of a teaching practice is contested and the transformed version is not taken up, I consider the publicized understanding of the teaching practice to be conventionalized.

A semester may not be a long enough period of time to state with complete certainty whether or not the understanding of a practice has been conventionalized within a community but there were some practices that had strong evidence towards conventionalization and other practices that had evidence that the meaning for the practices was moving toward conventionalization. Each of these two categories is discussed in more detail below.

Evidence of Conventionalization

There are 10 different teaching practices that showed evidence of conventionalization[4], either within the entire community of GTAs or within a sub-community of GTAs. Each of these practices along with the information about their publications, the events in which they were publicized, and the number of publications by groups of individuals are given below in Table 5.1. The ways in which the practices were determined to be conventionalized within the community was based on the number of publications, the number of events in which it was publicized, and how many of the GTAs publicized the teaching practice. Furthermore, it involved which GTAs were publicizing the practice.

There are two major categories within this set of practices: practices found in "traditional" teaching and those found in "active" teaching. In the "Traditional" teaching category are practices that may be found in a variety of mathematics classrooms, from all lecture to inquiry-oriented classrooms. "Active" teaching practices are more specific to the practices introduced to the GTAs throughout the semester for active learning. These can be further broken down into the three pillars[5], which were introduced during the summer seminar: 1) peer-to-peer engagement, 2) deep engagement with the mathematics, and 3) instructor interest in student thinking.

[4] Henceforth, the language used may suggest that it was the practice that was conventionalized but recognize that this is referring to the discourse about the practice that suggests a coherence in meaning.

[5] The construct of the three pillars is not a published construct. It is a combination of two other constructs: the two pillars of active learning and the two pillars of inquiry-based learning. These two constructs have an overlapping "pillar" and so when they are combined, they create the three pillars discussed here.

Table 5.1: The number of times each sub-practice that had evidence of conventionalization was publicized, the number of events it was discussed in, and the number of GTAs and PD leaders who publicized it.

Category	Teaching Practice	Number of Publications	Number of Events	Number of GTAs	Number of PD Leaders
"Traditional" Teaching	Scaffolding: Add Scaffolding	45	18	8	4
	Selecting: Asking	38	21	11	3
	Questioning: Evaluating	36	16	8	4
	Precision: Communication	36	10	10	2
	Motivation: Real Life	25	18	8	1
	Attention: Confidence	19	7	9	3
"Active" Teaching:	Participation Norms: Student Engagement	37	17	8	3
Peer-to-Peer	Establishing Norms: Peer-to-Peer	31	18	11	2
"Active" Teaching:	Questioning: Justification	87	38	11	5
TA Interest	Questioning: Check Understanding	39	16	10	5

There are several things to note about this group of conventionalized teaching practices. The first is the nature of the practices themselves. Six of the ten practices involve "traditional" teaching practices. In contrast, only four of the ten practices involve "active" teaching practices. These four "active" teaching practices fall into two of the three pillars of active learning: peer-to-peer engagement and TA interest in student thinking. Two of the ten practices could be directly related to aspects of active learning emphasized by the PD leaders. So, perhaps unsurprisingly, it was just as common for discourse about a "traditional" teaching practice to show evidence of conventionalization as it was for an "active" teaching practice.

A second noteworthy aspect of this group of practices is that seven of the ten involved more returning GTAs publicizing the practice than new GTAs, providing evidence that the returning GTAs had perhaps made sense of the practice, whereas new GTAs were still sharing their understanding. I found it also noteworthy to attend to temporal aspects in determining conventionalization. Four of those seven instructional practices were publicized at the end of the semester by a returning GTA and three of them ended with a new GTA, providing evidence that not only the returning GTAs were continuing the discussion moving forward. Only one of those practices involved a greater number of new GTAs publicizing the practice than returning GTAs, and only two involved an equal number of new and returning GTAs. For those practices in which more returning GTAs publicized their thinking than new GTAs, new GTAs were also more likely to publicize an elaboration. In the other three practices, no new GTAs publicized any elaborations to the practices. A new GTA did publicize a transformation to the practice of Adding Scaffolding, and it was his version that was conventionalized within the community of GTAs. However, that was a special case that will be described in detail later.

A final aspect of note is that with the exception of one practice, the practices were all introduced by a PD leader. Three were introduced by Dr. S, two by Dr. J, one by Dr. C, and three by the Calculus II Coordinator. From these numbers alone, we can state that at least eight of the ten practices were introduced during the PD summer seminar since Dr. S, Dr. J, and Dr. C only formally interacted with the GTAs at that time[6]. One practice, establishing group work norms around peer-to-peer interaction, was introduced by a returning Calculus II GTA, Sally. What is

[6] Dr. C did observe some of the GTAs and talk with them during the semester. However, these were not recorded and so they are not included here. Because of this, it can still be assumed that those practices that were recorded to be introduced by Dr. C were done so during the summer seminar.

interesting to note here is that the meanings for teaching practices seen as conventionalized were not introduced by a lead TA. However, Sally did go on to become the lead TA the following year.

By this criterion, we see that the PD leaders or the Calculus II coordinator almost universally first publicized understanding that became conventionalized. The lead TAs do not seem to have a large influence over what is taken up by the GTAs as a community. In fact, as we will see in a later section, what the lead TAs talked about most tended not to be taken up by their fellow GTAs. I had originally hypothesized that the lead TAs would have greater influence over what versions were taken up by the community of GTAs in the discourse because of their status of both peer and mentor.

There are a few possible reasons for why some of the teaching practices publicized the most by the lead TAs were not conventionalized. One reason could be that the fellow GTAs did not feel a need to discuss the practice in other situations. Since there is no direct data of their teaching, it could be that they did implement the practices as they were suggested by the lead TAs without feeling a need to discuss it directly within the various formal settings. Another possible reason is that the number of publications around the same teaching practice from a lead TA was artificially increased by the fact that they were giving the same advice to several different GTAs during different debriefing sessions and these debriefing sessions did not provide an opportunity for the larger community to hear and discuss them in the moment. So, if one just looks at numbers it may have seemed as though the lead TAs were publicizing various teaching practices often throughout the semester, but it was because they were repeating their understanding of the practice to several different GTAs.

Since each of these ten teaching practices was discussed with enough regularity and coherence to provide evidence of conventionalization, I share a subset of examples of how conventionalization was determined. As was discussed earlier, there are three main categories of teaching practices found within this set of ten: "Traditional" Teaching, "Active" Teaching: Peer-to-peer engagement, and "Active" Teaching: TA interest in student thinking. At least one teaching practice from each category will be discussed in more detail below. A brief overview of the practices not discussed in detail will be provided at the end of this section.

"Traditional" Teaching. Within this category there are six different teaching sub-practices with evidence of conventionalization: *adding scaffolding*, *asking students to present*, *evaluating student thinking*, *the use of precision for communication*, *motivating with real life examples*, and *gaining the classes attention through confidence*. Before I provide a deep analysis of each of these teaching practices and how they were discussed over the course of the semester, it is interesting to note when each of these sub-practices were first brought up and by whom. Three of the practices were introduced by a PD leader and the other three were introduced by the Calculus II coordinator. The practice of motivating with real life examples and the practice of adding scaffolding were both conventionalized within the sub-community of Calculus II GTAs rather than the entire community. The practice of evaluating student thinking only had evidence of being conventionalized within the sub-community of returning GTAs. While it met the second criteria described above that requires a variety of new and returning GTAs to publicize a practice for it to become conventionalized, the number of returning GTAs who publicized similar versions within this practice was too overwhelming to ignore.

The three practices within this category that will be described in more detail below are *adding scaffolding*, *asking students to present*, and *the use of precision in communication*. Each of these will be described within the context in which they were discussed. Chapter 4 provided an analysis of the changes themselves and this section places those changes within the temporal picture.

Scaffolding – Add Scaffolding. The practice of adding scaffolding to an activity was publicized 45 times during 18 different events by 8 different GTAs. Five of those GTAs were Calculus II GTAs, with three of them being new GTAs for Calculus II. The practice of adding scaffolding was first discussed as something to use only if it maintained the cognitive demand of the task; the version taken up by the Calculus II GTAs was that of using adding scaffolding to make the activity easier for the students, instead lowering cognitive demands. A temporal representation of the publications of this teaching practice is given below in Figure 5.2. There are a few important aspects of this figure that should be discussed. First, the different colors represent a change in the discourse, either an elaboration or a transformation, and the change is indicated under the date of the event and the speaker. The dotted line around an event distinguishes when it was the first time for that version to be publicized. Finally, there are some events within the chart that have a number next to it, which represents the number of times it was publicized by that speaker during that event.

This practice was first introduced by Dr. J as something an instructor could do to help students make progress on an activity without decreasing the cognitive demand of the task. Dr. D and Dr. B both emphasized this during the final session in the summer seminar where they both discuss the need to make sure all students have access to the task. This original version of the practice does not get publicized much throughout the semester. Instead, it is a transformed version that was publicized by a new Calculus II GTA, Charlie, that seemed to be taken up by the Calculus II GTAs. In this version, Charlie was still suggesting a way to help students but instead of keeping the cognitive demand at the same level, his suggestions tended toward making the task easier for students by doing more for them.

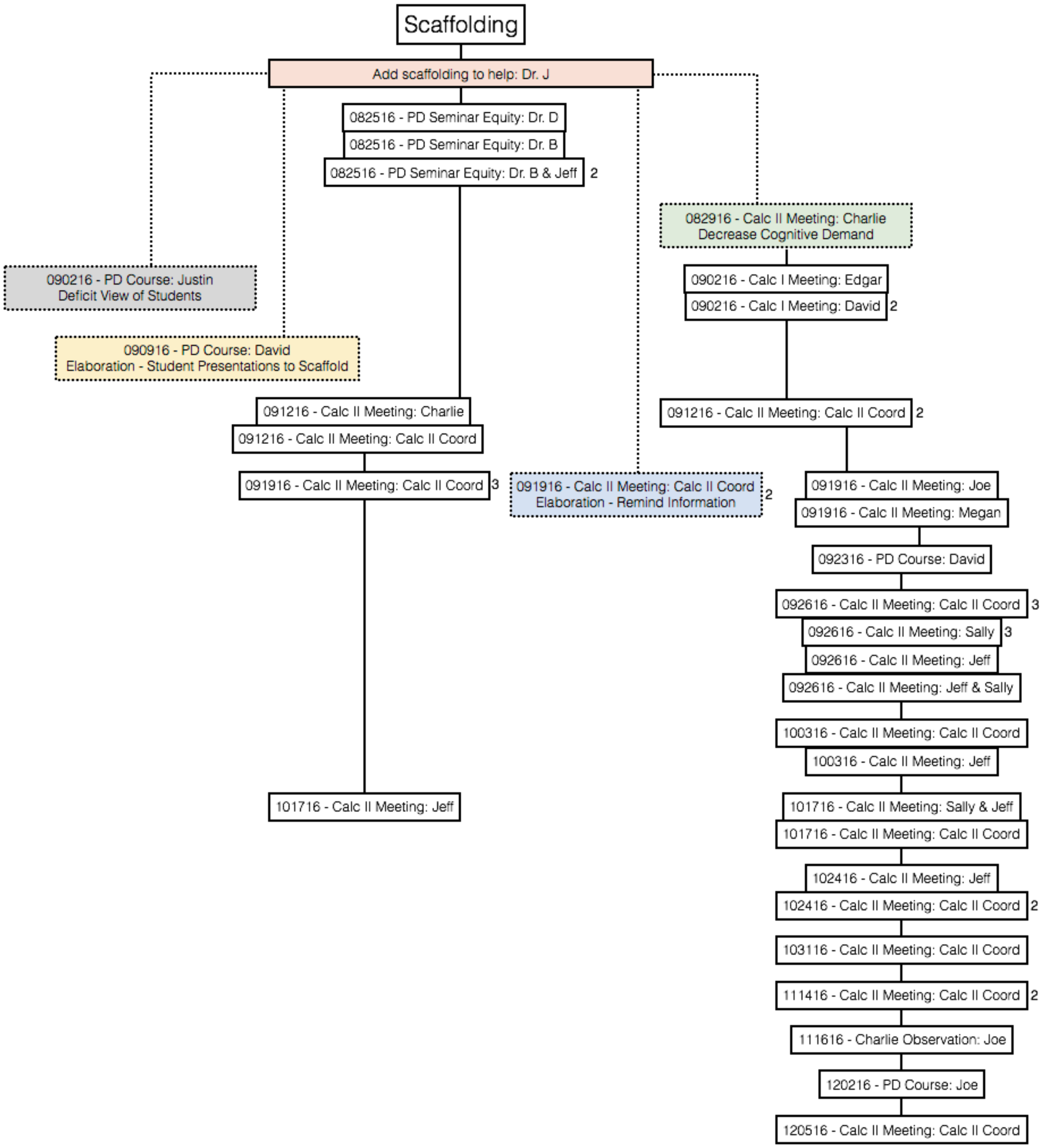


Figure 5.2: A temporal representation of the publications around the practice of adding scaffolding to an activity.

While it was Charlie's version that was taken up, Charlie himself publicized a few weeks later his understanding of the practice similar to the original version and there was no evidence of him subsequently publicizing his original transformed version. There was a second transformation publicized by Justin in which he stated that he felt there were some students who "you could give them as much scaffolding as you want, and they would still sit there and go 'I don't know how to explore that,'" essentially rejecting scaffolding as feasible (representing a deficit view of the students). Within the context of the discussion, he was suggesting that no matter how much one lowers the cognitive demand of a task, some students will continue to not engage with the activity. However, there is only evidence of this version being publicized once. Two elaborations were also publicized but neither one came up more than once.

Something interesting to note is that Jeff, the lead TA for Calculus II, publicized a version of the original teaching practice approximately half way through the semester after having publicized Charlie's transformed version earlier in the semester. However, much like in the case of the teaching practice of creating the participation norm of student engagement, no other GTAs publicized the original version after the lead TA had. In fact, there is evidence of the lead TA publicizing the transformed version.

Selecting – Asking. Another practice that showed evidence of conventionalization was that of asking students to present their work to the class. It was publicized 38 times during 21 different events by 11 different GTAs over the course of the semester. A temporal representation of the various publications around this practice is given below in Figure 5.3. The interesting aspect of this practice is that, again, the original version was not the commonly discussed version. Instead, it was a transformed version, publicized by Jeff, that was taken up and further elaborated on by others. The original version was publicized by the Calculus II coordinator in which he suggested asking students to present but without the option of declining. It was during the same meeting that Jeff transformed this by suggesting they instead ask students to present rather than tell them to. As can be seen in Figure 5.3, there were two different versions through the semester. While the original version was publicized again later in the semester, it was not the most commonly publicized version.

Note the publication by Dr. D that is connected to both branches, indicating its ambiguity of meaning. In this instance, Dr. D stated: “I thought, and um, definitely, you know, just again, giving them that advanced warning about sharing their stuff, I think is super helpful.” Within the context of the conversation, this suggestion could have been interpreted by the GTAs as telling students to share their work in advance or asking students to share their work.

There are three GTAs, Justin, Jeff, and Nancy, who publicized the original version rather than the transformed version. Furthermore, those three show no evidence of publicizing the transformed version after publicizing the original version. However, they were all present in later events in which a version of the transformed publication was discussed without any opposition. Since these two versions are not contradictory to one another, the GTAs could be holding both versions as viable understandings of the practice.

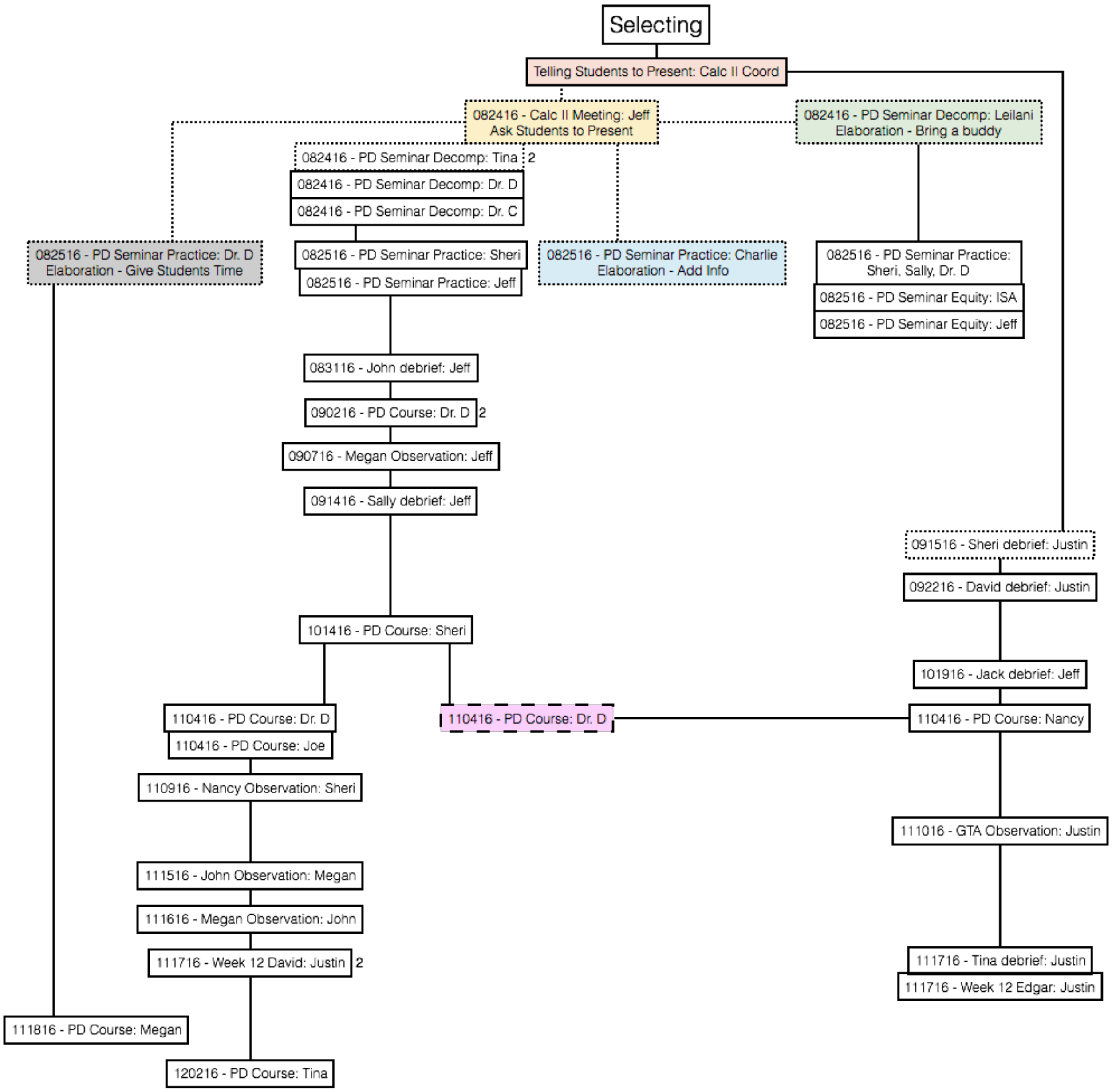


Figure 5.3: A temporal representation of the publications of the practice of asking students to present.

Precision – Communication. The practice of using precise language for communication was discussed in 10 different events over the course of the semester. And within those 10 events, there were 36 different publications that included 10 of the 16 GTAs, half of whom were new GTAs. As was seen in Chapter 4, it was first introduced by Dr. J during the summer seminar, with an ISA and Jeff each publicizing elaborations to the practice at different points. A temporal representation of the various publications is give below in Figure 5.4. This is an example of an instructional practice that was discussed and elaborated with no transformations.

The initial publication by Dr. J came during a discussion about the importance of precise language in a mathematics classroom in which she states that "… the teacher and the student should try to be precise." She goes on to ask why that may be important in the mathematics classroom, to which a returning GTA, Tina, states its importance in communication.

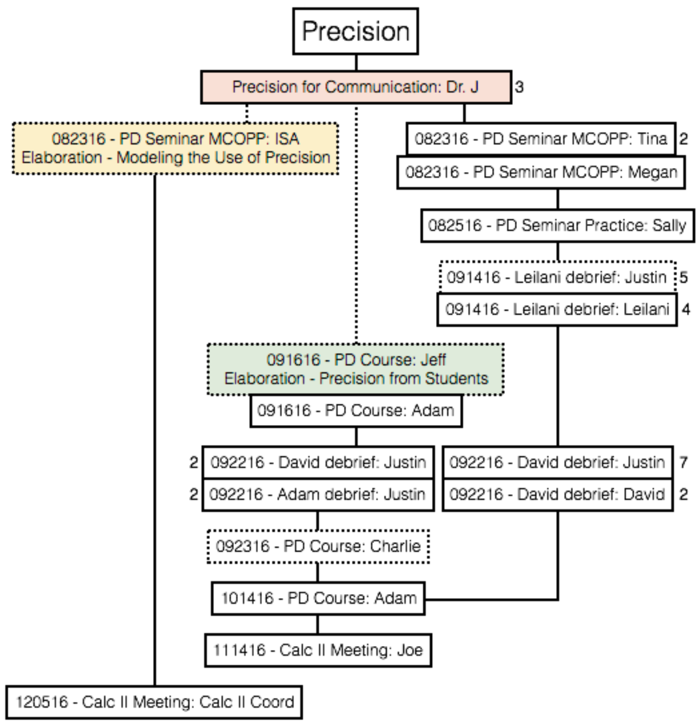


Figure 5.4: A temporal representation of the publications of the teaching practice of the use of precision in communication.

Later during the same summer session, an ISA elaborated on the use of precise language by adding that the teacher can model the use of precise language to their students. This particular elaboration does not seem to be taken up by the GTAs, with it only being publicized once more at the end of the semester by the Calculus II coordinator. In contrast, the elaboration publicized by Jeff did seem to be taken up by the GTAs, with two different new GTAs both publicizing similar versions, one independently of Jeff. In Jeff's elaboration, he added that the GTAs should be sure to ask for precision from their students to help them get used to the language of mathematics. Both of these elaborated versions show evidence of the same motivation as the version publicized by Dr. J and Tina in which precision is important for communication in a mathematics classroom.

Since this practice, with the same motivation behind the use of the practice, was publicized by a majority of the GTAs over the course of the semester, and since half of those GTAs were new, there is strong evidence of conventionalization. This is not entirely surprising as precision is a trait valued by mathematicians. Since the GTAs are all studying to receive an advanced degree in mathematics, it is not surprising that they would agree on the importance of precise language in a mathematics classroom. So, while there are not many events in which this practice is discussed over the course of the semester, the number of GTAs publicizing a version of this practice with similar motivation behind its use helps to provide evidence that the community as a whole agreed on the meaning and purpose of the practice.

"Active" Teaching: Peer-to-Peer. As has been discussed throughout this dissertation, one of the major changes to the Calculus program at SDSU was the inclusion of active learning in the break-out sections for Calculus I and II. When active learning was introduced during the summer seminar, the image of three pillars was used to describe the main goals of the pedagogy: peer-to-peer interaction, deep engagement in the mathematics, and instructor interest in student thinking. Much of the summer seminar and of the semester long PD seminar focused on these three aspects of active learning, so the fact that four of the practices with evidence of conventionalization involved aspects of these three pillars may not be surprising. What may be surprising instead is the fact that three showed evidence of conventionalization within the community of GTAs and the other one showed evidence of conventionalization solely within the community of Calculus I GTAs. Furthermore, one of the three which showed evidence of conventionalization within the entire community of GTAs was introduced by a returning GTA rather than a PD leader.

Within this category of “active” teaching, the focus of the practice was on ways to help encourage student engagement with one another. There are two practices within this category that showed evidence of conventionalization: setting up norms to support student engagement and establishing group work norms around peer-to-peer engagement. Both were introduced during the summer seminar and one was introduced by a returning Calculus II GTA. The practice of establishing group work norms around peer-to-peer engagement is the one described in more detail below because it was the only practice within the ten that was introduced by a GTA rather than a PD leader.

The practice of setting up norms to support student engagement showed evidence of being conventionalized within the sub-community of Calculus I GTAs and it was the original version that was taken up by the sub-community. The original version involved suggesting that the GTAs work to make sure their students speak to the entire class rather than only to the GTA. What is interesting to note about this is that there were three different elaborations publicized, also during the summer seminar, and only one transformed version that was never publicized again after the initial publication. So, through the analysis of the discourse, this practice seemed to be one commonly agreed upon by those who publicized their understanding of the practice. In contrast, as will be elaborated on below, the second practice within this category had two separate transformations, one of which was taken up by two different GTAs at different points in the semester. So, while there is evidence that this practice was conventionalized, it was not without some negotiation over the motivation for its use.

Establishing Norms – Peer-to-Peer. The second teaching practice within this category was that of establishing norms within groups around peer-to-peer interaction. This practice was publicized 31 times over the course of the semester in 18 different events by 11 different GTAs. Only one of those GTAs publicized a transformed version of the practice with the remaining 10 publicizing either the original or an elaborated version of the original. Furthermore, with the exception of David, if a GTA publicized a transformed version during the semester, there was evidence of them publicizing either the original version or an elaborated version later in the semester, providing evidence that they either held two versions or had changed their view. This instructional practice met the two criteria for conventionalization among the community of GTAs. A temporal representation of each publication of this practice can be found below in Figure 5.5.

As was discussed in Chapter 4, this practice was first publicized by a returning GTA, Sally, during the practice session at the summer seminar. In her publication, she made a suggestion to all of the GTAs that when they get a question from a student, instead of answering it directly, they ask the question back to the group the student is in to help foster peer-to-peer interaction:

> Can I ask a question to all the presenters basically? Um, so, I noticed since I'm sitting in the groups, as you walked around most of you, I don't remember exactly, but, um, when someone asked a question in the group, you would answer directly to that person instead of, like, branching out and asking 'Does anyone else in the group have an idea about that' or, like, just have more of that peer-to-peer interaction and, like, have them talk to each other rather than just a one-on-one conversation with you and the student.

Dr. C went on to add to this version by reminding the GTAs that they should be sure they are talking to the entire group and not just a single student at a time.

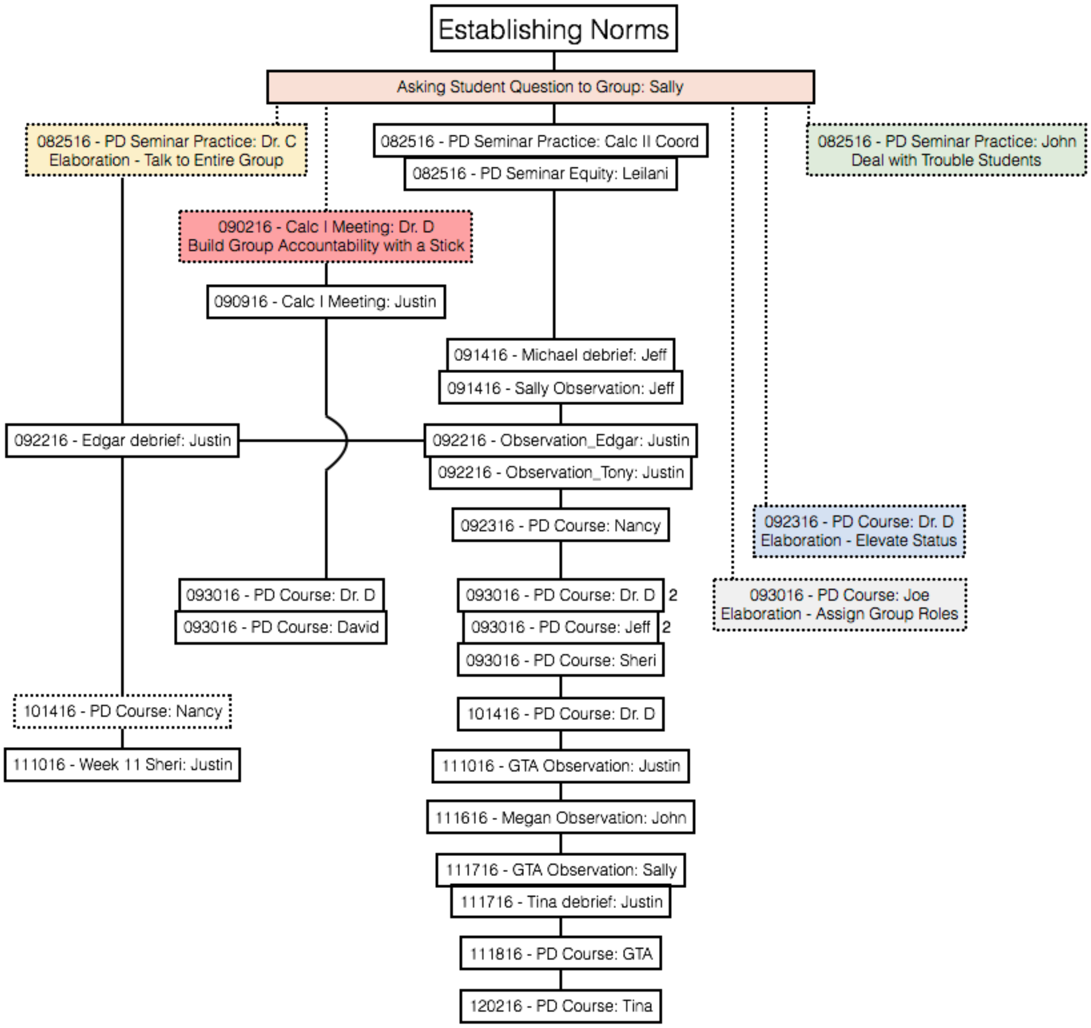


Figure 5.5: A temporal representation of the publications of the practice of establishing group work norms around peer-to-peer interaction.

As was seen in Chapter 4, during the same summer session, a new GTA, John, publicized a transformed version in which he suggested the use of the practice as a way to deal with "troublesome students": "And that might be a good way to like get them, if they have a big head about them anyway, they might try to help others." While he is still suggesting the use of the practice to encourage interaction, the motivation is more towards dealing with students who are not engaging with others. However, this particular version was not taken up by others with this being the only instance recorded. A second, similar transformed version was publicized by Dr. D during an early Calculus I meeting. In his version, he suggests building group accountability through making their participation grade dependent on the whole group rather than individually. So, again the motivation may be to encourage student engagement with one another, but the motivation given to the GTAs takes an accountability stance. This particular understanding is publicized three more times over the course of the semester but does not come up again after the end of September. There were two additional elaborations publicized later in the semester, one by Dr. D and one by Joe, but neither were publicized more than once.

"Active" Teaching: TA Interest. The final category within this group of teaching practices involves TA interest in student thinking, which is one of the three pillars of active learning. Each of these practices focuses on ways in which GTAs can engage with their students' thinking. There are two different teaching sub-practices within this category: *asking for justification* and *checking student understanding*. Both of these sub-practices are within the overarching practice of questioning. By asking students for justification, the GTA is showing interest in how the student found their solution. The sub-practice of checking student understanding is used to gauge how the students are making sense of the material and how to proceed so as to best support their learning. This practice is different from evaluation of student thinking because the motivation is to understand how the student is thinking about the mathematics rather than checking if they can give the correct answer.

Both practices within this category were introduced by Dr. S during the summer seminar and they both involved elaborations that were publicized often throughout the semester. They both also showed evidence of conventionalization within the whole community of GTAs. I will be focusing on the sub-practice of asking for justification because it was the most commonly publicized teaching practice throughout the semester. Furthermore, it provides a demonstration of how the first criteria of determining whether or not a practice was conventionalized was used.

Questioning – Justification. The most commonly discussed teaching sub-practice over the course of the semester was that of *questioning students for justification*. It was publicized 87 different times over the course of the semester in 38 different events, representing over half of all formal PD events. Eleven of the 16 GTAs and five of the eight PD leaders publicized some version of this practice. There were two elaborations and three transformations publicized, but only one of each of those were actually taken up by the GTAs over the course of the semester. Seventeen of those 87 publications were of a transformed version of the practice, meaning there were 70 publications either of the original version or of an elaborated version. A temporal representation of the various publications is given in Figure 5.6.

The two versions of the sub-practice that were taken up by the community were both publicized by Dr. S during the introduction of the summer seminar. The first publication was during a conversation about the first goal of active learning, students share their thinking, in which she suggested the GTAs could ask students to elaborate on their thinking. The second publication was during the same conversation but about a different goal, students deepen their reasoning through discourse, in which she suggested that the GTAs could push their students to specifically ask how they know the answer, which is an elaboration on the original version she had publicized earlier.

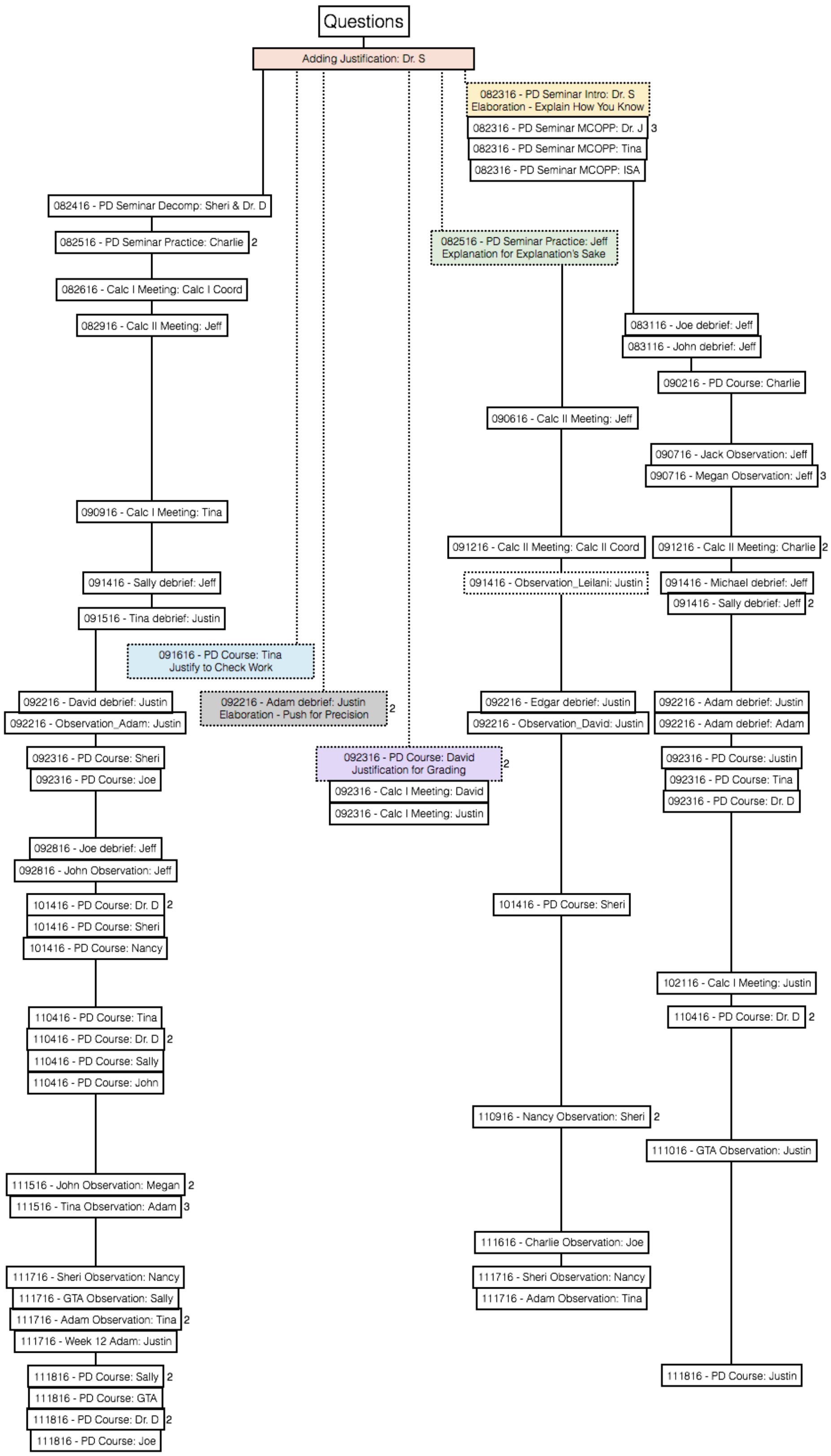


Figure 5.6: A temporal representation of the publications around the teaching practice of asking for justification.

The only other version that was taken up by the community for more than a single event was the transformed version publicized by Jeff. In his version, he suggested the use of the practice of asking for justification as simply a way to keep the students accountable for their work. This marks a transformation from the original because the motivation behind the use of the practice has changed. In the two versions publicized by Dr. S, the motivation was to encourage student engagement with the mathematics for the purpose of deepening reasoning. While Jeff's focus on accountability was publicized a handful of times throughout the semester, the overwhelming majority of the publications were based on the two versions publicized by Dr. S. Furthermore, with the exception of one GTA (Sheri), every GTA who publicized the transformed version went on to publicize one of the two original versions either during the same event or during a later event, providing evidence that they had a shared understanding of the practice related to originally publicized meaning. As individuals contributed to the community discourse there was evidence that there was agreement on the motivation behind the practice, providing evidence of possible conventionalization.

Approaching Conventionalization

There were some sub-practices that showed evidence within both of the criteria for a practice to be conventionalized within a community but did not have enough to state that the practice was conventionalized. These sub-practices were marked as ones becoming conventionalized within a community. Perhaps unsurprisingly, there are nearly twice as many sub-practices with evidence of it becoming conventionalized than there were of ones with evidence of it already being conventionalized within the community. However, what may be surprising is that only 19 of the 137 different sub-practices are within this category. For this section, I will discuss the group of 19 sub-practices that showed evidence of beginning to become conventionalized.

Table 5.2: The number of publications, events, GTAs, and PD leaders who discussed these various teaching practices.

Category	Teaching Practice	Number of Publications	Number of Events	Number of GTAs	Number of PD Leaders
"Traditional" Teaching	Lecturing: Struggling Students	34	10	8	1
	Connecting: Course Material	31	19	7	3
	Anticipation SQ: Awareness	27	16	7	2
	Attention: Draw Attention	27	13	7	2
	Wait Time	26	11	8	4
	Anticipation ST: Past Experiences	22	12	6	3
	Questioning: Forward Movement	21	12	7	3
	Lecturing: Forward Movement	21	11	5	2
	Group Creation: How to Group	20	13	10	1
"Active" Teaching: Peer-to-Peer	Questioning: Rephrasing	33	16	8	3
	Participation Norms: Sharing Ideas	27	12	6	5
	Questioning: Respond to Student	24	12	9	3
"Active" Teaching: Deep Engagement	Exploration: Agency	23	15	5	2
	Cognitive Demand: Simplifying	22	8	7	3
	Use Representations: Student Use, TA Generated	18	12	7	3
	Question: Alternative Methods	17	10	6	4
	Use Representations: Student Use & Generated	11	7	6	2

Table 5.2: The number of publications, events, GTAs, and PD leaders who discussed these various teaching practices, continued.

Category	Teaching Practice	Number of Publications	Number of Events	Number of GTAs	Number of PD Leaders
"Active" Teaching: TA Interest	Anticipation ST: Like a Student	23	16	8	1
	Checking In: Struggling Groups	13	12	6	1

An overview of the number of publications, events they were publicized in, and numbers of GTAs who publicized the practice is given above in

Table 5.2. One thing to note is how much more varied this group of teaching practices is compared to those in the previous section, with all three pillars of active learning being represented with several different sub-practices rather than the four we saw in the previous section. The only common aspect among these practices is the fact that they all contain a mix of both new and returning GTAs who publicize the practice.

The way they were determined to be at the beginning of conventionalization was based on the original two criteria used to determine if a practice was conventionalized. The difference was in the number of GTAs who publicized the practice. Instead of requiring at least half of the GTAs to publicize the practice, for a practice to be considered at the beginning of being conventionalized at least a third of the GTAs must have publicized some version of it at some point. The criteria of requiring evidence that the GTAs who did publicize a different version than what seemed to be becoming conventionalized either publicized a version aligned with the community or had at least participated in an event in which the converging version was publicized without challenge was still necessary.

An in-depth analysis of all 19 teaching sub-practices would be too repetitive to include in this chapter. Instead, I will provide an in-depth analysis of three illustrative examples to show the ways in which the level of conventionalization was determined and to give a picture of the variety of teaching practices within this section. Before this analysis, however, a longer discussion about the various practices within this section is needed to give a broader picture.

When the community as a whole and the two sub-communities based on the Calculus course are considered separately, there is evidence of practices from all of the categories becoming conventionalized within the entire community and within the community of Calculus I community alone. The community of Calculus II GTAs, in contrast, only had evidence of practices from the "traditional" teaching and deep engagement with mathematics categories becoming conventionalized.

When the person who introduced these various practices are considered, it is not much different from the previous section. The PD leaders introduced the majority of the practices (11 of the 19 introduced practices). Two of them were introduced by the Calculus II coordinator, one by a mathematics education lecturer, three by returning GTAs, and one by a new GTA. More GTAs were involved in the introduction of these practices than before but it was still dominated by the leaders themselves. Another thing to note is that, just as before, neither of the lead TAs introduced the practices within this section. This, along with the evidence in the previous sections in which the transformed versions publicized by lead TAs did not seem to be taken up, further supports the finding that the lead TAs are not the ones introducing the practices taken up by the GTAs (at least through discourse).

Below I go through an analysis of three different sub-practices within this section: *connecting to course material*, *giving students agency over their work*, and *asking students to rephrase what was just said*. These sub-practices were chosen as interesting examples within this section and help to show the ways in which the sub-practices were determined to be at the beginning of conventionalization. Each one is also within a different category, as can be seen above in

Table 5.2. As was stated in Chapter 3, I created a temporal representation for all 137 teaching sub-practices (which can all be found in Appendix E) and I'll share the relevant ones in this section.

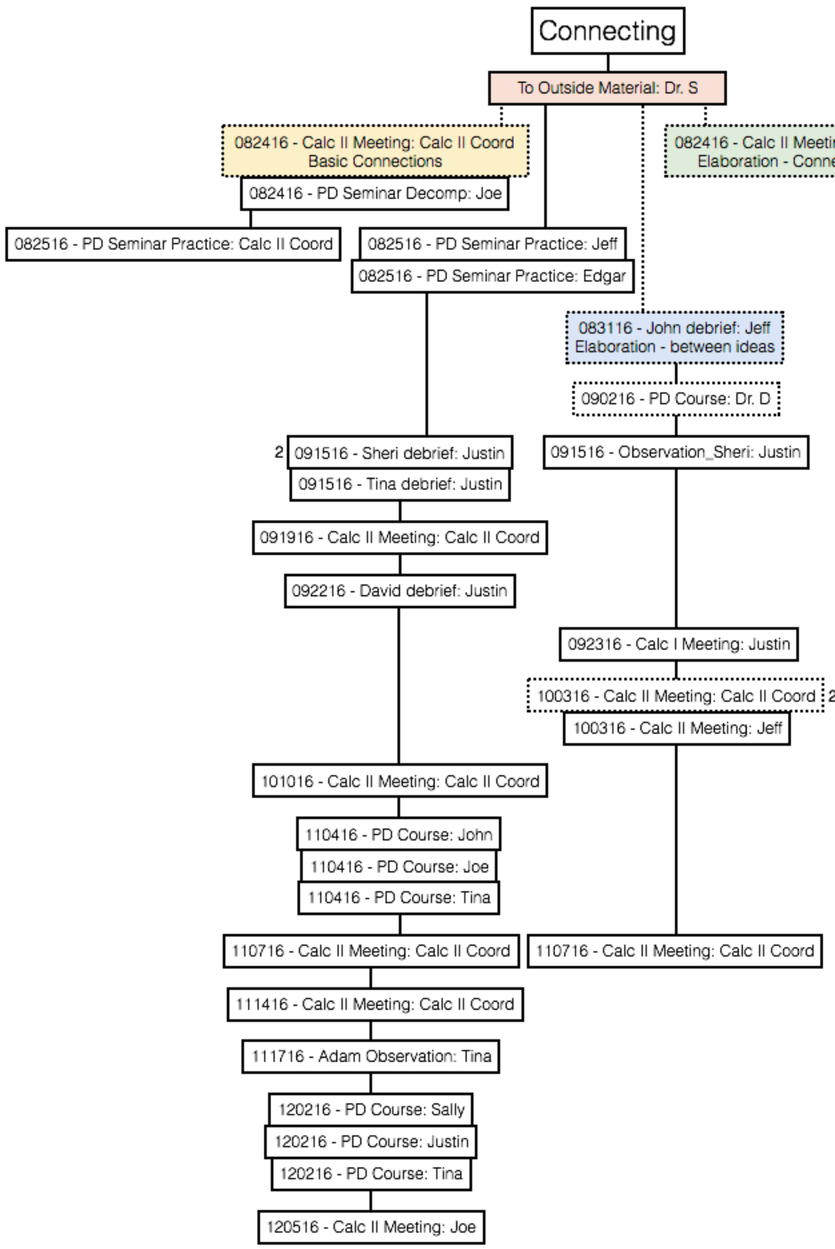


Figure 5.7: A temporal representation of the publications around the practice of connection to course material.

Connecting – Course Material. On the surface, the teaching sub-practice of connection to course material has many of the same characteristics of those within the previous section. This "Traditional" teaching practice was publicized a total of 31 times over 17 different events and a majority of those publications were either between the original version or an elaborated version, as can be seen in the temporal representation in Figure 5.7 above. However, only seven different GTAs publicized this practice over the course of the semester and there was not a majority from one of the sub-communities of GTAs. So, while it did not meet both criteria for being labeled conventionalized, there is enough evidence to state that this practice was approaching conventionalization within the entire community of GTAs.

The evidence that this practice was moving toward conventionalization was mainly in the fact that only the original version seemed to be the commonly publicized version. A transformation was publicized by the Calculus II coordinator during the summer seminar, and it was recorded twice more after that initial publication, but it was the original and an elaborated version publicized by Jeff that seemed to move forward through the semester. Furthermore, the elaboration publicized by Jeff was only publicized by Justin, the Calculus II coordinator, and Dr. D. The majority of the graduate students only publicized the original version, showing evidence of convergence on a single version. Finally, although a majority of the publications were from returning GTAs, the final publication was from a new GTA, suggesting that the new GTAs were beginning to take on that particular version of the practice.

Exploration – Agency. The teaching sub-practice of helping students take agency over their thinking did not have as much evidence of conventionalization as the practice just discussed. It was publicized 23 times over 15 events by only 5 different GTAs. However, there were a few aspects of the discussions around this practice that provided evidence that it may have been beginning to become conventionalized within the community. As was already discussed in Chapter 4, this sub-practice underwent a single transformation and a single elaboration. The transformation was publicized by Jeff and in it he suggested limiting the options for the students so that they feel like they are deciding a method for themselves, but they are actually deciding between a predetermined set of methods. Sally, a returning GTA, and the Calculus II coordinator both publicized similar versions after this. However, Sally publicized the elaboration version later in the semester, in which the discussions were around finding the balance of helping students move forward and giving them the space to take ownership over their work, showing either that she held two different understandings of the practice or there was a possible shift in her understanding of the practice.

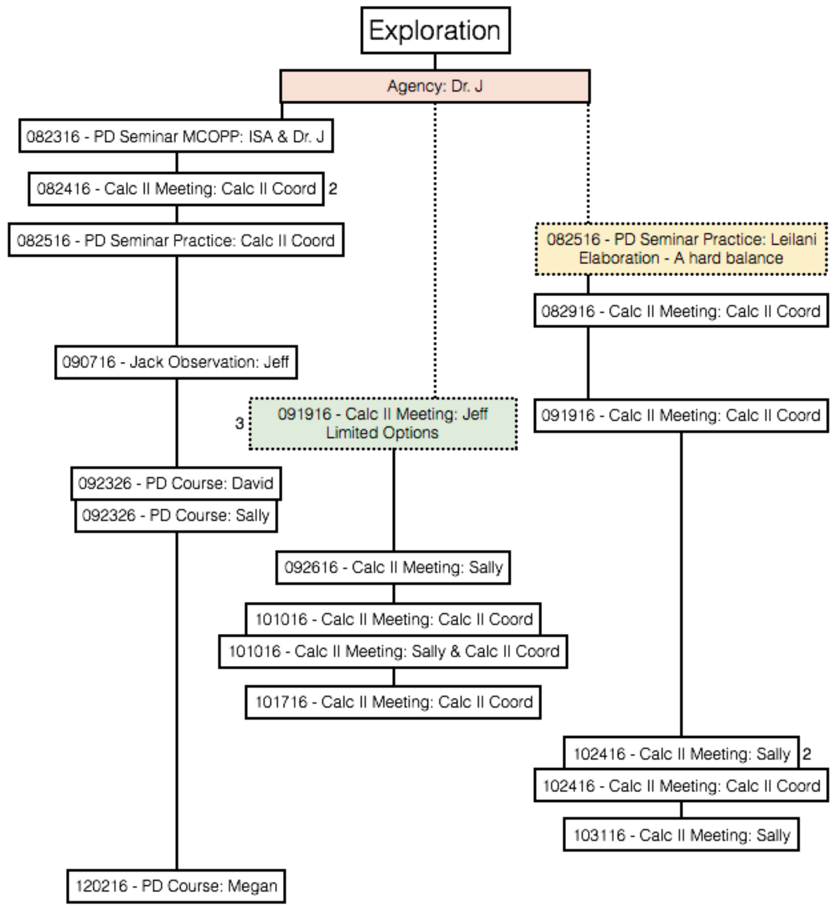


Figure 5.8: A temporal representation of the publications of the practice of helping students take agency over their thinking.

As mentioned, only five GTAs publicized their understanding of the practice, and most of those publications came from the two returning GTAs. However, the new GTAs only publicized versions that had the same motivation or meaning as the original, providing evidence that the new GTAs were converging on the same understanding of the practice. Furthermore, one of the returning GTAs began publicizing a version with the same motivation or meaning as the original after publicizing a transformed version, without publicizing a transformed version later in the semester. This, along with evidence of the other returning GTA participating in events in which the original motivation or meaning was publicized, provides evidence that the returning GTAs were also converging on the same understanding of the practice.

Questioning – Rephrasing. The last practice that will have a deeper analysis in this section is of particular interest because of the variety of interpretations within it. However, even with all of the various interpretations, there is evidence of convergence onto a common understanding. It was publicized 33 times over 14 events by 9 different GTAs. The original publicized version contained two different motivations for the use of the practice within it and so, for the remainder of the semester, there were publications that involved those two motivations separately and together, totally in three different interpretations. As was discussed in greater detail in Chapter 4, there were two common changes that were publicized amongst the three versions. Figure 5.9 gives a temporal representation of these different interpretations as they occurred over the course of the semester.

As can be seen in Figure 5.9, it was a lecturer who first publicized the practice of asking students to rephrase something another student had said in class. In her publications, she gave two motivations behind its use: as a way to check student understanding and as a way to get students to engage with one another during whole class discussions. Dr. S went on to reiterate what the lecturer had publicized but in a more general form by giving the GTAs examples of what it may sound like in the classroom, giving the third version in the figure.

There were two publicized changes that were recorded within more than one of the versions of this sub-practice. The elaborated practice first publicized by Dr. D was recorded in both the overall sub-practice and the checking for understanding version. In the elaboration, Dr. D suggested that the sub-practice could help to give students more confidence in the classroom. Justin went on to publicize a similar version connected with the checking understanding motivation much later in the semester. The transformed practice first publicized by Jeff was recorded in both of the versions of the sub-practice, but not the overall sub-practice. The transformation publicized by Jeff suggested the use of the practice as a way to get students to listen. It was initially publicized within the motivation of supporting student engagement, but Justin also publicized this soon after within the motivation of checking student understanding.

While none of the elaborations or transformations publicized over the course of the semester seemed to be taken up uniformly by the community, there were several instances in which the interpretation of the publication could have been in question. The most notable instance was in a publication by Dr. D during a PD course meeting. By this point in the semester, both Jeff and Justin had publicized the transformed version of the practice that motivated its use through classroom management. So, they, along with those they had publicized this version to, were coming into the course with a different understanding of the motivation behind the practice than what was originally publicized. It was within this context that Dr. D publicized the following: "If you use things like asking them to repeat what somebody else said, asking them to explain what somebody else said, those types of things, those can help get students to listen to each other." This particular publication could be interpreted both with the motivation of encouraging student engagement and with the motivation of classroom management. How it was interpreted by the GTAs depended greatly on what their current understanding of the practice was at the time.

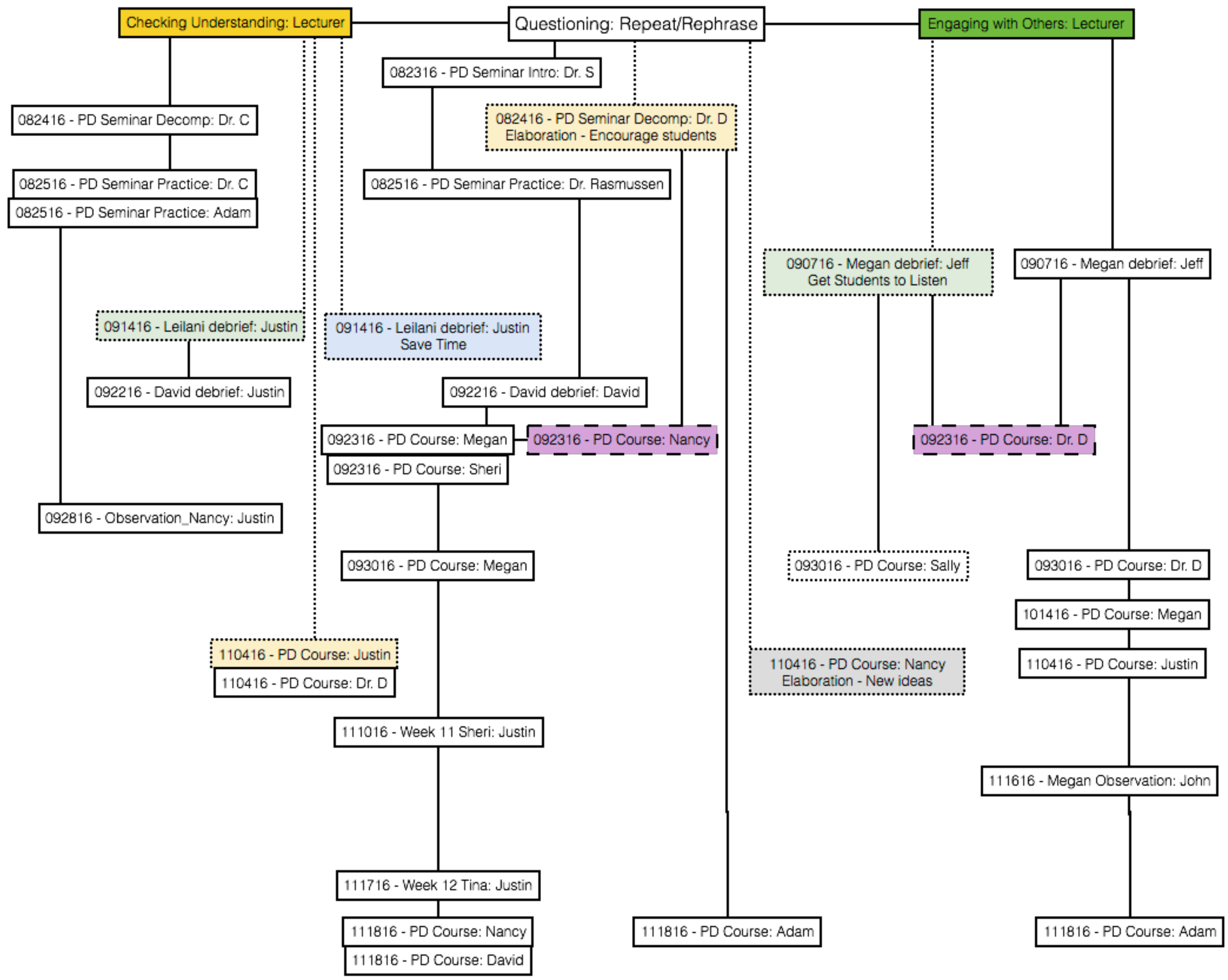


Figure 5.9: A temporal representation of the publications of the teaching practice of asking students to rephrase one another.

While there is little evidence to suggest that the transformed version was taken up by the GTAs, this example does provide an interesting instance in which the intended interpretation may not match up with the actual interpretation by the GTAs. However, without access to all aspects of discussions around teaching practices, no one person can be certain that what they are suggesting is being interpreted in the way they expect. In this instance, Dr. D was most likely suggesting the use of the practice to encourage student engagement but within the context of the transformed version, it could have been interpreted very differently.

Shifting back to the discussion around the conventionalization of the practice, Figure 5.9 provides a visual representation of how the conventionalization could have been progressing. The version in which the motivation was to checking student understanding was not publicized after the beginning of the semester but the version with the motivation of student engagement and the more general version were publicized throughout the remainder of the semester. Furthermore, it was the original version for each of those motivations that were publicized throughout the semester, with the exception of a single publication of an elaborated version near the end of the semester. Recall the two criteria for a particular understanding of a teaching practice to be considered conventionalized within the discourse of the community. There were two versions of this sub-practice publicized throughout the semester and the transformed versions were not taken up by the GTAs. The practice was publicized by numerous GTAs over the course the semester and appeared to be appropriated and publicized in a consistent manner, however there were fewer GTAs than expected for conventionalization.

Summary

There are interesting results from the examination of the 29 sub-practices with evidence of conventionalization or evidence of approaching conventionalization. First, only one of the 29 sub-practices was introduced by a lead TA. Of the remaining 28 sub-practices, 15 were introduced by PD leaders, five by the Calculus II coordinator, one by a returning Calculus I GTA, three by a returning Calculus II GTA, and one from an experienced lecturer. The lead TA who introduced a sub-practice that later showed evidence of becoming conventionalized introduced a total of 13 other sub-practices that did not show evidence of conventionalization. In contrast, the returning GTA from Calculus II who publicized the three sub-practices that showed evidence of conventionalization only introduced four others that were not. So, the lead TAs did introduce multiple practices, even though the count shows that they only had one approaching conventionalization.

There were two practices that showed evidence that the transformed version become conventionalized: *selecting – asking* and *scaffolding – add scaffolding*. For the practice of *selecting – asking* the transformation was a movement away from a management approach towards one that involved creating a more comfortable environment for students to share their work. However, for the practice of *scaffolding – add scaffolding*, the transformation moved away from adding scaffolding with the goal of assisting while maintaining the cognitive demand of the task towards making the task itself easier. This transformation changed the meaning of the practice and it was that meaning that was conventionalized within the sub-community of Calculus II GTAs.

A similar result was evident in two other sub-practices where a transformed version approached conventionalization: *group creation – how to group* and *use representations – student use, TA generated*. Notably, the practice of *use representations – student use, TA generated* involved a version that involved the GTA dictating to the students how to use the representation given to them, thus decreasing student agency.

The fact that both aspects of teaching, "traditional" and "active," are within the category of conventionalization is not surprising. For many instructors new to active learning, they are still working out how their "traditional" teaching fits within this new classroom format while they are learning about new teaching techniques (Marrongelle & Rasmussen, 2008). However, even when the practices that showed evidence of conventionalization and those that showed evidence of becoming conventionalized are combined, it still leaves over 100 sub-practices that did not have evidence of conventionalization within the community. Reasons for why so many practices were not conventionalized vary greatly, and each will be discussed in later sections of this chapter.

Dominated Discussions

When the Vygotsky Space was first used within the realm of education, researchers used it to describe the development of an individual as they interacted with the community (Peck et al., 2009). They put individual learning in the foreground. In this study, I did not foreground the individual actor within the community but instead placed emphasis on a sub-practice as it is publicized by an individual within various communities. The practices within this section did not have numerous GTAs contribute as in conventionalization, but instead had one individual dominate the conversation. So, harkening back to the original use of the framework within the field of education, these practices coupled with observations might provide insight into the development of individuals around a particular teaching practice.

In other words, while others did publicize their understandings of these various teaching practices, over half of the publications were from the same person or same two people. Based on the criteria for conventionalization outlined earlier, this category of practices did not meet the second criteria of a variety of GTAs publicizing their understandings over the course of the semester. Of the teaching practices introduced over the course of the semester, 24 were dominated by one or two people. They were determined based on the number of publications made by a single person compared with the total number of publications over the course the semester. If that proportion was 50% or higher, it was considered to be dominated by that person.

There were only four different people who dominated the publications of these 24 practices: Dr. D, the Calculus II coordinator, Justin, and Jeff. Both Dr. D and the Calculus II coordinator met with the GTAs often and discussed teaching with them more than the other PD leaders. While the Calculus I coordinator also met with his GTAs often throughout the semester, he met with them almost half as much as the Calculus II coordinator did and their meetings tended to focus more on administrative issues rather than teaching practices. The other two people, Justin and Jeff, were the two lead TAs and had several opportunities to meet one-on-one either their fellow GTAs, giving more opportunities for them to repeat their understanding of a teaching practice in several different events with several different people.

Justin was by far the one who most commonly dominated the publications of these teaching practices. Twelve of the 24 were dominated by Justin, which represents half of all of the practices within this section. However, this could be because in his debriefing sessions, Justin talked with his fellow GTAs for between 20 and 40 minutes, giving him ample time to repeat various understandings of teaching practices with several GTAs, which would artificially increase the number of publications from him. The Calculus II coordinator dominated four of the practices, Dr. D dominated four of the practices, and Jeff dominated three of the practices. The remaining practice in this section was dominated by Jeff and Justin together. Jeff and Justin both met individually with their fellow GTAs, providing them a larger number of events in which they could publicize their understanding of the various teaching practices. Furthermore, they both would do at least two observations during the same implementation of an activity, which means that it may appear this was because they provided similar advice to multiple GTAs. Justin did his observations over the course of two weeks, giving him several opportunities to provide the same advice to many GTAs. Justin's debriefing sessions with his fellow GTAs also were much longer than Jeff's, averaging about 30 minutes compared to Jeff's average of about 3 minutes. I think the repetition of particular practices is noteworthy, as well as the fact that others were not publicized.

While acknowledging the repetition, as was stated earlier, since each of these practices were dominated by an individual, this is possible evidence of how that individual person developed their understanding of a particular practice over the course of the semester. For the two PD leaders, the Calculus II coordinator and Dr. D, the teaching practices where they dominated the conversations showed more of aspects important to them about the practices. Within all eight of the practices that were dominated by either one of them, they both either predominantly publicized the original version or an elaborated version but never a transformed version. In fact, if a transformed version was publicized within any of these eight practices, there was no evidence of them publicizing that transformation at any point in the semester.

A particularly interesting example of a dominated discussion can be found within the practice of lecturing when there is a felt need from the students. This practice was dominated by Justin with him making up 18 of the 31 publications over the course of the semester. A temporal representation of how this practice was publicized over the course of the semester can be found below in Figure 5.10.

This practice was first publicized by Dr. S in which she suggested the use of lecturing only when there is a felt need from the students. However, Justin was not present during the summer seminar and so the first time it was publicized to him during the semester was in the first PD course meeting with Dr. D. The version publicized by Dr. D was similar to that of Dr. S in that he reiterated the motivation of using lecture when students need it rather than assuming their need. Soon after, there was evidence of Justin publicizing this version during a debriefing session with a new GTA, Leilani. However, he also publicized an elaboration to this practice and a transformed version similar to one publicized by Sally during a Calculus II meeting, as was discussed in Chapter 4. In a single event, Justin publicized two different versions of the practice, and on one he elaborated.

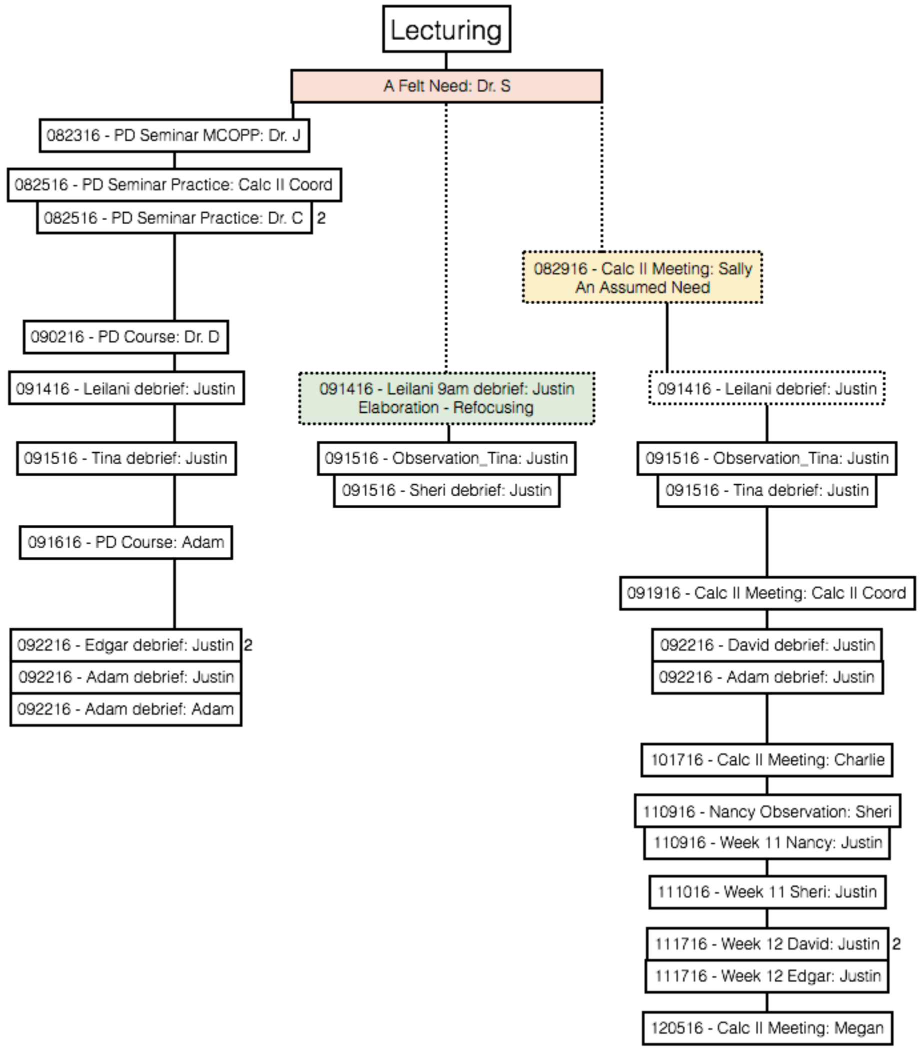


Figure 5.10: A temporal representation of the publications of the practice of lecturing when there is a felt need from the students.

Throughout the remainder of the semester, Justin tended to publicize either the transformed version or the original version during various events. However, after the month of September, there was only evidence of him publicizing the transformed version of the practice. What this shows is evidence of him developing his understanding of the practice of lecturing. In the beginning, he almost seemed to be debating with himself on which motivation behind the practice made the most sense to him. As the semester continued on, he began to publicize the transformed version in which he assumed the need of the students and it is that version that he seems to settle on at the end of the semester. The evidence for this comes from the fact that he repeats this version in several different debriefing sessions, which means it is the version he feels comfortable with providing as advice for others.

Something interesting to note within this example is that Justin only publicized his understanding of the practice during debriefing sessions. The only other place he would have heard others publicize it was during the PD course meetings or during his one-on-one sessions with his fellow GTAs. He only heard the original version being publicized three times over the course of the semester: twice during two different PD course meetings and once after he had publicized the same version to a fellow GTA during a debriefing session. For the transformed version, there was no evidence of him hearing it from someone else in a different formal professional development setting. So, his transformation may have come from him making sense of the practice against his own experiences and understandings rather than from the publications of the community.

The remaining teaching sub-practices publicized over the course of the semester were tagged as infrequent or not taken up by the community. In the next section I will go into detail about these practices and what themes there are among them.

Inconclusive Discussions

There were practices in which the discussion over time showed no evidence of agreement at the end of the semester. For each of these practices there were at least two conflicting motivations behind the use of the practice that showed no evidence of agreement amongst the community of GTAs. In terms of the criteria for conventionalization described earlier, practices within this category do not satisfy the first criteria: When no member of the community challenges the publicized understanding of a teaching practice, and/or if the publicized understanding of a teaching practice is contested and the transformed version is not taken up, I consider the publicized understanding of the teaching practice to be conventionalized. Table 5.3 below gives the overall counts of publications, events, and GTAs who publicized the practice of the course of the semester.

Table 5.3: The number of publications, events, and GTAs who discussed each teaching practice over the course of the semester.

Teaching Practice	Number of Publications	Number of Events	Number of GTAs
Lecturing: Lecturing	20	14	8
Cognitive Demand Planning: High Ceiling	19	10	6
Cognitive Demand: Lowering through Guiding	19	6	4

As was discussed in Chapter 4, each of these three teaching sub-practices had evidence of transformations and elaborated versions, along with publicized understandings, show a lack of agreement amongst the GTAs. For instance, the sub-practice of *lowering the cognitive demand through guiding* underwent three elaborations and a transformation over the course of the semester, as can be seen in Figure 5.11 below. In the original publication, and the elaborated versions, the motivation was around ways in which to try and avoid lowering the cognitive demand through guiding the students. However, a returning GTA, Michael, publicized a transformed version in which the motivation was to use the practice to get the students moving forward on the activity. While this version was not publicized often, there was evidence of a new GTA, Charlie, changing his view from the original version to the transformed version because the two versions are contradictory to one another. Without further evidence of other publications, there currently seems to be a non-agreement on which motivation to use behind the practice.

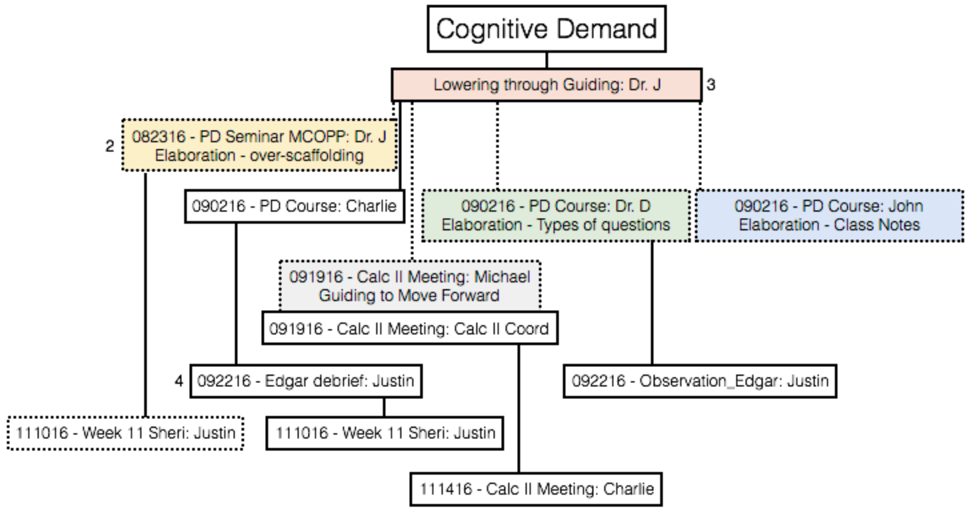


Figure 5.11: A temporal representation of the publications of the practice of lowering the cognitive demand of a task through guiding.

For the two practices focused on the cognitive demand of the task, either during implementation or planning, the reasons for why they were not agreed upon are not clear. While it is difficult to find a balance between helping students and making the task easier, there were other practices that could be considered difficult for new teachers as well and yet they were not within this category. In contrast, it may not be surprising to find the practice of traditional lecturing within this category. Instructors new to active learning do have a difficult time with negotiating between lecturing and student discovery, and so the lack of evidence of agreement for the use of the practice of lecturing may be because historically it is something instructors grapple with (Marrongelle & Rasmussen, 2008).

Not Common or Not Taken Up

A majority of the teaching sub-practices were not commonly discussed over the course of the semester. These sub-practices did not necessarily fail to meet the criteria for conventionalization completely but did not contain enough publications to provide evidence for either of the two criteria. There are three different categories that these sub-practices fall within: infrequent, rare, and essentially ignored. Within each of these categories were particular commonalities and patterns. Because of this, each of the categories will be discussed separately.

Infrequent

Within the category of infrequent there were 19 different sub-practices. A teaching sub-practice was determined to be infrequent if it was publicized at least 10 times but less than 20 times. There were exceptions to this rule. For instance, if the number of publications was dominated by a single person, it was placed within the section of dominated discussions. Furthermore, if there was evidence of the beginning stages of conventionalization and it was near the 20 publications mark, it was placed within a different category. Finally, there needed to be some evidence of agreement amongst the various publications. If there was no evidence of this, it was considered a sub-practice with no agreement and was described earlier in the chapter.

In addition to the categories used in

Table 5.4, these 19 sub-practices can be separated into three other main categories. The first category includes seven sub-practices in which there was a gap in the publications. There was evidence of this sub-practice being discussed through September and then it did not come up again until November. The second category includes sub-practices in which there was no evidence of publications after a certain point in the semester. There were three sub-practices within this category, with two ending in September and one ending in October. Finally, the last category includes the nine remaining sub-practices that were discussed relatively consistently throughout the semester but still did not come up more than 18 times over the course of the semester.

Table 5.4: The various sub-practices within the categories of "traditional" teaching and "active" teaching, along with the number of times it was publicized, by whom, and the number of events.

Category	Teaching Practice	Number of Publications	Number of Events	Number of GTAs	Number of PD Leaders
“Traditional” Teaching	Using Representations: Use by Instructor	18	8	4	1
	Visible Work: Instructor Written	18	8	4	5
	Motivation: Grading	13	9	4	3
	Attention: Elementary	13	7	5	2
	Anticipation SQ: Avoid Confusion	12	9	4	1
	Body Position: Position in Class	11	6	5	3
	Answering: Take Away Agency	10	8	5	2
	Anticipation SQ: Previous Experience	10	6	5	0
“Active” Teaching: Peer-to-Peer	Think-Pair-Share	15	11	5	2
	Selecting: Multiple Strategies	15	10	6	1
	Selecting: Incorrect	13	10	6	3
	Group Creation: Number	13	10	6	1
	Selecting: Partially Completed	13	10	4	3
	Participation Norms: How to Participate	13	7	4	1
	Selecting: Comparison	12	7	3	3
	Visible Work: Student Written	12	7	5	4
	Body Position: Group Engagement	10	7	4	1

Table 5.4: The various sub-practices within the categories of "traditional" teaching and "active" teaching, along with the number of times it was publicized, by whom, and the number of events, continued.

Category	Teaching Practice	Number of Publications	Number of Events	Number of GTAs	Number of PD Leaders
“Active” Teaching: Deep Engagement	Questioning: Conceptual	13	6	3	3
	Exploration: Get Hands Dirty	12	6	3	1

Over all of these three new categories, it was most common to see the originally publicized version being the dominantly publicized version. Only 7 of the 19 sub-practices did not have evidence of this being true. A possible explanation for this is that the GTAs and PD leaders did not feel a need to discuss these sub-practices further because there was already agreement amongst those in the community. However, since there are so few publications within this category, there is not enough evidence to state that these sub-practices were conventionalized.

When the two different ways of categorizing these sub-practices are combined with one another, there is evidence of both “Traditional” and “Active” teaching in all three of the secondary set of categories. Within the category of practices with a gap in publications, two were “Traditional” teaching sub-practices and five were “Active” teaching sub-practices. The category of sub-practices that ended after the first month or two had two “Traditional” teaching sub-practices and one “Active” teaching sub-practice. Finally, the last category of consistent, but not commonly discussed, practices had four “Traditional” teaching sub-practices and five “Active” teaching sub-practices.

Some sub-practices were discussed less frequently than those in this category, but still more than those within Essentially Ignored. The analysis of these sub-practices is given next.

Rare

Thirty-seven of the total sub-practices discussed over the semester were deemed to be rare. For a sub-practice to be marked as rare, it needed to be publicized less than ten times over the course of the semester and to have at least two different GTAs publicize it. If there was less than two GTAs who publicized the practice, it was marked as essentially ignored. There were a handful of exceptions in which two GTAs did publicize the practice, but it was still marked as essentially ignored, and those will be described in the next section.

The group of rare teaching sub-practices is the largest group of practices. Since there were 137 different teaching sub-practices that were publicized over the course of the semester, it is not surprising that a large number of them would not show evidence of being taken up. However, it is interesting to study which of those sub-practices fall within this category and what similarities we can see between them.

A majority of the sub-practices within this category were mainly publicized by GTAs, with three of them publicized only by GTAs. Those three sub-practices were *giving students the opportunity to take agency*, *using the physical placement of desks to establish group norms*, and *helping students to develop relationships with one another in their groups*. The first two sub-practices were introduced by Justin and Jeff and the third sub-practice was introduced by an ISA during the summer seminar. A possible explanation for why these three were the only ones that had no PD leader input is that they were something discussed in the PD the year before. Both Justin and Jeff participated in the PD the year before and would have already heard about various teaching practices from there. So, those practices may have been something discussed in the prior year by different PD leaders.

The remaining sub-practices were either mostly publicized by the PD leaders or were discussed the majority of the time during the summer seminar but not after. The sub-practices in which it was mostly PD leaders publicizing the practices, there is evidence that they were sub-practices not fully understood by the GTAs or practices that they struggled with. For instance, one of the sub-practices was that of *decreasing the scaffolding of an activity*. Since many of these GTAs were still learning how to implement the activity itself, it is not surprising that they did not discuss ways to decrease the scaffolding in the problems. Furthermore, it was more common for the GTAs to talk about ways to add scaffolding to help make the activity go quicker, as has been seen in early sections. Furthermore, the GTAs were mostly concerned with completing the activities within the allotted time and so they did not discuss additional problems they could have for the students, which was another sub-practice within this group.

When the sub-practices are separated into the categories used in previous sections, we see there are eleven within the "Traditional" teaching category and 26 in the "Active" teaching category. When the "Active" teaching category is further broken down, there are eleven sub-practices within Peer-to-Peer, ten within Deep Engagement, and five within TA Interest. In many of the other sections in this chapter, with the exception of the section of "Infrequent" sub-practices, the majority of the sub-practices fell within the "Traditional" teaching sub-practices category. Reasons for why the opposite is true within this category could vary greatly. It could be that the GTAs were unsure of their understandings of the sub-practices within this section and did not feel comfortable publicizing them in a formal setting. Or, the GTAs could have felt confident enough in their understanding of these sub-practices that they did not see a need to discuss them in a formal setting. Without additional evidence, one cannot be sure which is the reason for the low number of publications of these various teaching sub-practices.

Essentially Ignored

The remaining 24 teaching sub-practices were marked as essentially ignored. An important note for this is that even though these practices were not discussed by more than one GTA (and in a few exceptions, two GTAs), it does not mean that the practice itself was ignored, as the name may suggest. Instead, it simply means that these practices were not taken up in the discussions themselves. Whether or not they were still taken up in their actual practice is a topic for a future study and beyond the scope of this current study. However, analyzing which teaching practices were not discussed by the GTAs does provide an interesting beginning to such a study to see how the practices that are discussed are actually used in the classroom.

Within this group of 24 teaching sub-practices, there were five that were publicized by two different GTAs, eleven that were publicized by only one GTA, and eight that were only publicized by PD leaders. Twelve of these sub-practices were first introduced by GTAs, with six of those twelve being introduced by one of the lead TAs. Five of the twelve sub-practices publicized by only one GTA and two of the five sub-practices publicized by two GTAs were not publicized at all by any of the PD leaders. For the sub-practices that were only publicized by PD leaders, only one of them was publicized by more than one PD leader. All of this information, as well as publication and event counts, can be found in

Table 5.5 below.

Table 5.5: The number of publications, events, and GTAs and PD leaders who publicized these teaching practices over the course of the semester.

Category	Teaching Practice	Number of Publications	Number of Events	Number of GTAs	Number of PD Leaders
“Traditional” Teaching	Attention: Focus	9	6	2	0
	Participation Atmosphere: Question Use	5	1	1	2
	Answering: Equal Playing Field	4	4	1	1
	Moving Forward: When to Move	4	3	0	3
	Practicing Procedures: Procedure without connections	3	3	1	2
	Connecting: Conventions	3	2	0	1
	Motivation: Class Material	3	2	0	1
	Goals: Coverage	3	1	1	1
	Anticipation ST: Future	2	2	1	1
	Participation Carrot/Stick: Sign-In	2	1	1	0
	Attention: Prepare	1	1	1	0
	Checking In: Scaffolding	1	1	1	0
	Scaffolding: Under Scaffolding	1	1	1	0
	Elaboration: Requested Information	1	1	0	1
	Moving Forward: Attention	1	1	0	1
	Participation Atmosphere: Grading	1	1	0	1

Table 5.5: The number of publications, events, and GTAs and PD leaders who publicized these teaching practices over the course of the semester, continued.

Category	Teaching Practice	Number of Publications	Number of Events	Number of GTAs	Number of PD Leaders
"Active" Teaching: Peer-to-Peer	Participation Atmosphere: Presentations	1	1	1	0
	Connecting: Across Students	1	1	0	1
	Establishing Norms: Notes	1	1	0	1
"Active" Teaching: Deep Engagement	Motivation: Challenge	7	3	2	1
	Cognitive Demand: Raise with Questions	5	2	1	2
	Goals: Active Learning	4	3	2	1
	Goals: Structure	6	6	2	2
"Active" Teaching: TA Interest	Precision: Understand Why	7	5	2	0
	Precision: State Why	3	3	2	2

When we consider the sub-practices within the categories they are separated into in Table 5.5, it is interesting to note who was introducing which of those practices. For the "Traditional" teaching sub-practices, there were representatives from every community introducing the practices. Five were introduced by PD leaders, three by lead TAs, one by a Calculus I GTA, three by a Calculus II GTA, and four by the Calculus II coordinator. None of the "Active" teaching categories had the same representation. In fact, the "Active" teaching practices of Peer-to-Peer and Deep Engagement were only introduced by PD leaders and lead TAs. The "Active" teaching practices of TA interest were only introduced by Calculus II GTAs. Comparing to the results of other studies (Beisiegel, 2017), it may be that the GTAs felt confident in their understandings of the "Traditional" teaching practices and did not feel a need to discuss them further but did feel confident in introducing the practice in a formal setting. It may be the case that the practices within the "Active" teaching category were more difficult to make sense of for the GTAs and they did not feel confident in discussing them in a formal setting, with mainly the PD leaders and the lead TAs feeling confident enough to introduce the practices to the community.

Conclusions

In this chapter, a methodology for determining whether or not the discourse around particular teaching practices was conventionalized within a community was introduced and used to describe the changes that occurred over the course of the semester. Based on the criteria used for determining whether an idea *functions as if shared* (Cole et al., 2011), the criteria for determining if the discourse around a particular understanding of a practice was conventionalized are:

1. The teaching practice has been publicized by numerous GTAs (more than 50% of the TAs within the entire community or within a sub-community), both new and returning, over the course of different events throughout the semester. In other words, numerous individuals contributed to and shaped the meaning of the teaching practices, which in turn was appropriated and publicized in a consistent manner.
2. When no member of the community or sub-community challenges the publicized understanding of a teaching practice, and/or if the publicized understanding of a teaching practice is contested and the transformed version is not taken up, I consider the publicized understanding of the teaching practice to be conventionalized.

Using these criteria, ten different sub-practices were identified as being conventionalized within either the whole community of GTAs or within a sub-community of GTAs. Furthermore, 19 sub-practices were identified as beginning to be conventionalized because there was not enough evidence to state that they already were conventionalized based on the criteria.

Perhaps unsurprisingly, there are nearly twice as many sub-practices with evidence of it becoming conventionalized than there were of ones with evidence of it already being conventionalized within the community. However, what may be surprising is that only 19 of the 137 different sub-practices are within this category. The fact that both aspects of teaching, both traditional and active, are within this section of moving towards conventionalization is not surprising. For many instructors new to active learning, they are still working out how their "traditional" teaching fits within this new classroom format while they are learning about new teaching techniques.

When a practice did not meet the second criteria because of a single person becoming the predominant voice, it was considered to be a dominated discussion. There were 24 practices identified as dominated discussions, and there were only four people who became a predominant voice: Justin, Jeff, Dr. D, and the Calculus II coordinator. Justin was the most likely of the four to be the predominant voice, but this was most likely based on the fact that his debriefing sessions were longer than Jeff's and he would repeat advice to multiple GTAs. Furthermore, he was move likely to run the Calculus I meetings than Jeff was to run the Calculus II meetings based on the assumed role of the two coordinators. So, there were more opportunities for Justin to repeat advice, which would then artificially increase the number of publications around a single practice.

When a practice did not satisfy the first of the two criteria, it was considered to be an inconclusive discussion. Only three practices were categorized as inconclusive. This does not mean that a majority of practices came to some conclusion at the end of the semester. A majority of the practices were publicized too few of times to be able to determine whether or not a consensus was reached. Instead, these three practices were discussed with enough regularity by enough GTAs to show they had not yet come to a consensus by the end of the semester. What was interesting was the three involved cognitive demand and lecturing, which are two difficult aspects of facilitating active learning classrooms for the first time (Marrongelle & Rasmussen, 2008). So, it is unsurprising that it was those three practices that fell within the category of inconclusive discussions.

Within the category of conventionalized discussions, there were examples of practices that were conventionalized (or beginning to be conventionalized) within the whole community and within two sub-communities. In this study, the Calculus I and II GTAs attended the same PD course but outside of that, their weekly meetings were with different coordinators and each sub-community had their own lead TA. Because of this, it is not very surprising that there were times in which one sub-community showed evidence of conventionalization when the other did not. When the community as a whole and the two sub-communities based on the Calculus course are considered separately, there is evidence of practices from all of the categories becoming conventionalized within the entire community and within the community of Calculus I community alone. The community of Calculus II GTAs, in contrast, only had evidence of practices from the "traditional" teaching and deep engagement with mathematics categories becoming conventionalized.

A final note is that the lead TAs did not seem to have as much influence over the versions of the practices that were taken up by their fellow GTAs as originally expected. Neither of the lead TAs introduced any of the practices within the category of conventionalized practices. Furthermore, there was evidence that the transformed versions publicized by lead TAs did not seem to be taken up by their fellow GTAs. Instead, it was much more common for a practice introduced by a PD leader to be taken up by the GTAs and show evidence of conventionalization. A possible explanation for this is that the GTAs did not feel a need to discuss what was focused on by the lead TAs in the formal settings. Instead, the GTAs may have simply taken the advice of the lead TAs and implemented it in their classrooms without feeling the need to discuss it with others.

Chapter 6: Discussion and Conclusion

Graduate teaching assistants (GTAs) have become increasingly significant in teaching undergraduate mathematics. Many universities have increased the number of large sections (150+ students) in lower division courses and employ graduate students as teaching assistants, increasing the impact the graduate students have on the experiences of undergraduate students (Luo et al., 2001). In fact, Speer and her colleagues (2009) estimated that more than a third of undergraduates will have a TA as a mathematics instructor. GTAs teaching Calculus are particularly important given that many students cite their experiences in Calculus as a top reason for switching out of the STEM majors (Seymour & Hewitt, 1997). In recognition of the significant impact of GTAs, and as some departments follow the recommendations of the Characteristics of Successful Programs in College Calculus (Bressoud et al., 2015), most doctorate- and Masters-granting institutions offer some type of professional development for their GTAs (Deshler, Hauk, & Speer, 2015). Yet, there has been little research done on how graduate students learn from training and support in their teaching roles. The findings of this dissertation study contribute to the field by illuminating the development of understandings of various teaching practices of graduate teaching assistants (GTAs) who participate in professional development (PD) around active learning.

This dissertation study contributes to the research base on PD programs for GTAs by taking a deep look into the ways in which the discourse around various teaching practices in the professional development on leading student-centered classrooms is transformed and elaborated over the course of a semester. I approached this study from a socio-cultural perspective, drawing heavily from the theory of Vygotsky (1987). There are three main aspects of this perspective that informed several aspects of this study: genetic (developmental) analysis, thought mediated through language, and the reciprocal relationship between the individual and social planes. My study took place as the GTAs were learning various teaching practices for facilitating an active classroom, which incorporated the genetic analysis aspect of the socio-cultural learning theory. In other words, the focus was on capturing the process and not on the product. I utilized what was publicized by the GTAs as a proxy for their learning and understanding with the idea that thought is mediated by language. Language is central to the appropriation of knowledge. Thought is shaped by language and language is a "murky window" into thought (Alrø & Skovsmose, 2004). Finally, I studied the ways in which the ideas about teaching practices were appropriated and incorporated into the community of discourse, where publicized ideas, in turn, could then become a resource for others, emphasizing the interdependence between the individual and the community. I developed a methodology for making sense of the changes recorded in the discourse and how those changes came about. With the use of a modified version of the Vygotsky Space framework (Harré, 1983), I analyzed the ways in which the discourse around various teaching practices developed and how individuals participated in the community discourse.

To answer Research Question 1, I examined the understanding publicized for each of the teaching practices by analyzing the various elaborations and transformations the discourse underwent over the course of the semester. I examined which of the publicized understandings showed evidence of conventionalization. In answering Research Question 2, I further investigated who publicized each of the teaching practices and when in the semester they did so. I focused on who was publicizing and in what context because, as argued by Bakhtin, an utterance reflects not only who is doing the speaking but also who is being addressed (as cited in Wertsch, 1991). In this chapter, I summarize these results and provide a broader picture of the implications of the answers to both of the research questions. In Chapters 4 and 5, with the various teaching practices in sub-practices, I report on a deep analysis of the changes each practice underwent throughout the semester. This chapter works to bring all of those pieces back together and provide a cohesive picture of the overall results. I then go on to elaborate on the methodological and theoretical significance of this study, as well as discuss some of the limitations of the study. The chapter concludes with a discussion about areas for future research.

Summary of Findings

Through my process of coding using a priori and emergent codes, and the constant comparison method, I had 33 codes describing the teaching practices (see Appendix D) discussed by the professional development leaders, the 16 Calculus I and II GTAs, and the course coordinators. The settings for these discussions were the three-day summer seminar, the PD course meetings, the weekly meetings with the course coordinators, and the observations and debriefings of the break-out sections that were taught by the GTAs. There were 137 sub-practices identified. Not all were discussed in equal measure; roughly one-third were taken up and discussed by the community. The rest were rarely discussed or essentially ignored by the community. I analyzed the discourse around the sub-practices because it revealed the GTAs' understanding of the meanings of the practices, including the context and motivation for their use. From this analysis, we can see what is challenging, when the community seemed to agree on meaning, and the role of the lead TAs and others in the shaping of the various discussions.

Overall, there were six main findings; three within Research Question 1 and three within Research Question 2. As a reminder, the two research questions guiding this dissertation are:

RQ1: How do the GTAs' publicized understandings of various teaching practices change (through elaboration or transformation) over the course of a term? How do these publications highlight which teaching practices are most salient to their needs?

RQ2: How do the lead TAs and others influence the shaping of the various teaching practices discussed in the professional development on leading a student-centered classroom?

The three findings within Research Question 1 are that:

1) GTAs do appropriate the language of mathematics education but may have different understandings of those practices than the PD leaders;
2) there is evidence that the GTAs found the practices of cognitive demand and lecturing challenging within the new context of active learning; and
3) there is evidence that the GTAs found the practices of asking for justification, checking for understanding, and precision for communication important to discuss but seemed to agree on their meaning and use.

The three findings for Research Question 2 are that:

1) the topic of Classroom Management was one that was important to the GTAs but not discussed often by the PD leaders;
2) the role of the lead TAs was not to influence which practices were discussed and in what ways, but they may have had a role in the implementation of the practices themselves; and
3) there were differences between the Calculus I and II communities in terms of the practices that became conventionalized and the roles of those involved in those communities.

In this section, I discuss these overall results in more detail.

Answering Research Question 1

In answering Research Question 1, I examined publications and found the meaning and motivation for a practice was unchanged, elaborated, or transformed. For a publication to be classified as an elaboration, the meaning, motivation, and purpose behind the practice could not be changed. Instead, the publication would only contribute to the understanding of the practice, discussing its use within a new context or giving an additional way the practice could be used. For a publication to be classified as a transformation, the meaning, the motivation, or the purpose behind the practice would have been changed. In some cases, the change is obvious. For instance, in the sub-practice of asking students to rephrase something that had just been said, there were two distinct motivations publicized: the motivation of understanding student thinking and the motivation of classroom management. However, there were cases in which the transformation affected the meaning but the motivation did not appear to have changed for the speaker. An example of this was seen in the analysis of the sub-practice of *adding scaffolding*. In the case of Charlie, his goal was still to provide students access to a task, much like the original version of the practice. However, his publication suggested one adds scaffolding to simplify the task for students by doing more for them, rather than providing access to the task while maintaining the cognitive demand.

I developed a methodology for determining whether or not the discourse around a practice was conventionalized within a community. Based on the criteria used for determining whether an idea *functioned as if shared* (Cole et al., 2011), the criteria for determining if the discourse around a particular understanding of a practice was conventionalized are:

1. The teaching practice has been publicized by numerous GTAs (more than 50% of the TAs within the entire community or within a sub-community), both new and returning, over the course of different events throughout the semester. In other words, numerous individuals contributed to and shaped the meaning of the teaching practices, which in turn was appropriated and publicized in a consistent manner.
2. When no member of the community or sub-community challenges the publicized understanding of a teaching practice, and/or if the publicized understanding of a teaching practice is contested and the transformed version is not taken up, I consider the publicized understanding of the teaching practice to be conventionalized.

It is important to note that the small two-person debriefs, or observations, were not used in establishing criteria 2. For example, I did not consider the two-person dyad a community in which a member would challenge a publicized understanding of a practice.

Using these criteria, ten different practices were identified as being conventionalized within either the whole community of GTAs or within a sub-community of GTAs. Furthermore, 19 practices were identified as approaching conventionalization because, although they met some criteria, there was not enough evidence to state that they already were conventionalized. When a practice did not satisfy the first of the two criteria in terms of being publicized in a consistent manner, it was considered to be an inconclusive discussion. When a practice had a single person becoming the predominant voice, it was considered to be a dominated discussion. Finally, if there was not enough evidence available to determine whether or not either of the criteria were met, they were considered not taken-up by the community.

My assumption is that the teaching practices that were discussed, or taken up, provide insight into sub-practices that either are challenging to understand or important to the GTAs. Of the 38% of the sub-practices that had a transformation, 59.6% of the sub-practices were taken-up by the GTAs. The teaching practices that were publicized more often by the GTAs were more likely to involve at least one transformation of the practice, indicating that the GTAs were still making sense of the practice within their own context.

Result 1. The GTAs were appropriating some of the language of mathematics education but their publications revealed different meanings or motivations. This was particularly evident in practices such as *scaffolding – add scaffolding* in which what became conventionalized was a transformed version of the practice. Three other sub-practices had a transformed version approaching conventionalization: *group creation – how to group*, *use representations – student use TA generated*, and *use representations – student use and generated*. Furthermore, the GTAs saw the purpose of some sub-practices as management based, which is discussed further in the results from Research Question 2. I took the criteria of conventionalization, the number of transformations, and what the transformations conveyed about the GTAs' understanding of the teaching practice to provide evidence for their appropriation of the language from mathematics education. So, even though the GTAs were using the language of mathematics education, they could be using it in a different way than it was originally introduced or as understood by the mathematics education community. For example, math educators might think of scaffolding as in making connections to background knowledge to help the students move toward stronger understanding, rather than doing more of the problem for the students.

Result 2. When looking at what was challenging for the GTAs, the inconclusive practices provided a starting point. Only three sub-practices were categorized as inconclusive. These three sub-practices were discussed with enough regularity by a sufficient number of GTAs, with both transformed versions and the original version being publicized at the end of the semester. This does not mean that a majority of practices came to some conclusion at the end of the semester. A majority of the practices were publicized too few of times to be able to determine whether or not a consensus was reached. Instead, these three practices were discussed with enough regularity by enough GTAs to show they had not yet come to a consensus by the end of the semester.

The first of two practices that had evidence of being challenging for GTAs was *cognitive demand*. Two of the three sub-practices within the inconclusive category involved cognitive demand: *planning – high ceiling* and *lowering through guiding*. Furthermore, there was another cognitive demand practice that had evidence of approaching conventionalization (*cognitive demand – simplifying*), which gives evidence that the GTAs were discussing the practice often throughout the semester. Finally, the practice of *adding scaffolding* involved discussions around ways to make activities simpler by doing parts for them, which is connected to cognitive demand by the decreasing of the difficulty of the task, and it was a transformed version of the practice that became conventionalized. One of the cognitive demand sub-practices involved planning and the other three involved enacting or teaching lessons, with all three of the sub-practices involving simplifying the activity for the students. This provides evidence that the GTAs were wrestling with ways to provide access to their students without lowering the cognitive demand of the task. So, there is a large amount of evidence that the practice of cognitive demand may have been a challenging one to understand.

The second challenging practice was that of lecturing. Lecturing was also a practice that had a sub-practice with discourse deemed inconclusive (*lecturing*) and two sub-practices with evidence of approaching conventionalization (*struggling students* and *forward movement*). *Forward movement* refers to the practice of telling the class something to keep move the class going at an expected pace; *struggling students* publications related to how much to let students struggle before telling them something. So, there is evidence that the practice of lecturing was something commonly discussed by the GTAs over the course of the semester, which may indicate that it was a more challenging practice to understand within an active learning setting. It is not surprising that cognitive demand and lecturing were both practices that showed evidence of being challenging practices because there is evidence in other studies that they are two difficult aspects of facilitating active learning classrooms for the first time (Marrongelle & Rasmussen, 2008).

When looking at the practices overall, there are two main categories: “traditional” teaching practices and “active learning” practices. “Traditional” teaching practices are practices that would be found in any mathematics classroom. “Active learning” practices are ones found specifically in an active learning, student-centered classroom, and can be further broken down into three sub-categories: peer-to-peer, TA interest, and deep engagement with mathematics. Of those 29 sub-practices that were determined to be conventionalized or approaching conventionalization, approximately half can be characterized as “traditional” teaching practices. So, the GTAs were equally likely to discuss “traditional” and “active learning” practices, which is an indication of the challenges they may have faced in incorporating “traditional” teaching practices within a new student-centered environment.

Result 3. Another reason particular practices were discussed often was that individuals found the practice important enough to discuss them in formal setting even with aligned meanings. In other words, multiple individuals discussed the same practice several times throughout the semester without the meaning or motivation behind the practice changing. The practice of asking for justification was the most commonly discussed practice over the entire semester with almost twice as many publications than the second most common practice. This may be a product of the importance of justification in mathematics through its role in proof. Discussions around justification also did not include many transformations, providing evidence that the community of GTAs agreed early into the semester on the meaning and motivation behind the practice.

There were two other practices that were discussed often with very few transformations publicized. One was the practice of checking understanding, which was the third most publicized practice. Checking understanding referred to asking questions to students with the goal of checking the understanding the students had of the task or activity. It contained only one transformation publication, and the transformation was brought up only once throughout the semester, providing evidence that the GTAs agreed on the motivation and meaning of the practice early on. The other practice was that of precision, which was the teaching practice of being precise in the GTA's communication, and no transformations were publicized throughout the semester. It was the most discussed practice to have no publicized transformations, giving evidence that the GTAs agreed early on in the semester on the meaning behind the practice.

All of these results arose from the analysis of what was discussed with what frequency, the nature of the transformations and the elaborations, temporally when they occurred in the semester, and the qualitative analysis of whether there was some agreement amongst the GTAs of the meaning or motivation of the practice.

Answering Research Question 2

In answering Research Question 2, I utilized the analysis methods described in answering Research Question 1 with explicit attention to individual's contributions, the community to which they belonged, and the temporal context. I identified the role of the lead TAs and others in what is taken up or conventionalized, as well as what understandings of the various teaching practices were evident. Furthermore, I was able to examine some differences between the two sub-communities of GTAs: the Calculus I and Calculus II GTAs.

Result 4. When the practices themselves are considered more broadly, it becomes evident that some of the introductions, elaborations, and transformations of classroom teaching practices involved a management approach to teaching. Classroom management refers to behavior-modification approaches that "prioritize behavioral learning, emphasize the contingencies that exist in the classroom and implicate reinforcement strategies, shaping, and response costs as key techniques" (Rimm-Kaufman et al., 2006, p. 145). As discussed in Chapter 5, for example, a GTA may explicitly or implicitly suggest that a particular instructional practice could be used to "scare" students into paying attention.

While the behavior-modification theme in the ways teaching practices are discussed may seem like a finding within Research Question 1, what is interesting to note about these practices is who is the one publicizing the introductions, elaborations, and transformations that are management based. As can be seen in Table 6.1 below, it is not the PD leaders who are talking about management-based practices. So, while the PD leaders did have influence over many of the other sub-practices discussed by the GTAs, they were not publicizing an aspect of teaching the GTAs seemed to find important. It is unsurprising that the GTAs would focus more on classroom management because this phenomenon has been documented elsewhere (Beisiegel, 2017). What is surprising is the fact that the PD leaders rarely explicitly discussed the classroom management aspect of teaching while working with the GTAs.

Table 6.1: Number of publicized introductions, elaborations, and transformations that involved a management approach to the teaching practice compared to the total. This is a reproduced version of Table 4.6.

Speaker	Management	Total	Percentage
PD Leaders	9	127	7%
Calculus Coordinators	11	43	26%
Lead TAs	28	110	25.5%
Calculus GTAs	25	87	29%

Result 5. The lead TAs did not have as much influence over the versions of the teaching practices that were taken up by their fellow GTAs in the public discourse, in the sense that neither of the lead TAs introduced any of the practices within the category of conventionalized practices and the Calculus II lead TA only had one of the practices he introduced within the category of approaching conventionalization. A possible explanation for this is that the PD leaders are the ones introducing potentially new teaching practices or suggesting a new way of using traditional teaching practices and so it may not be surprising that the lead TAs essentially had none of their introduced practices show evidence of conventionalization. However, their fellow GTAs had several of their introduced practices show evidence of conventionalization and so this explanation does not completely account for the differences.

Instead, there is evidence that the role of the lead TA was more towards affecting change in implementation of the practices within the classroom rather than influencing the discourse around the various teaching practices. The lead TAs conducted observations and debriefs with their fellow GTAs, and so their publications during those debriefs were rooted in what they had directly witnessed in the classroom rather than a general discussion about teaching practices.

Furthermore, there was evidence in the debriefing sessions that the lead TAs may have influence over the teaching of their fellow GTAs in the responses given from the observed GTA. For instance, in response to a suggested practice from Justin, Adam stated, “I'll definitely try that for my next activity on Thursday.” So, the GTAs may have not felt a need to discuss the practices introduced by the lead TAs in formal settings because they were implementing them in their classrooms and possibly discussing the outcome in more informal settings later.

Result 6. Within the category of conventionalized discussions, there were examples of practices that were conventionalized (or beginning to be conventionalized) within the whole community and within two sub-communities. In this study, the Calculus I and II GTAs attended the same PD course but outside of that, their weekly meetings were with different coordinators and each sub-community had their own lead TA. Because of this, it is not very surprising that there were times in which one sub-community showed evidence of a teaching practice becoming or approaching conventionalization when the other sub-community did not. When the community as a whole is considered, all four categories of teaching practices (traditional and the three sub-categories of active learning) are represented within the section of conventionalization. In contrast, when examining what was conventionalized within each of the Calculus I and II sub-communities, not all of the different categories are represented.

The Calculus I sub-community showed evidence of conventionalization for the sub-practice of *participation norms – student engagement* and showed evidence of becoming conventionalized for the sub-practice of *checking in – struggling groups*, which incorporates two of the three parts of “Active” teaching: peer-to-peer and TA interest. Both of these are related to orchestrating whole-class discussions. In contrast, the sub-community of Calculus II GTAs had evidence of conventionalization, or the beginnings of conventionalization, for the “Traditional” teaching category and for the "Active" teaching category of deep engagement with mathematics. Furthermore, there was evidence of six different sub-practices with evidence of some level of conventionalization: *scaffolding – add scaffolding*, *motivation – real life*, *lecturing – struggling students*, *lecturing – forward movement*, *cognitive demand – simplifying*, and *use representations – student use, TA generated*. Four of these relate to supporting students working on challenging tasks.

A further difference between the two sub-communities is what version of these sub-practices was showing evidence of conventionalization. For both of the sub-practices showing evidence of conventionalization within the sub-community of Calculus I GTAs, it was either the original or an elaborated version that was becoming conventionalized. However, for the Calculus II GTAs, two of the six sub-practices showed evidence of a transformed version becoming conventionalized within the sub-community. There are implications for professional development that will be described later in the chapter.

While there are differences between the sub-practices focused on by the two sub-communities, a direct comparison of them may not be appropriate. While both groups had a course coordinator, a lead TA, and the same basic structure, everything else was quite different. The weekly meetings for Calculus II were structured and run mostly by the coordinator. In contrast, the weekly meetings for Calculus I varied greatly, occurred less consistently throughout the semester, and was mostly run by the lead TA. The debriefings conducted by the two lead TAs were quite different as well. The Calculus II lead TA had an observation protocol that he had created and met for no longer than 5 minutes with the GTA right after the observation. The lead TA for Calculus I took all of his notes without an observation protocol and scheduled a 20- to 40-minute meeting with the GTA at a later time. Furthermore, the role of the two lead TAs and the two coordinators were very different, which effected what happened within the two sub-communities.

There were 24 practices identified as dominated discussions, and there were only four people who became a predominant voice: Justin, Jeff, Dr. D, and the Calculus II coordinator. Justin was the most common person who dominated discussions, but this was most likely that he had debriefing sessions that were longer than Jeff's and he would repeat advice to multiple GTAs. It's not, perhaps, surprising that he was a predominant voice. Furthermore, he was move likely to run the Calculus I meetings than Jeff was to run the Calculus II meetings based on the roles of the two coordinators. So, there were more opportunities for Justin to repeat advice, which would then artificially increase the number of publications around a single practice. The differences between the two communities may be things to attend to in future research.

Contributions

Having summarized the findings of this study, I turn now to the significance this study holds. In this section, I elaborate several of this study's theoretical contributions, particularly with reference to professional development programs for graduate teaching assistants. I then discuss the methodological significance of this study, specifically focusing on the use of the modified Vygotsky space in Chapter 4 and the criteria for determining a conventionalized practice in Chapter 5. Finally, I discuss the implications for professional development based on the results of this study.

Contributions

The findings in this study contribute to the field's understanding of GTA professional development in several different ways. This is empirical research with a focus on the "process" rather than the product. This extends existing, critical research on the structure and effectiveness of existing GTA programs (e.g. Belnap & Allred, 2009; Speer et al., 2009). In this research on GTA professional development, we learned that only about one-third of the instructional practices introduced in the discourse were taken up. The GTAs found cognitive demand and lecturing challenging teaching practices to make sense of. They discussed traditional practices an equal amount to active learning practices, apparently trying to make sense of them in an active learning classroom.

I identified aspects of teaching that are relatively easy for a community to make sense of. In Chapter 5, a list of ten practices was given that showed evidence of conventionalization. A majority of those practices fell within the "traditional" teaching category; there were four others that fell within the "active" teaching category. Many times, GTAs are coming from past experiences in mathematics classrooms that are taught in a "traditional," lecture format. So, it is not surprising that they functioned as if they had a shared understanding of "traditional" teaching practices. However, there were four "active learning" practices, two of which focused on student engagement and two of which focused on questioning, that showed evidence of conventionalization. So, while there is evidence of GTAs struggling with the implementation of some "active" teaching practices, there is evidence that they feel comfortable with the practices of facilitating student engagement and asking for justification and understanding.

GTAs can have different understandings of practices' meaning and motivations than the PD providers. What is important to note about this finding is that, much like it has been found in the K-12 literature (Coburn, 2001; Coburn et al., 2016; Cohen & Ball, 1990), there is evidence of the GTAs appropriating the practices as they are explained by the PD leaders and modifying them to fit within their own experiences and context, sometimes changing the meaning of the practice from its original version. This means that even if the GTAs and the professional development leaders seem to be speaking about the same teaching practices, their understandings of the practice may not be aligned, which can lead to misunderstandings. In professional development, it is important to attend to the possibility of this occuring and to consider what can be done to avoid it.

Sometimes the GTAs considered classroom management as the motivation for the use of instructional practices. While it may be true that the use of teaching practices such as think-pair-share can contribute to classroom management, this indirect effect may not be apparent to the GTAs. The GTAs focus on management was related to behavior-shaping; their concern was not addressed by the professional development leaders. The findings in this study point to a need to provide support to lead TAs within a lead TA structured program. This is particularly true in a program that is predominantly made up of Master level graduate students. The program at San Diego State University has their GTAs for no more than two years, with the rare exception. Based on the findings in this study and others (Beisiegel, 2017), new GTAs are still making sense of the basics of running a classroom in their first two years of teaching. When the lead TA position is held by GTAs who are at most in their second year of teaching, it is not surprising when they publicize versions of various teaching practices that involve classroom management. However, this also points to the need of supporting new GTAs in not only facilitating a student-centered classroom but also in classroom management. Until the GTAs feel confident in their ability to manage a classroom, they will struggle with implementing more complex teaching practices.

Prior to conducting the study, I had conjectured that the lead TAs would have a large amount of influence over the publicized understandings of their fellow GTAs. This was because they were a peer and teaching the same course as their fellow GTAs, placing them “in the trenches" together. However, as was stated in the findings, the lead TAs did not have as much influence in the discussion as originally hypothesized. This leads to the finding that while the lead TAs are in a position of authority, they may not have as much influence over the publicized understandings of various teaching practice from their fellow GTAs. However, they may have more direct influence over the actual implementation of the practice in the classroom. This remains a question for further study. As noted, the role of the lead TA in the different sub-communities seems to be related to the differences in the coordinator's role.

Methodological Significance

A major aspect of the significance of this study is the methodologies generated to analyze the data. The first was the modification and use of the framework known as the Vygotsky Space. Prior to this study, the Vygotsky Space was a theoretical framework that had been adapted for use in literacy education (Gallucci et al., 2010). The Vygotsky Space was used to describe the development of a teacher's understanding of teaching literacy as they interacted with professional development and enacted it in their own classroom. For this study, the Vygotsky Space was modified for its use in describing the changes various publicized understandings of a teaching practice underwent, altering the unit of analysis from an individual's learning in relation to the community to the discourse around particular teaching practices. Instead of a lens foregrounding an individual, the modified version focused on the understanding of a practice within a community, emphasizing the reflexive relationship between the individual and the community. In this way, we could better comprehend the understanding of the meaning and motivation of the various teaching practices as the GTAs publicized their understandings of them in various public spaces. The relationship between the individual learning and the learning of the community, hence, is co-evolutionary (Peck et al., 2009).

The use of the modified Vygotsky Space led to the distinction between a transformed version and an elaborated version of a practice. Transformation in the original Vygotsky Space (Harré, 1983) meant the changes an individual made to a particular topic, idea, or practice as they made sense of it within their own context. I made a distinction between elaboration and a change in the meaning or motivation of a practice. This distinction between the two allows for a better understanding of how GTAs make sense of various teaching practices within their own contexts and helps to shed light on what changes are being made to a practice from the original intent. It also was fundamental in determining what meanings and motivations of a teaching practice in a student-centered classroom might be more easily understood or challenging.

Another methodologically significant aspect of this study was the creation of the criteria for a practice to be considered conventionalized within a community. Based on the criteria for a mathematical idea to *function as if shared* (Cole et al., 2011), the criteria for a publicized understanding of a practice to be considered conventionalized within a community were created to help provide rigorous analysis of the interactions within a community. These criteria were used in combination with temporal diagrams to assist in determining which practices reached a consensus and which did not. Below in Figure 6.1 is a general version of the temporal diagrams used in the analysis. Diagrams of this sort were created for each of the 137 sub-practices identified within the discourse. (See Appendix E.) Each time the practice was publicized, it was recorded on a diagram similar to that in Figure 6.1 along with the name of the event, the date of the event, and the speaker. The type of colors used, and the format of the lines connecting the various publications, indicate its relationship to the original publication. The publications were situated on the diagram in the order they occurred, with different dates being separated by connecting lines.

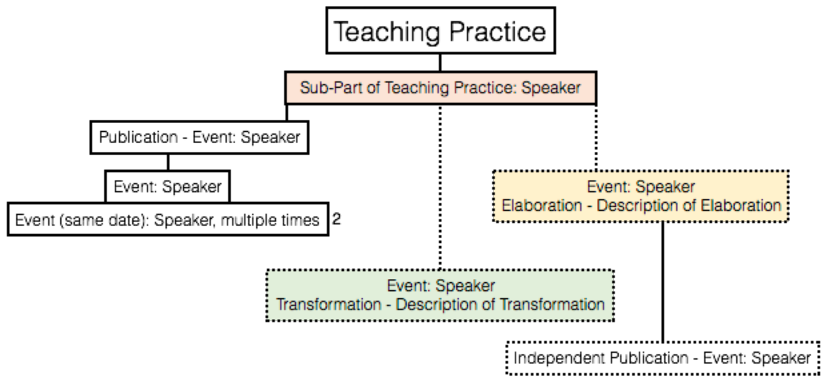


Figure 6.1: A general version of the temporal diagrams used to represent the various publications throughout the semester around a particular teaching practice.

Through the use of the temporal diagrams of the various publications around a particular teaching practice, and the distinction between an elaboration and a transformation, the use of the criteria provided a concrete way to determine which practices reached a consensus and which did not. Furthermore, it allowed for the distinction between various types of discussions within a community, as in dominated discussions and inconclusive discussions. With the creation of the criteria and method for analyzing and organizing the data, the field has a methodologically significant way of tracking and making sense of changes within a community through their discussions.

Implications for Professional Development of GTAs

There are two major categories of implications for professional development: PD for the GTAs as a whole and the lead TAs specifically. The first result that was discussed pointed to the finding that GTAs did appropriate the language of mathematics educators around various teaching practices, but their understanding of those practices may be different that that of the intent from the professional development leaders. An implication of this is that professional development leaders should be explicit when discussing the meaning or motivation of a teaching practice. Furthermore, the leaders should attend to publicized alternative meanings or motivations to avoid misalignment.

Additionally, in this study there were 137 different sub-practices identified. A more narrow focus on a subset of these practices could help GTAs have more opportunities to make sense of the practices. In particular, focusing on those practices that have been shown to be challenging would be important. In this study, there were two teaching practices that showed evidence of being challenging for the GTAs: *lecturing* and *cognitive demand*. While there likely were other teaching practices that the GTAs had difficulty understanding, these two practices show evidence of how difficult they were for the GTAs. For the practice of *lecturing*, the GTAs struggled with the role traditional lecturing could play in an active learning, student-centered classroom. Furthermore, decisions about practices in which cognitive demand was maintained or lowered was a difficult idea for the GTAs, particularly ways in which to maintain the difficulty of a task. This is challenging for experienced teachers as well.

Approximately half of the practices that showed evidence of some level of conventionalization were within the “traditional” teaching category. This is not surprising as the GTAs most likely had the most experience with “traditional” math classrooms rather than classrooms that utilized “active learning” teaching practices. Future iterations of this professional development program and programs at other institutions may want to consider ways to bridge the “traditional” and “active learning” teaching practices to help the GTAs with how those seemingly different types of teaching practices can work together.

In a study done by Beisiegel (2017), the researcher found that GTAs in their first couple of years of teaching were concerned primarily with classroom management. It was not until they had experience that they began to feel confident in implementing more advanced teaching practices in their classrooms. This finding is related to the fourth result and can be seen in the various transformations and elaborations publicized by all of the GTAs, including the lead TAs.

Both of the lead TAs publicized a transformation to ask students to repeat or rephrase in which the practice could be used to scare students into paying attention in class. Both of the lead TAs publicized a version related to the original later in the semester and also worked to incorporate more advanced teaching practices into a classroom management practice. Many PD programs for GTAs are focused on the first time GTAs and fewer after they have taught for the first year (Belnap & Allred, 2009). Perhaps PD programs will need to begin to incorporate classroom management techniques into their training, possibly making explicit the management consequences of more advanced teaching techniques and practices. Many of the teaching practices found within an active learning classroom do have the indirect effect of classroom management, but without making those effects more directly observable by the GTAs, they may not see the benefits on their own. If programs do not take into account the context in which the GTAs are working, it may take them much longer to incoorporate other active learning practices in their classrooms.

A fifth possible implication for professional development is that of supporting lead TAs in fullfilling their duties as lead TA. The lead TA structure was found to be used in 22.8% of professional development programs across the United States (Palmer, 2011). However, what constitutes a lead TA structure can vary greatly, as it only must include a more experienced peer providing support to their fellow GTAs with a professional development component (Ellis, 2015). This can range from a single lead TA serving as a support for all GTAs in the department, regardless of the course to having a lead TA for each course. Based on how many peers the lead TA must support, the level of support the lead TA can provide will vary. However, the results of this study, described in the fifth result above, state that the lead TAs may not have much influence over how teaching practices are discussed and understood but may instead have a larger impact over what is implemented in the classroom through their observations. So, if a lead TA program does not include regular observations from the more experienced peer, the influence of the lead TA may be greatly diminished. Furthermore, if the lead TAs do have a larger influence over the implementation of the teaching practices, it will be important to provide them support to conduct those observations and provide feedback to their peers.

As was stated above, if we, as PD leaders and providers, want our lead TAs to assist in promoting the teaching practices as we understand them, we need to provide the lead TAs with additional support and training. We may suggest they need to explicitly address management. Furthermore, within the case of a Masters-granting institution, many of the GTAs only hold their position for no longer than two years, which does not provide them much time to learn to facilitate a student-centered classroom, let alone learn how to support others in their facilitation. So, for the lead TAs to have the tools with which to support their fellow GTAs in this endeavor, they will need narrower additional support as they continue to learn about facilitating an active learning class. However, without knowing how the lead TAs affect the actual teaching of their fellow GTAs, rather than the discussions around teaching, a complete recommendation on how to support the lead TAs is not possible.

Finally, it is important to take into consideration the differences in the adopted roles taken on by the members in the sub-communities. At this particular institution, there was a distinct difference in the adopted roles of the two course coordiantors, which led to some of the differences between the two sub-communities. The course coordinator for Calculus I was more likely to have the lead TA run the weekly meetings, which led to a smaller number of things discussed during the meetings outside of administrative issues. Furthermore, the activities in Calculus I were considered to be easier than that of Calculus II (by the GTAs themselves) and so the GTAs in Calculus I may have had more of a chance to discuss ways to engage students in the activities or focus on scaffolding social interaction, rather than how to help students with the demand of the activities.

The Calculus II coordinator was much more involved in the weekly meetings, and tended to keep the structure of the meetings the same each time (e.g., begin with how last week went, talk about next week's activity, and end with administrative discussions). Furthermore, aspects of teaching that were important to him, such as making connections to real life applications in the material, became common talking points, as evidenced in what showed evidence of some level of conventionalization.

We cannot possibly prepare our GTAs for all of the demands of teaching at the undergraduate level. There are many challenges in facilitating an active learning classroom: orchestrating whole class discussions, eliciting and coordinating student contributions to a desired end, providing the social scaffolding for students to share their thinking, and deciding how to support students to move forward the mathematical goals of the class (Speer & Wagner, 2009), just to name a few. Even so, with a narrower focus, more explicit discussions, and tools for the GTAs to learn from their own teaching, we can help support their learning process (Kung & Speer, 2009).

Study Limitations

One limitation of this study was that publications were limited to verbal and written records of formal situations. Classroom video could be used to look at instructional practice of the GTAs and how they publicized their understanding of teaching practices through their facilitation of an activity. The classroom videos that were collected in this study were a subset of a GTAs' practice. The videos were of classes the lead TA observed, which may not be representative of all teaching. Furthermore, the camera focused on the front of the room in an attempt to keep the distraction of the camera at a minimum. So, while there was some data of the teaching practices used in the classroom, there was not enough to provide evidence of the teaching practices the GTAs were implementing in the classroom. The intent of the classroom videos was as a resource for providing context for me to correcting interpret the debriefing sessions, not as data to be analyzed on its own. This meant that my results were based on the publicized understandings from the GTAs rather than what they were actually doing in the classroom, providing a different view of the practice of teaching.

A second limitation is that it was conducted at a single institution. While there are significant findings from this study, they would be supported by similar findings at other institutions, especially those with a lead TA structure. In the future, as more data are collected, and further analysis done, we can continue this work and provide additional comparisons.

Furthermore, the differences between the Calculus I and II communities was great enough to make an explicit comparison between them difficult. Although I can note differences in the Calculus I and II sub-communities, we must be careful about comparisons. As was discussed in Chapter 5, there were some practices that had evidence of conventionalization in one but not the other. However, the differences in the way each sub-community was run and in the adopted roles of those running the sub-communities made it such that comparisons provided interesting, albeit specialized, information that highlights things to consider for future research.

Finally, as I have noted elsewhere, the data that I collected was only within formal events within the GTA program itself. This meant I did not have data on the individual conversations between the GTAs in various informal settings. The GTAs all share an office and they reported talking to one another about their teaching often while working in their office or between classes.

So, there most certainly was learning, appropriation and transformation that occurred during these informal moments that were not captured in the data.

Future Research

The field of research focusing on GTA professional development is still within its infancy and so there are many places for growth in this research. First, I am interested in analyzing the interviews that I conducted with a majority of the GTAs in my study after the semester had ended. I will compare what teaching practices the GTAs felt were important and useful to them to what was discussed in the various formal events throughout the semester. Furthermore, the interviews will provide deeper insight into how the GTAs themselves thought about the professional development program as a whole, which they may not have discussed openly in other settings.

Furthermore, I would be interested in conducting a similar study in which the focus is more on the practice implemented by the GTAs in their classroom and how it relates to the advice given to them by their lead TAs. As I noted earlier, even though many of the versions of various practices publicized by the lead TAs were not taken up by the other GTAs within the discourse, they may still have been implementing the practices in their classrooms. Additionally, I have been the instructor for the PD course during the current academic year and the two lead TAs, who are both female, have complained that they feel unheard by their fellow GTAs. I would be interested to study how much influence the lead TAs do have over the teaching of their fellow GTAs and possibly what may factor into the amount of influence they do have.

A study similar to this one would be difficult to conduct remotely but I would be interested in working with others to conduct similar studies at other institutions to add to the literature on how GTAs make sense of various teaching practices. More studies are beginning to surface that follow GTAs over time as they engage with professional development and results from in depth studies such as this one would help add to the field's understanding of how GTAs develop their teaching and would, in turn, affect the professional development offered to them.

Finally, I am currently discussing a future project with a colleague that would look at the role of empathy in the teaching done by graduate students. While my study did not directly focus on empathy, there were many instances in which empathy, or the lack thereof, did come up in various discussions, including the interviews conducted at the end of the semester. The current idea is to take my dissertation data and her data to form a basis to better understand how empathy affects the ways in which GTAs talk about teaching and their students. From there, we plan to conduct further studies on how empathy training could be implemented in GTA professional development and the possible implications of its inclusion.

The socio-cultural framework will undoubtedly continue to be the lens for future work, either foregrounding individual learning as affected by and affecting the social sphere or foregrounding the learning of the community of GTAs as individuals contribute to and affect a change in the social sphere. Through the use of genetic analysis, future work will continue to add to the literature base by providing a deeper understanding of how GTAs develop their understandings of teaching practices and the practice of teaching itself. By studying the changes as they occur through their interactions with one another, we can better support them in their teaching in the future.

Appendix A: Summer Professional Development Schedule

<table>
<tr><th></th><th>TUESDAY, 8/23 (all groups)</th><th>WEDNESDAY, 8/24 (Calc I & II)</th><th>THURSDAY, 8/25 (Calc I & II)</th></tr>
<tr><td>BLOCK 1
9:00-10:15)</td><td>Quick Introduction/Overview
Icebreaker
Recruitment (Hayley)
Background survey
Experience & prior training
Research evidence on the effects of active learning on student success (Chris)</td><td>Meet with course coordinators
Integrating lecture and lab is important; connection must be reinforced on both ends
Introduction of lead TAs and description of their roles</td><td>Group A teaches group B by content groups (with coordinators, lead TAs, Chris, Mike, Daniel)

Rehearsal: How do I introduce myself on day 1?
How do I launch lab 2?</td></tr>
<tr><td>BLOCK 2
(10:30-11:45)</td><td>Engaging in Active Learning as a student (Chris or Mike and Susan?)
Model active learning in mathematics
Engage in mathematics and second person points out teaching decisions and strategies. Discuss rationale grounded in research evidence on the effects of active learning on student success (i.e., continue as needed)</td><td>Intro to idea of Decomposition of Practice (Daniel)

Select from these:
• Intro to 5 practices for Productive Discussion
• Launch, Explore, Summarize
• asset model vs deficit model
• some focus on language

Discuss meeting times for bi-weekly meeting</td><td>Group B teaches group A by content groups … continue</td></tr>
<tr><td>12-1</td><td>LUNCH</td><td>LUNCH</td><td>LUNCH</td></tr>
<tr><td>BLOCK 3
(1-2:00)</td><td>Stereotype threat (David Marx & Susan):
Intro to research & constructs
Discuss personal stories
How to address
Intro to research that will take place</td><td>Plan for teaching lab #1
Coordinators (& MTEs circulate?)

Share out math solutions
Fill out planning sheet
Work through first lab
Work through the mathematics
Share lesson planning</td><td>Equity (Bill Zahner)
Equity & Diversity
Scaffolding
Launching the Task
Representing the task (making good drawings)
Asking high-level questions (intro to cog demand ideas)</td></tr>
<tr><td>BLOCK 4
(2:15-3:15)</td><td>Two videos of Calc classrooms – Using MCOPP (Janet)
10 minute videos</td><td>Other general teaching stuff (Toni and Ricardo)
Active learning on demonstration days
What works/didn't work for you?
Board work
Review pedagogical routines</td><td>Wrap up
Review--Susan (?)
Take it back to classroom take away reflection questions
Evaluation</td></tr>
<tr><td>HW:</td><td>1. Math Content homework
Precalc, Calc I & II do activity #1
Fill out planning sheet for
What will you do on first class?
How are you going to sell it?</td><td>1. Read Freeman paper http://www.pnas.org/content/111/23/8410.full.pdf
2. Prepare for lab #2 practice teaching</td><td></td></tr>
</table>

Appendix B: Syllabus for the Professional Development Course

MATH 790: TEACHING AS SCHOLARLY ACTIVITY

FALL 2016 – SPRING 2017

Education is not preparation for life; education is life itself. –John Dewey

COURSE INFORMATION

Instructor: Dr. Daniel Reinholz
Class Times: Friday, 12:00-1:00
Class Location: GMCS405

Email Contact: daniel.reinholz@sdsu.edu
Office Hours Times: T TH 10:45-12:00 (and by appt.)
Office Hours Location: LL328 (Math Learning Center)

COURSE OVERVIEW

This is a crash course in creating meaningful learning experiences. Together we will create a space to reflect on our teaching and to grow as educators. Along the way, we will study learning theories and develop tools for becoming lifelong learners. Our exploration will be based on two axioms; good teaching:

1. is student-centered, not teacher-centered; and
2. focuses on what students can do, not what they cannot do.

This means that we take an *asset* stance to teaching and learning, rejecting *deficit* models.

To develop our skills, we will focus on the building blocks of productive learning environments. These ABCs are:

A. **Assessment:** What math are students asked to do? What does it tell us about their thinking?
B. **Beliefs:** What do students think math is about? How do we help them develop positive identities?
C. **Community:** How do students interact? Do they feel connected to their peers?
D. **Discourse:** How do students talk about math? How is talk used to support learning?
E. **Equity:** How do we make our instruction accessible? How do we differentiate for individual learners?

These questions are tools for reflection; pondering them will help us grow as educators for years to come.

COURSE SCHEDULE

- Week01 (Sep2): Introductions. **Assessment** and the "asset" approach.
- Week02 (Sep9): **Beliefs**, feedback, and use of language.
- Week03 (Sep16): **Community**, culture, and building norms.
- Week04 (Sept23): **Discourse**, questioning, and accountable talk.
- Week05 (Sep30): **Equity** and differentiation.
- Week07 (Oct14): Video Reflections (Part 1).
- Week09 (Oct28): Video Reflections (Part 2).
- Week12 (Nov18): Peer observations. Putting it all together.
- Week14 (Dec2): Reflections and celebration.

Spring 2017 schedule TBD.

COURSE ASSESSMENT AND GRADING

Your grade consists of the following components:

- Reading Reflections 30%
- Classroom Assignments 40%
- Teaching Portfolio 30%

Reading Reflections

Before each class session, you will complete 1-2 short readings. These will introduce you to key ideas from the study of teaching and learning. On Blackboard, you will write reflections, in which you: (A) identify 1-3 big ideas that you can apply to your teaching, and (B) pose 1-3 questions you have related to the reading. Your reflections will provide the basis for our discussions in class and for your statement of teaching philosophy.

Classroom Assignments

These assignments involve you doing "something" in the classroom. For instance, you may be asked to use a specific teaching technique or ask a certain type of question to your students. Afterwards, you will reflect on your experiences and exchange feedback with your peers on Blackboard. For each assignment you will provide feedback to at least one peer. You will also have an opportunity to video record your own teaching and share it with the class (weeks 07 and 09).

Teaching Portfolio

The culminating project is your teaching portfolio. This is a collection of documents that describes your approach as an educator and documents the impact of your teaching. Most teaching jobs will require that you submit these materials as a part of your application. By developing your portfolio in this course, you will be prepared if you choose to go on the job market for teaching. Your portfolio will have (at least) the following components:

A. Written Statements
   a. Teaching Philosophy
   b. Reflection of Growth
   c. Description of Attached Materials
B. Instructional Materials
   a. Syllabus
   b. A Sample Lesson Plan
   c. Student Evaluations
C. Supporting Materials (from others)
   a. Letter of Recommendation
   b. Teaching Awards / Courses taken (as applicable)

Your reading reflections and classroom assignments will provide the raw materials for a strong portfolio.

Blackboard

Blackboard (http://blackboard.sdsu.edu) will provide access to class materials and your current grades. Student support for Blackboard is provided by the Library Computing Hub, located on the 2nd floor of Love Library. They can be reached at 619-594-3189 or hub@mail.sdsu.edu

Students with Disabilities

If you are a student with a disability and believe you will need accommodations for this class, it is your responsibility to contact Student Disability Services at (619) 594-6473. You can also learn more about the services provided by visiting the Student Disability Services website. To avoid any delay in the receipt of your accommodations, you should contact Student Disability Services as soon as possible. Please note that accommodations are not retroactive, and that accommodations based upon disability cannot be provided until you have presented your instructor with an accommodation letter from Student Disability Services. Your cooperation is appreciated.

Appendix C: Calculus II Lead TA's Observation Protocol

Active Learning Observation Guide

This is a reference to help reference Active Learning goals while observing TAs.
Simply take notes under the appropriate category – either things you saw that worked well, or hints and suggestions.

5 Goals for Active Learning

(1) Students share their thinking

(2) Students orient to and listen carefully to other students

(3) Students deepen their reasoning through discourse

(4) Students engage with others' reasoning

(5) Students (and instructor) build on and extend students' ideas

Five Practices

(1) Anticipating

(2) Monitoring

(3) Selecting

(4) Sequencing

(5) Connecting

General Comments

Appendix D: The 33 Teaching Practices

In my initial coding, I remained open to what could be discerned from the data. These initial codes were provisional and grounded in the data. Sometimes these codes were markers of the participants speech. After I had coded a body of data, I was able to do more focused coding to categorize larger segments of the data (Glaser, 1978). What emerged was a framework of teaching practices that revealed a broader structure. I found that the discussion of teaching practices could be related to the frameworks we used to introduce many ideas around learning to teach in an active learning classroom. The codes could be related to these frameworks and to the context in which they were discussed.

There are 33 main codes used to distinguish teaching practices used in my dissertation. The teaching practices within these categories are not meant to be exhaustive or complete. In this appendix, I will be explaining what each of those codes represent and how they fit within a broader structure of teaching practices. The main categories I used when creating these codes were the Five Practices for Orchestrating Productive Mathematics Discussions (Smith & Stein, 2011), traditional teaching practices, and active learning practices, which was further broken down into the three pillars. Each of these, along with a category containing practices within multiple categories, will be described in detail below.

The Five Practices

In coding, one particular resource for the focused codes was that of the Five Practices for Orchestrating Productive Mathematics Discussions (Smith & Stein, 2011). The five practices are: Anticipation, Monitoring, Selecting, Sequencing, and Connecting. Each of these, except for Sequencing, were represented in the 33 overall teaching practices. Sequencing was only discussed during the summer seminar and was not taken up by the GTAs and so it was not included as part of the 33 main codes in the focused coding.

Anticipation

According to Smith and Stein (2011), anticipation involves the instructor envisioning how students might approach a task, how they may interpret the task, and how their various approaches and interpretations relate to the mathematics involved in the task. The discussion entailed three broad instructional practices related to anticipation.

Anticipation – Additional Problems: The creation of additional tasks to give students in class if they finish the activity early or are struggling with the activity and may need additional support or examples.

Anticipation – Student Questions: What types of questions students may ask during the activity. Also includes possible stumbling points the students may encounter with the activity, which may result in them asking a question or simply getting stuck on the task.

Anticipation – Student Thinking: What they believed students would do with an activity in terms of their solution paths, but it does not include how they may get stuck.

Monitoring

Monitoring involves the instructor circulating the room while students are working in their groups and gathering information about their thinking and solution paths. There was only one broad instructional practice related to monitoring.

Monitoring: Circulating the classroom and assessing what students are doing with the activity. This could include taking notes on what students are doing or simply checking in with groups to assess progress.

Selecting

After monitoring the various solution paths of the students, the instructor can make a decision regarding which students will share their thinking with the rest of the class. Selecting is based not only on the solutions or methods of the students but also how those help the class reachthe mathematical goals of the activity. There was only one broad instructional practice related to selecting.

Selecting: Includes ways to ask students to present and reasons to ask students to present but does not include the order in which students present. Reasons to ask students to present include to show a completed answer, to show multiple strategies, to show an incorrect strategy, to show a partially completed answer, or to conduct a comparison between strategies.

Connecting

Connecting involves the instructor helping the students connect the various solutions and methods shared with their own, as well as connecting strategies to the mathematical goals for the activity. There were two broad instructional practices related to connecting.

Connecting: Creating connections between different aspects of mathematics within the task or connecting different strategies together in some way. This is generally done by the GTA.

Synthesizing: Bringing everything together at the end of class. This is very similar to connecting but is specifically discussed as a practice done at the end of class.

Traditional Teaching Practices

In my axial coding I distinguished between mathematical practices considered peculiar to active learning and any practices that could be found within any mathematics classroom are considered traditional teaching practices. There are eight that had all of their sub-practices considered traditional practices.

Lecturing: Includes all discussions around the practice of lecturing and when it should be used.

Moving Forward: Ways in which to move the class forward in the activity when they seem to be stagnating.

Checking In – Whole Class: Includes discussions around checking on the progress of the whole class. Also includes reasons and ways to bring the whole class together again.

Attention: Discussions around how to get attention of the students or times in which it is important to make sure the class is paying attention. For example, discussions could include where the GTA should stand in the classroom to maintain the students' attention.

Participation – Carrot/Stick: Teaching practices that explicitly involve either positive or negative reinforcement of participation norms in the classroom.

Practicing Procedures: Any discussions that focused on ways to practice various procedures during a given activity.

Wait Time: Any discussions about providing wait time in the classroom.

Answering: Providing answers to student questions, including what to do when the GTA does not know the answer to the student question.

Elaboration: Any discussions around the GTA adding to what a student has said. This includes rephrasing something with more precise language and restating what a student has said while including more information.

Scaffolding: Discussions on ways to structure an activity to help students get access to solving it. Usually discussions included ways to break down an activity into smaller, easier parts for the students.

Active Learning Practices

Practices within this category are found in student-centered, active learning-based classrooms. This category is further broken down into the three pillars of active learning: peer-to-peer engagement, deep engagement with the mathematics, and GTA interest in student thinking. The three pillars of active learning come from a combination of the two pillars for inquiry-oriented learning (instructor interest in student thinking and deep engagement with the mathematics) and the twin pillars of inquiry-based learning (deep engagement with the mathematics and peer-to-peer engagement). Each of these will be described separately.

Peer-to-Peer Engagement

Practices within this sub-category include ways to encourage student engagement with one another in their small groups and within whole class discussions.

Establishing Norms: Creating the norms around group work by utilizing various teaching practices to encourage students to talk with one another.

Participation – Norms: The creation of norms around participating in class: what is expected of the students. This also includes ways in which the GTAs and students co-construct an understanding of how one does mathematics.

Think-Pair-Share: A particular teaching practice that involves having students discuss something with the person next to them and then share with the class what they discussed.

Deep Engagement with the Mathematics

Practices within this sub-category include ways to engage students with the mathematics at a deep, conceptual level.

Cognitive Demand – Planning: Discussions around how difficult a problem is as it is written and/or how it will be changed to either raise or lower the cognitive demand of the task.

Exploration: Teaching practices that encourage students to explore the mathematics on their own. This includes providing opportunities for students to have agency over their own thinking and work, to assess different methods or their own thinking, and to struggle with a problem as long as they are moving forward.

Using Representations: This includes the use of various mathematical representations in class. It is from the MCOPP (Gleason et al., 2015) and includes students creating graphs or drawings to help them solve a task. In this particular study, the discussions around this teaching practice involved how the use of representations could work to engage students with the mathematics.

TA Interest in Student Thinking

Practices within this sub-category include ways in which GTAs have opportunities to engage with their students' thinking and show interest in their ideas.

Checking In – Group Work: Teaching practices that involve checking-in with individual groups as they are working together.

Other Categories

During the coding process, there were other teaching practices that were introduced such as discussions about creating an atmosphere that was comfortable for student participation. As broad teaching practices, they could not be described as traditional or active learning. They are described below.

The 33 teaching practices were broken down into sub-practices so as to create equal parts. During the process of axial coding, there were some teaching practices that had sub-practices fall within different categories. As a result, 9 of the 33 teaching practices seemed to fit within multiple categories.

Traditional and Peer-to-Peer Engagement

Practices within this combination of categories had sub-practices that fell either within traditional practices or the sub-category of peer-to-peer engagement.

Body Position: This refers to discussions around how the GTA's position with respect to their students can affect the outcomes. This includes the GTA positioning themselves to be at the same level as their students in their groups or sitting with the class during presentations to help encourage students' engagement with one another. It also includes the GTA standing near groups or students who are being disruptive so as to gain their attention.

Group Creation: This includes discussions about how to create groups and why. This may be simply the way to count off groups or it could be about ways to help create groups to encourage students to work together.

Participation – Atmosphere: This involves discussions about the atmosphere of the classroom and how to create a comfortable environment for students to participate in class.

Visible Work: Work that has been either student or GTA generated that has been made visible to the whole class in some way. The reasons for this practice could be to encourage student's engagement with one another's thinking or to provide formulas or a graph to assists students in the completion of the task.

Traditional and Deep Engagement

Practices within this combination of categories had sub-practices that fell either within traditional practices or the sub-category of deep engagement with the mathematics.

Cognitive Demand – Whole Class: This includes the ways in which how a task is presented or facilitated can affect the difficulty level of the task.

Goals: Discussions have a focus on the learning goals for a task and what aspects of the task that need to be emphasized by the GTA.

Motivation: This includes ways in which to motivate why the students are working on a task and why they are working in groups.

Traditional and TA Interest

Precision had sub-practices that fell either within traditional practices or the sub-category of TA interest in student thinking.

Precision: This includes discussions about the use of precise language by the GTA and the students.

Traditional and Active Learning Practices

The practice of Questioning included sub-practices from traditional teaching practices and all three of the pillars of active learning. The practice of questioning involved any and all questions the GTAs did or could ask during whole class discussions and small group work. Since it is such a broad practice, it is not surprising that there are sub-practices that fit within each of the types of practices. Below are some examples of sub-practices within all four categories/sub-categories.

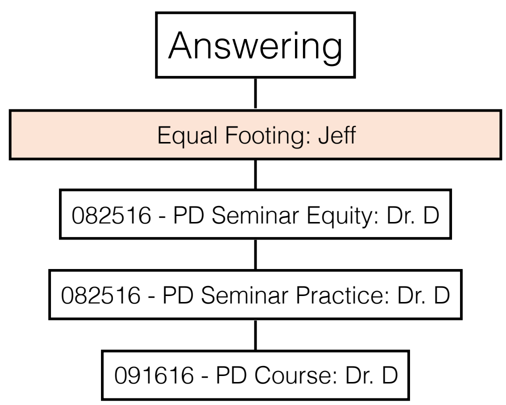
Questioning – Evaluating: This involves questions that evaluate student thinking, which would be categorized as a traditional teaching practice.

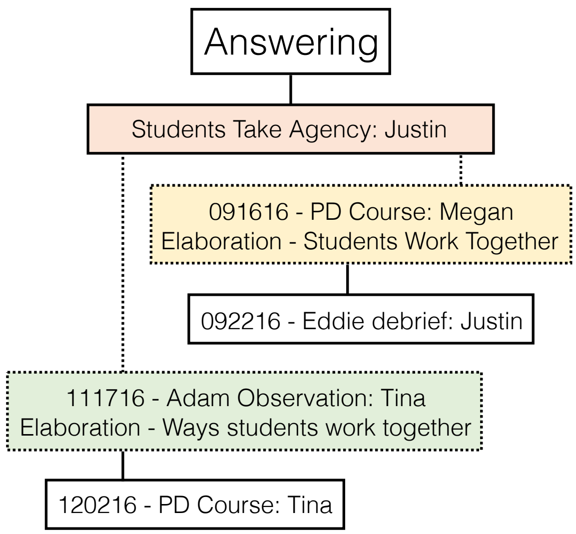
Questioning – Rephrase: This involves questions that ask students to rephrase what another student has said, which would be categorized as peer-to-peer engagement.

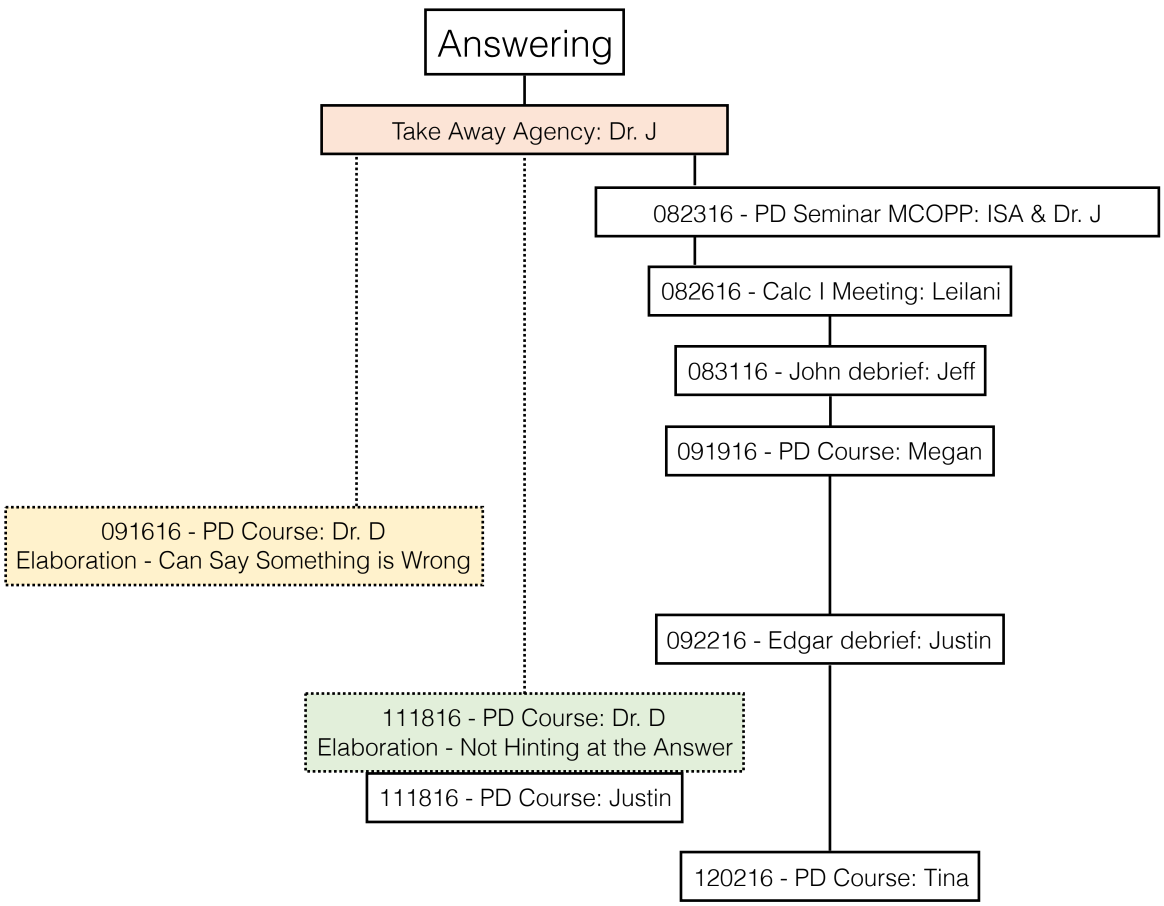
Questioning – Justification: This involves asking students to justify their answers, which would be categorized as TA interest in student thinking.

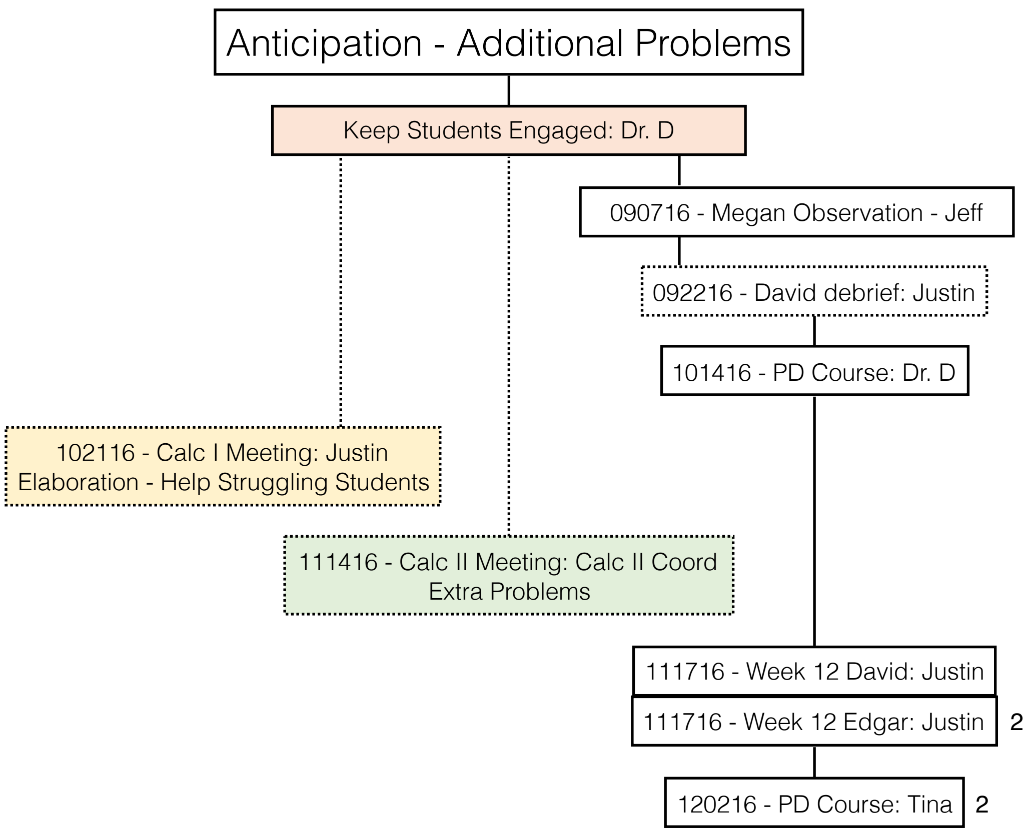
Questioning – Conceptual: This involves asking conceptual questions to the students, which would be categorized as deep engagement with the mathematics.

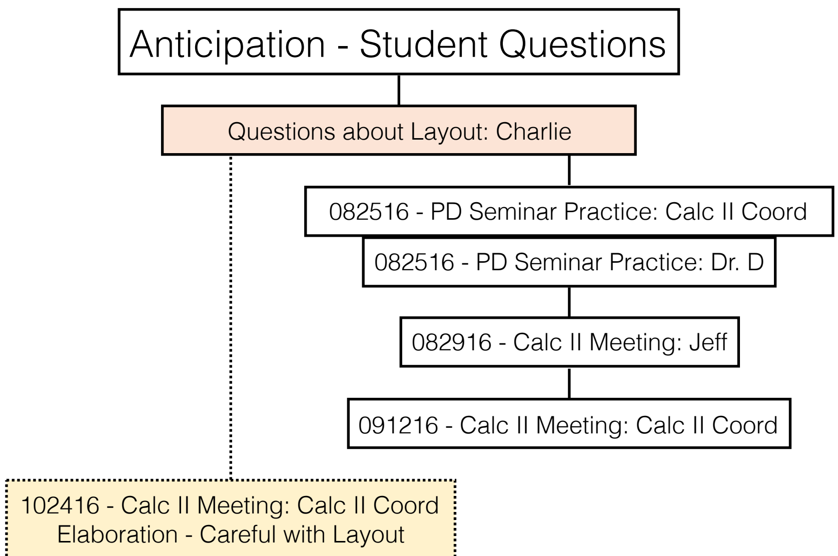
Appendix E: Temporal Diagrams for all 137 Sub-Practices

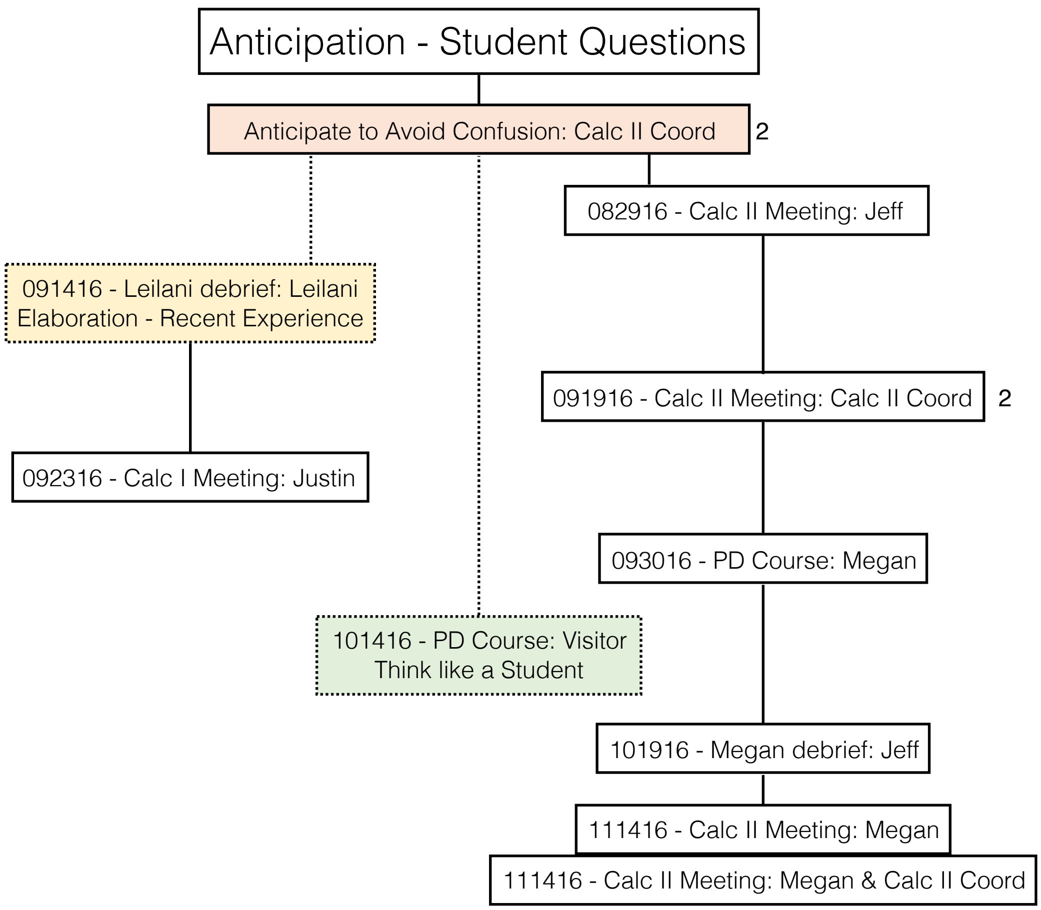


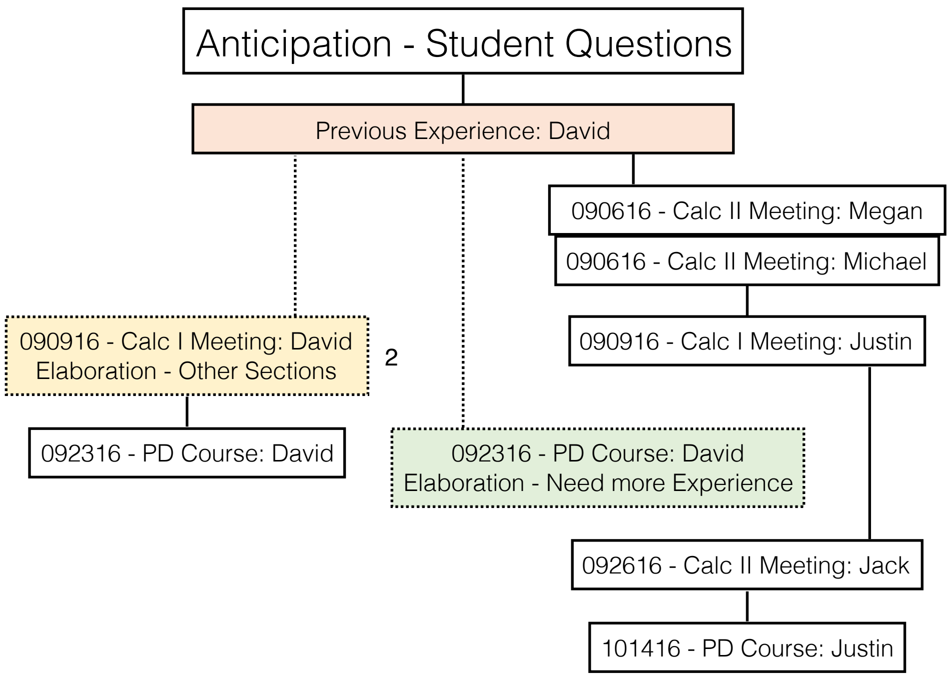

Answering
Students Take Agency: Justin
091616 - PD Course: Megan
Elaboration - Students Work Together
092216 - Eddie debrief: Justin
111716 - Adam Observation: Tina
Elaboration - Ways students work together
120216 - PD Course: Tina


Answering
Take Away Agency: Dr. J
082316 - PD Seminar MCOPP: ISA & Dr. J
082616 - Calc I Meeting: Leilani
083116 - John debrief: Jeff
091916 - PD Course: Megan
091616 - PD Course: Dr. D
Elaboration - Can Say Something is Wrong
092216 - Edgar debrief: Justin
111816 - PD Course: Dr. D
Elaboration - Not Hinting at the Answer
111816 - PD Course: Justin
120216 - PD Course: Tina

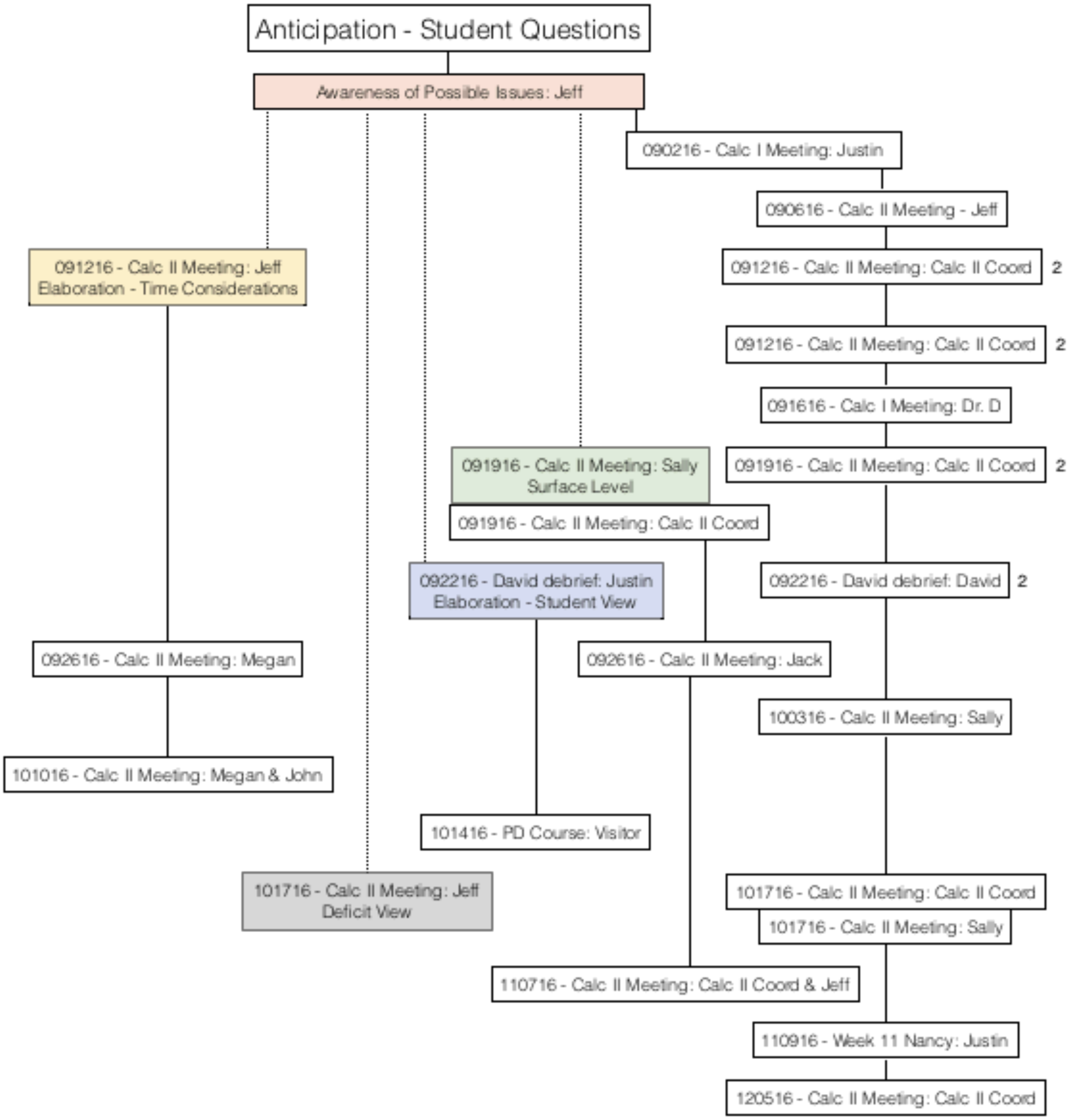

Anticipation - Additional Problems
Keep Students Engaged: Dr. D
090716 - Megan Observation - Jeff
092216 - David debrief: Justin
101416 - PD Course: Dr. D
102116 - Calc I Meeting: Justin
Elaboration - Help Struggling Students
111416 - Calc II Meeting: Calc II Coord
Extra Problems
111716 - Week 12 David: Justin
111716 - Week 12 Edgar: Justin
2
120216 - PD Course: Tina
2

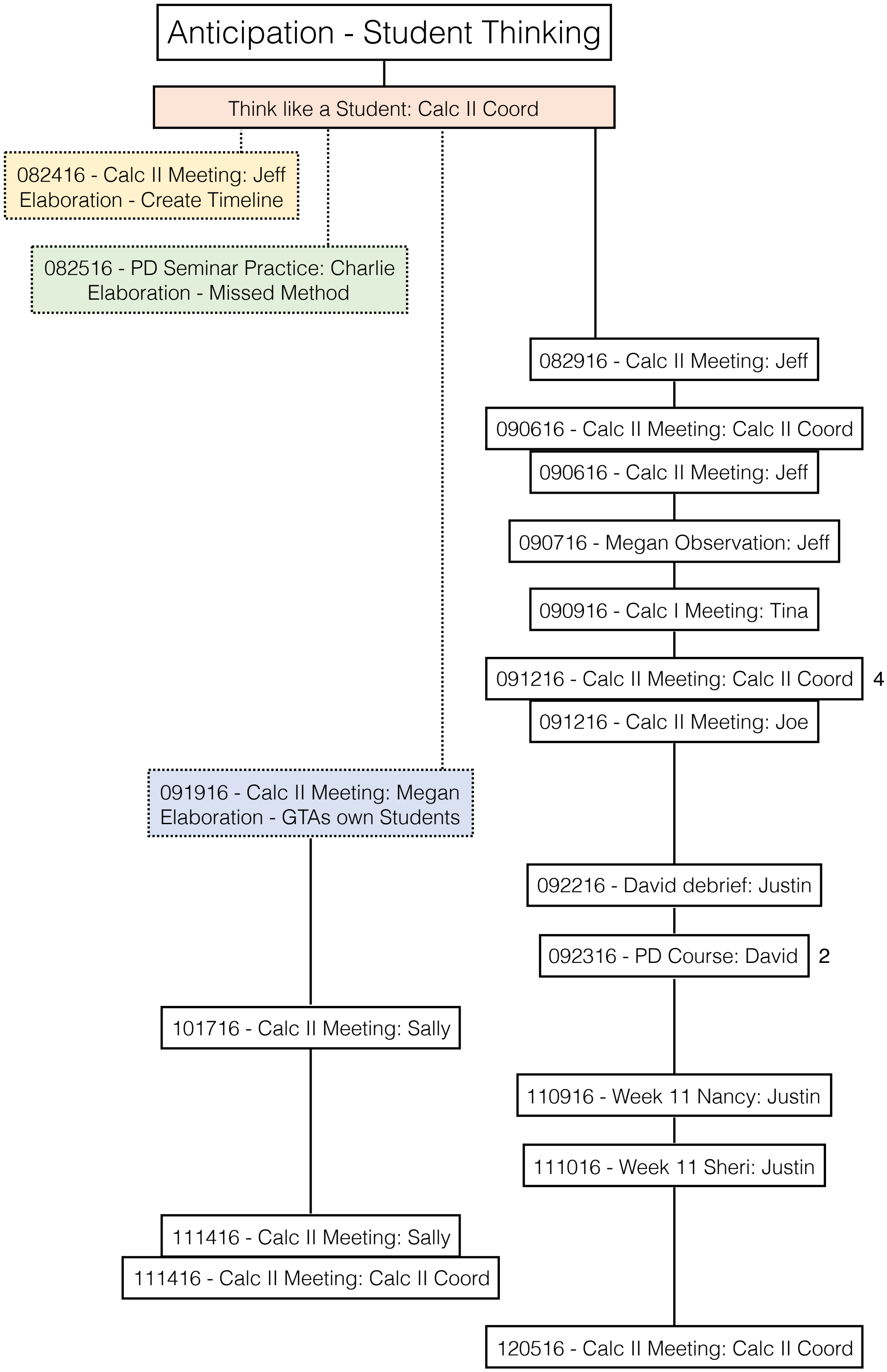

Anticipation - Student Questions
Questions about Layout: Charlie
082516 - PD Seminar Practice: Calc II Coord
082516 - PD Seminar Practice: Dr. D
082916 - Calc II Meeting: Jeff
091216 - Calc II Meeting: Calc II Coord
102416 - Calc II Meeting: Calc II Coord
Elaboration - Careful with Layout

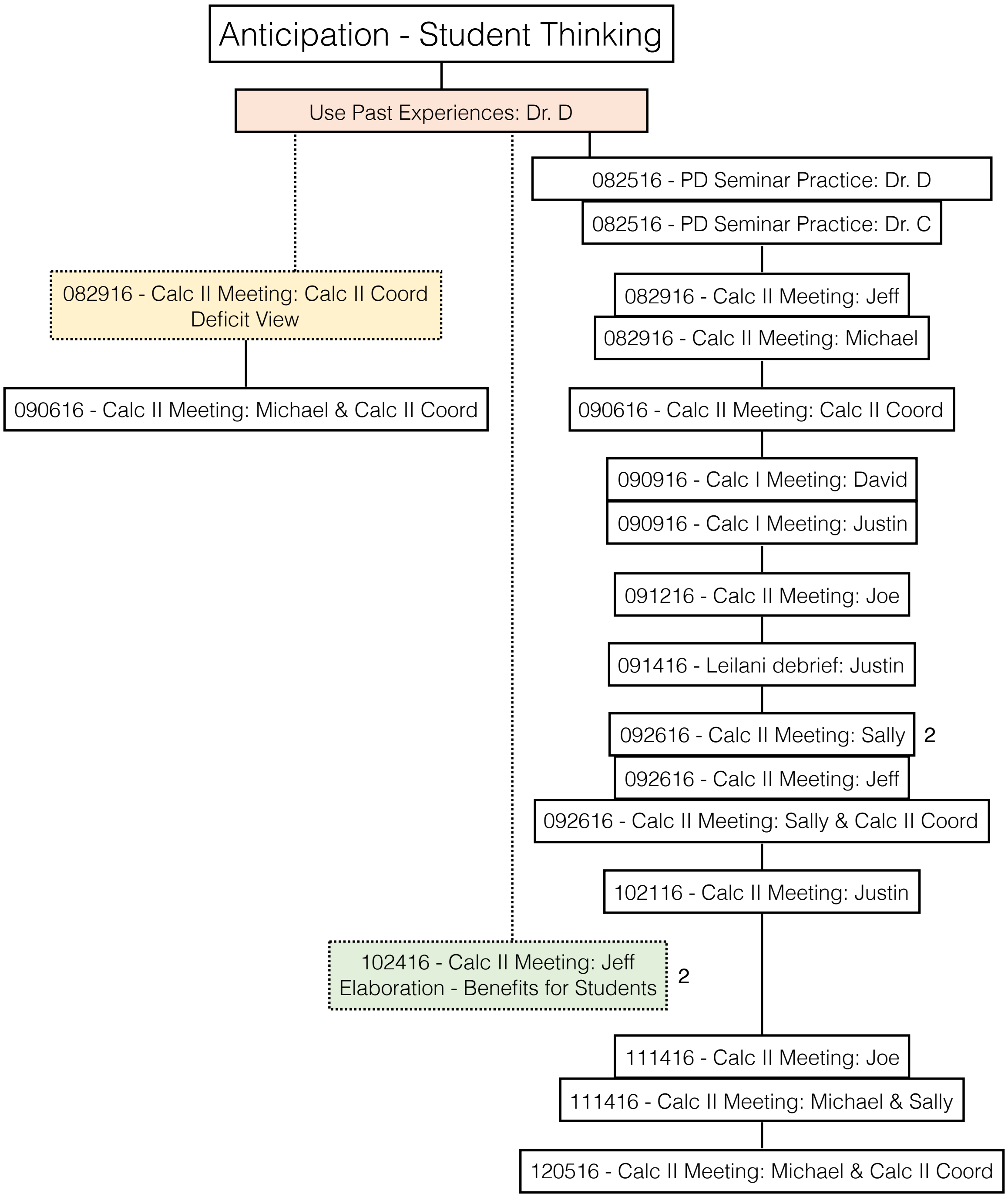

Anticipation - Student Questions
Anticipate to Avoid Confusion: Calc II Coord
2
091416 - Leilani debrief: Leilani
Elaboration - Recent Experience
092316 - Calc I Meeting: Justin
101416 - PD Course: Visitor
Think like a Student
082916 - Calc II Meeting: Jeff
091916 - Calc II Meeting: Calc II Coord
2
093016 - PD Course: Megan
101916 - Megan debrief: Jeff
111416 - Calc II Meeting: Megan
111416 - Calc II Meeting: Megan & Calc II Coord

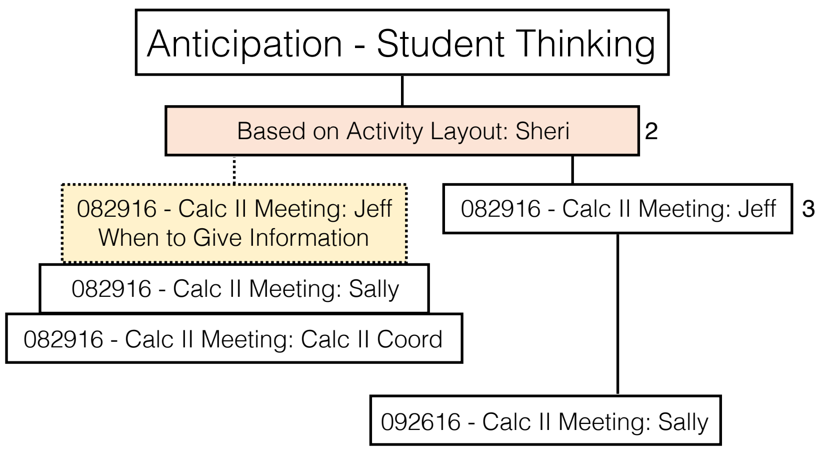


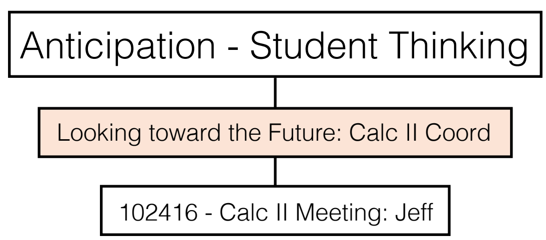
Anticipation - Student Questions
Previous Experience: David
090616 - Calc II Meeting: Megan
090616 - Calc II Meeting: Michael
090916 - Calc I Meeting: David
Elaboration - Other Sections
2
090916 - Calc I Meeting: Justin
092316 - PD Course: David
092316 - PD Course: David
Elaboration - Need more Experience
092616 - Calc II Meeting: Jack
101416 - PD Course: Justin

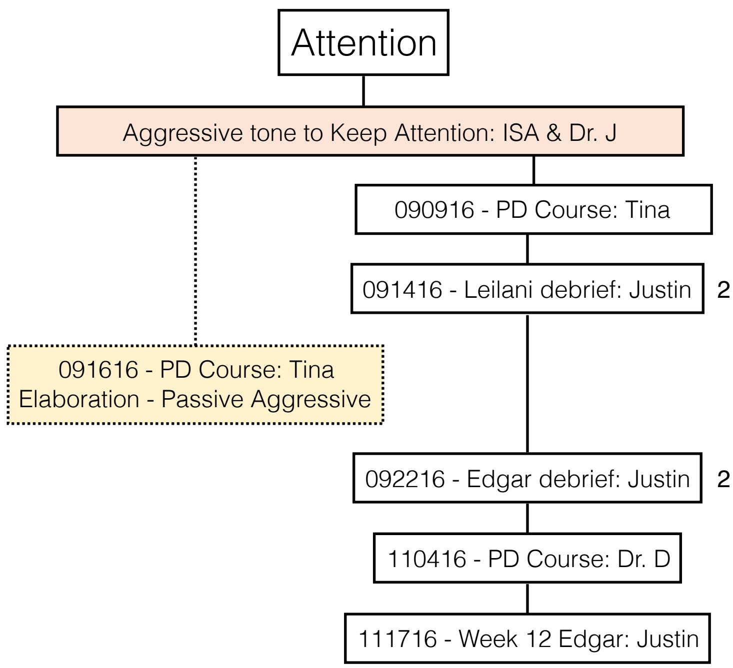

Anticipation - Student Questions
Awareness of Possible Issues: Jeff
090216 - Calc I Meeting: Justin
090616 - Calc II Meeting - Jeff
091216 - Calc II Meeting: Jeff
Elaboration - Time Considerations
091216 - Calc II Meeting: Calc II Coord
2
091216 - Calc II Meeting: Calc II Coord
2
091616 - Calc I Meeting: Dr. D
091916 - Calc II Meeting: Sally
Surface Level
091916 - Calc II Meeting: Calc II Coord
2
091916 - Calc II Meeting: Calc II Coord
092216 - David debrief: Justin
Elaboration - Student View
092216 - David debrief: David
2
092616 - Calc II Meeting: Megan
092616 - Calc II Meeting: Jack
100316 - Calc II Meeting: Sally
101016 - Calc II Meeting: Megan & John
101416 - PD Course: Visitor
101716 - Calc II Meeting: Jeff
Deficit View
101716 - Calc II Meeting: Calc II Coord
101716 - Calc II Meeting: Sally
110716 - Calc II Meeting: Calc II Coord & Jeff
110916 - Week 11 Nancy: Justin
120516 - Calc II Meeting: Calc II Coord

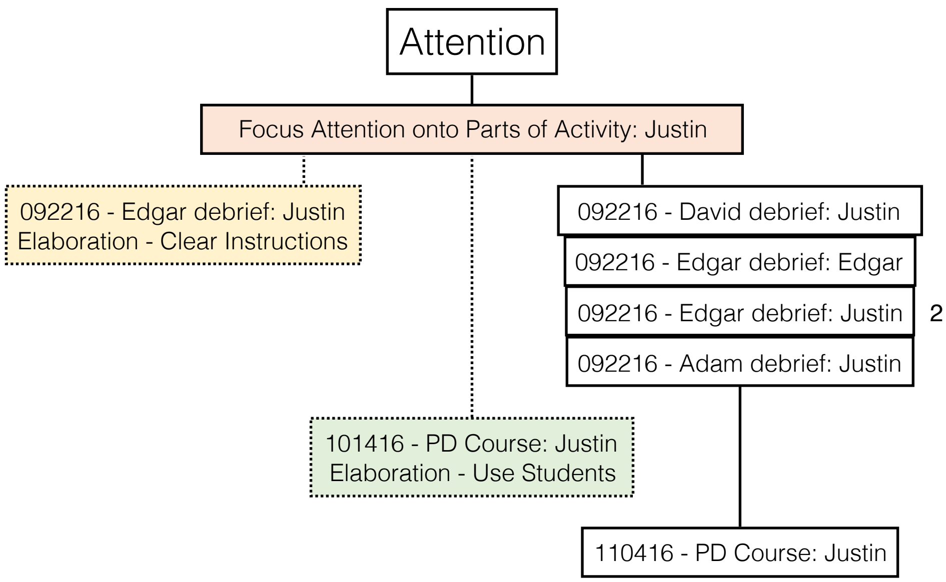

Anticipation - Student Thinking
Think like a Student: Calc II Coord
082416 - Calc II Meeting: Jeff
Elaboration - Create Timeline
082516 - PD Seminar Practice: Charlie
Elaboration - Missed Method
082916 - Calc II Meeting: Jeff
090616 - Calc II Meeting: Calc II Coord
090616 - Calc II Meeting: Jeff
090716 - Megan Observation: Jeff
090916 - Calc I Meeting: Tina
091216 - Calc II Meeting: Calc II Coord
4
091216 - Calc II Meeting: Joe
091916 - Calc II Meeting: Megan
Elaboration - GTAs own Students
092216 - David debrief: Justin
092316 - PD Course: David
2
101716 - Calc II Meeting: Sally
110916 - Week 11 Nancy: Justin
111016 - Week 11 Sheri: Justin
111416 - Calc II Meeting: Sally
111416 - Calc II Meeting: Calc II Coord
120516 - Calc II Meeting: Calc II Coord

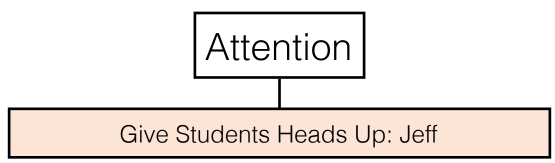

Anticipation - Student Thinking
Use Past Experiences: Dr. D
082516 - PD Seminar Practice: Dr. D
082516 - PD Seminar Practice: Dr. C
082916 - Calc II Meeting: Calc II Coord
Deficit View
082916 - Calc II Meeting: Jeff
082916 - Calc II Meeting: Michael
090616 - Calc II Meeting: Michael & Calc II Coord
090616 - Calc II Meeting: Calc II Coord
090916 - Calc I Meeting: David
090916 - Calc I Meeting: Justin
091216 - Calc II Meeting: Joe
091416 - Leilani debrief: Justin
092616 - Calc II Meeting: Sally
2
092616 - Calc II Meeting: Jeff
092616 - Calc II Meeting: Sally & Calc II Coord
102116 - Calc II Meeting: Justin
102416 - Calc II Meeting: Jeff
Elaboration - Benefits for Students
2
111416 - Calc II Meeting: Joe
111416 - Calc II Meeting: Michael & Sally
120516 - Calc II Meeting: Michael & Calc II Coord

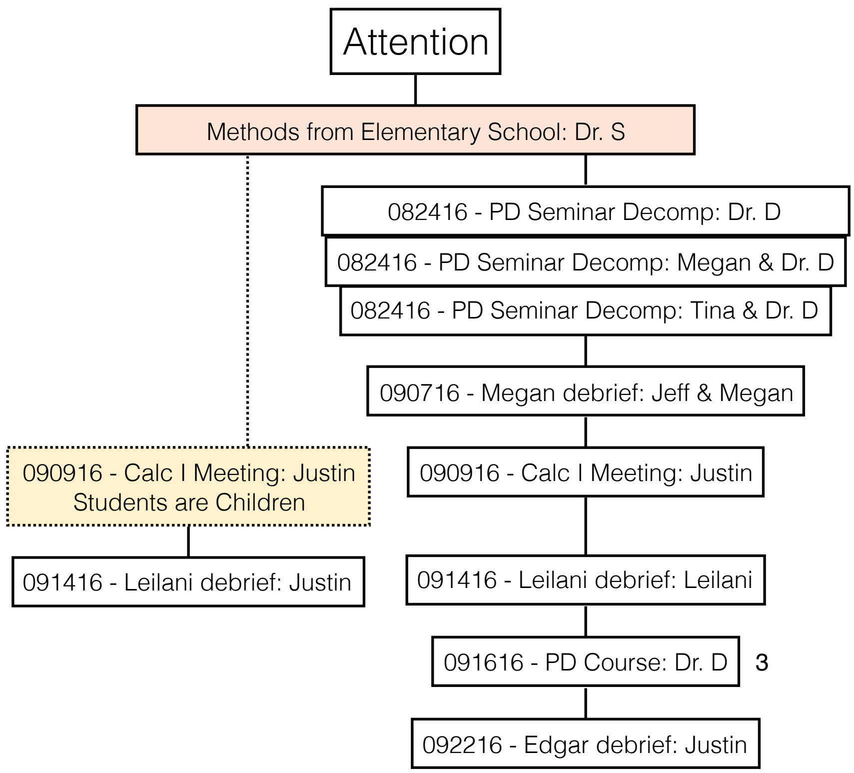

Anticipation - Student Thinking
Based on Activity Layout: Sheri
2
082916 - Calc II Meeting: Jeff
When to Give Information
082916 - Calc II Meeting: Jeff
3
082916 - Calc II Meeting: Sally
082916 - Calc II Meeting: Calc II Coord
092616 - Calc II Meeting: Sally

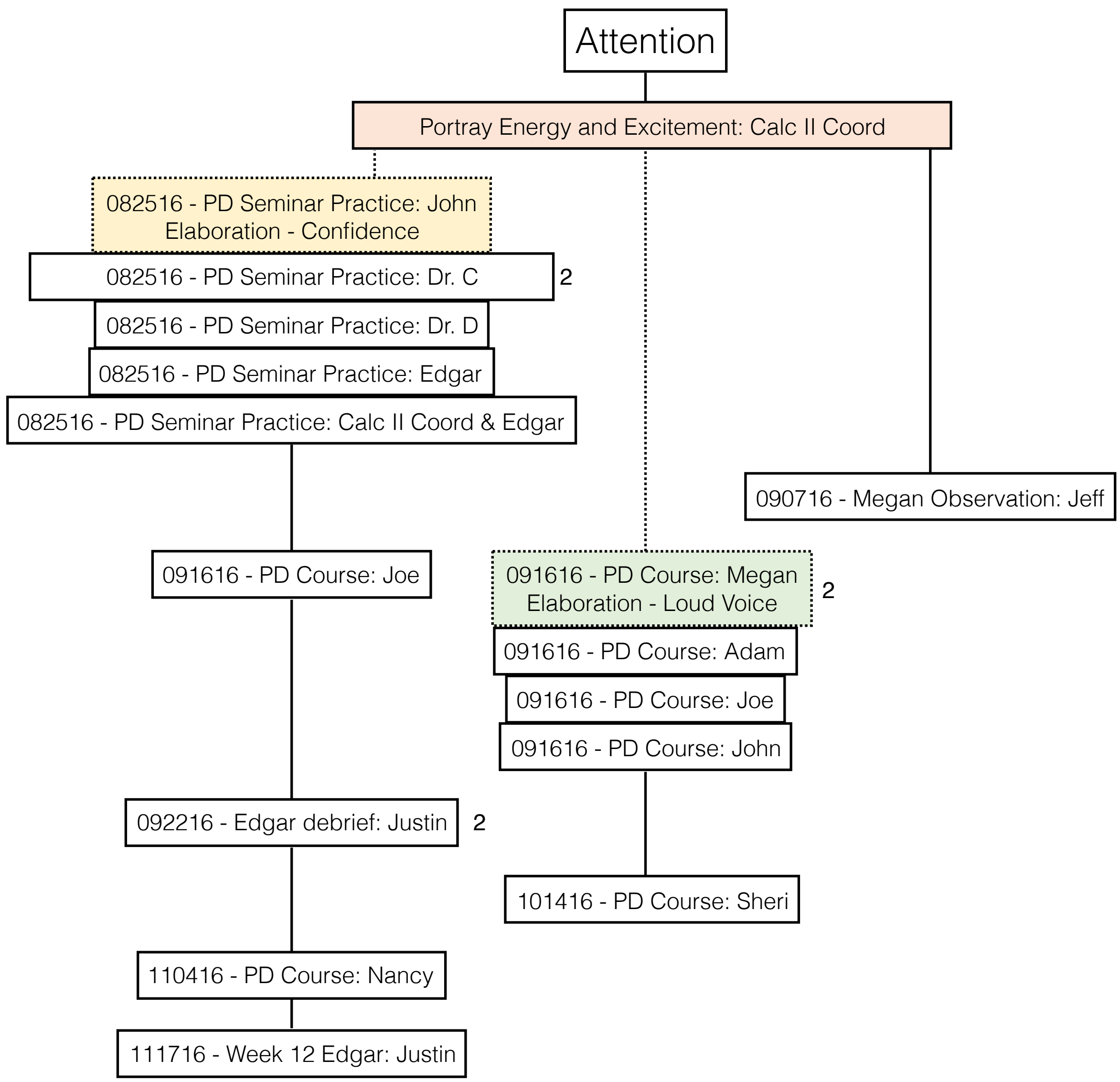

Anticipation - Student Thinking
Looking toward the Future: Calc II Coord
102416 - Calc II Meeting: Jeff

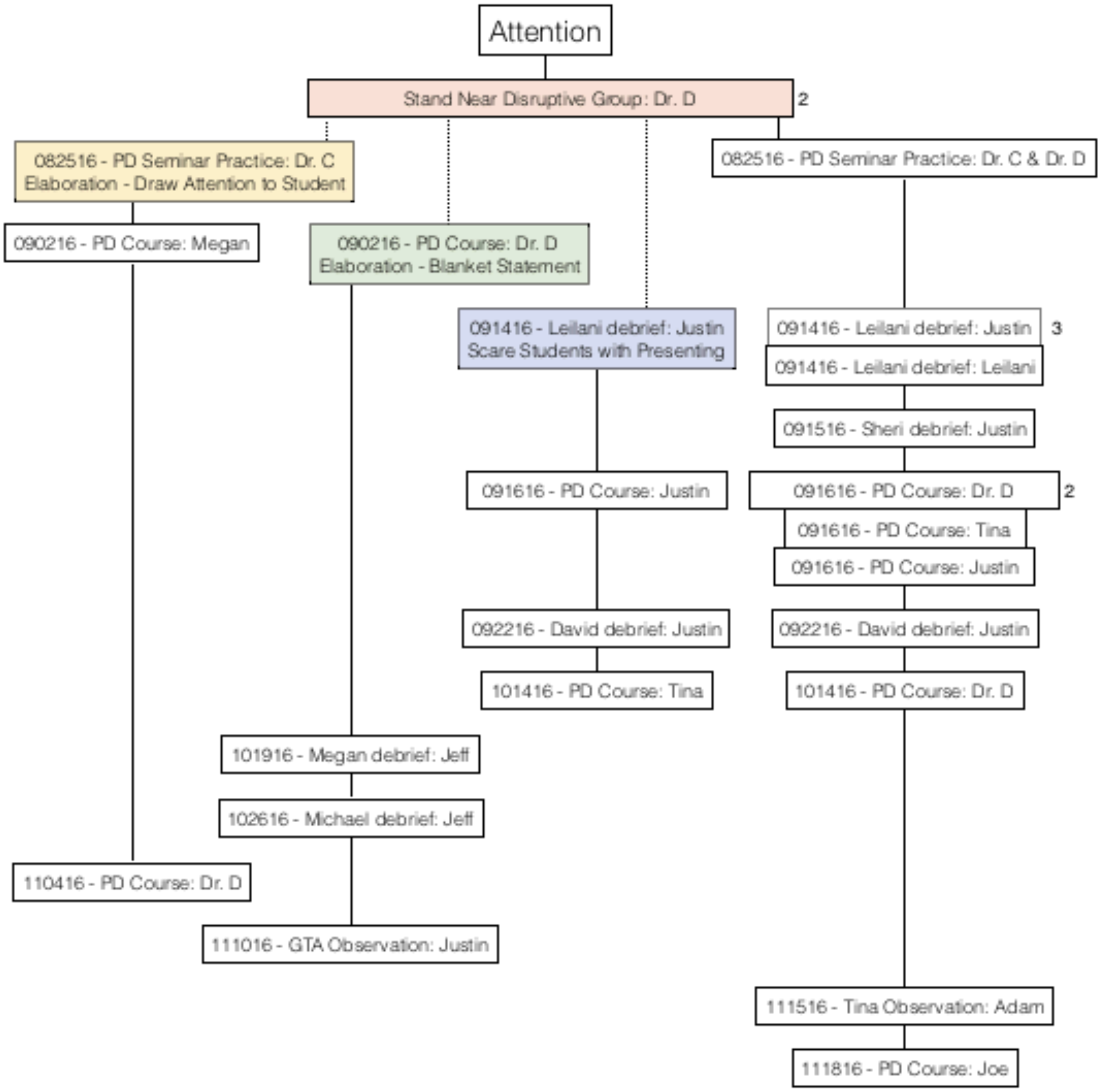

Attention
Aggressive tone to Keep Attention: ISA & Dr. J
090916 - PD Course: Tina
091416 - Leilani debrief: Justin
2
091616 - PD Course: Tina
Elaboration - Passive Aggressive
092216 - Edgar debrief: Justin
2
110416 - PD Course: Dr. D
111716 - Week 12 Edgar: Justin

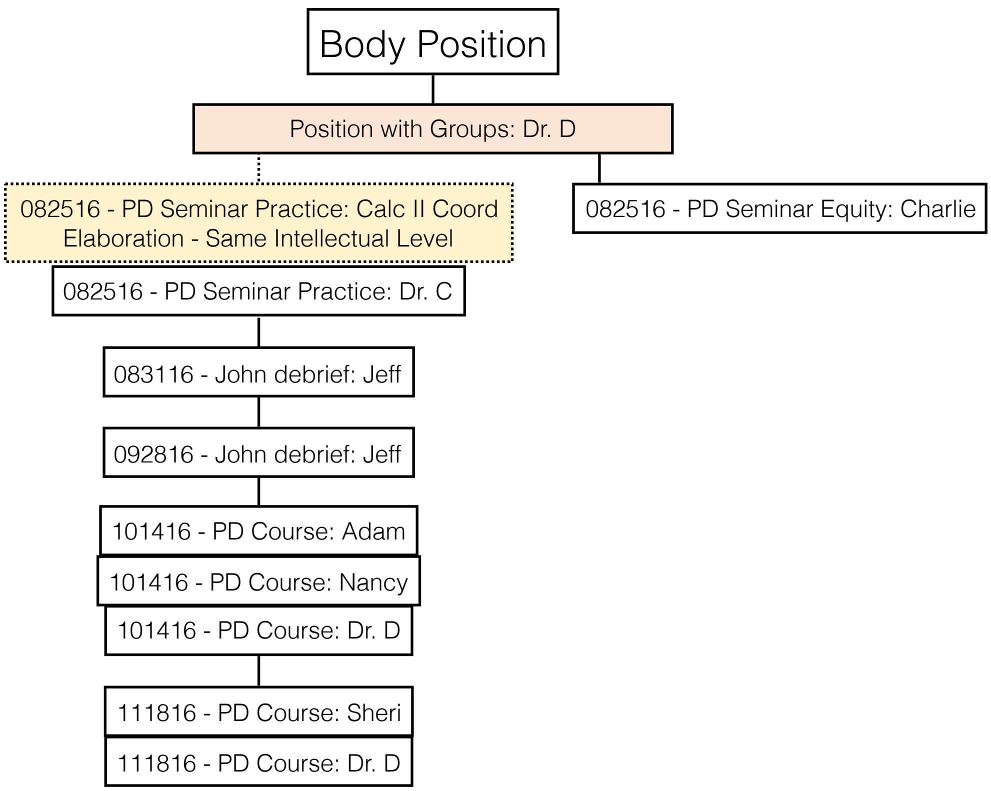

Attention
Focus Attention onto Parts of Activity: Justin
092216 - Edgar debrief: Justin
Elaboration - Clear Instructions
092216 - David debrief: Justin
092216 - Edgar debrief: Edgar
092216 - Edgar debrief: Justin
2
092216 - Adam debrief: Justin
101416 - PD Course: Justin
Elaboration - Use Students
110416 - PD Course: Justin

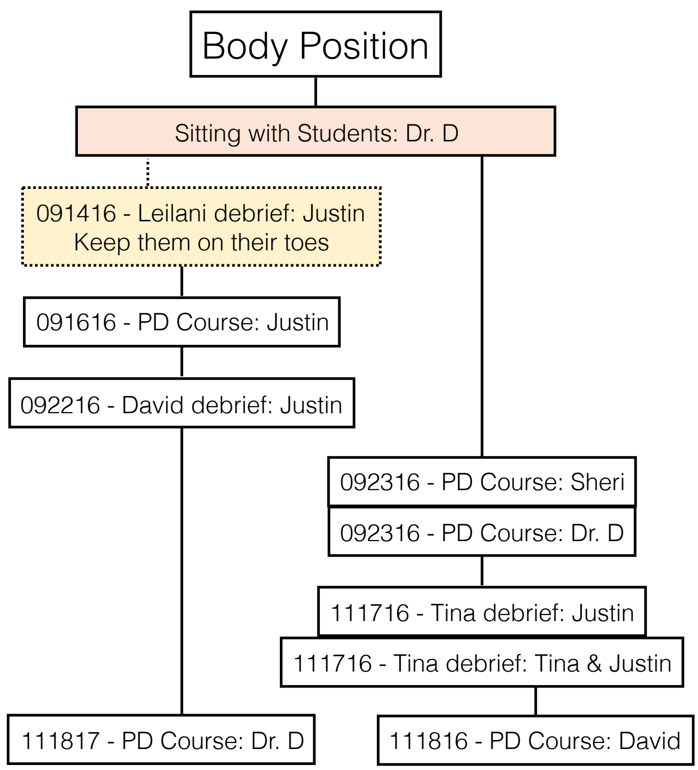

Attention
Give Students Heads Up: Jeff

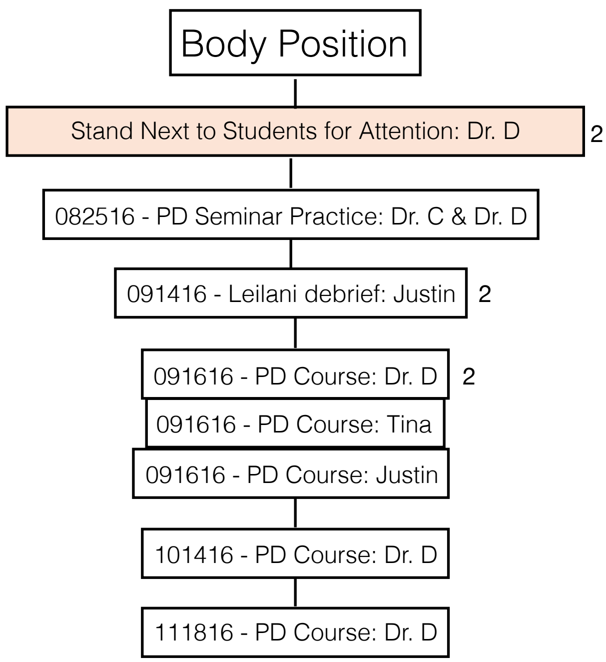

Attention
Methods from Elementary School: Dr. S
082416 - PD Seminar Decomp: Dr. D
082416 - PD Seminar Decomp: Megan & Dr. D
082416 - PD Seminar Decomp: Tina & Dr. D
090716 - Megan debrief: Jeff & Megan
090916 - Calc I Meeting: Justin
Students are Children
090916 - Calc I Meeting: Justin
091416 - Leilani debrief: Justin
091416 - Leilani debrief: Leilani
091616 - PD Course: Dr. D
3
092216 - Edgar debrief: Justin

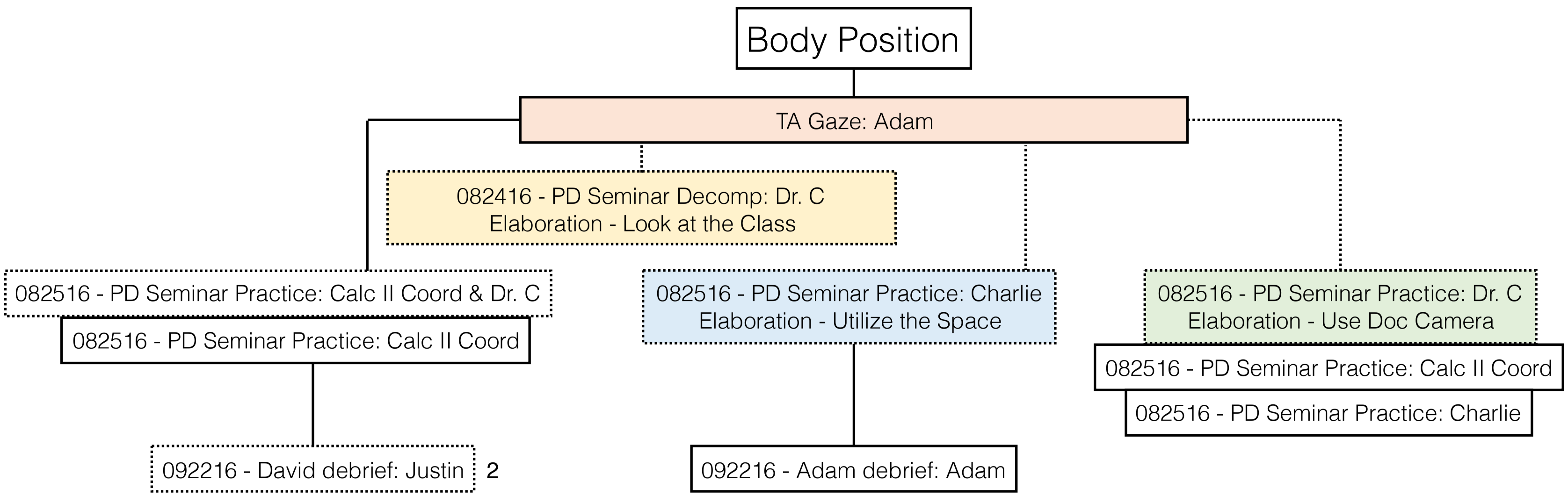

Attention
Portray Energy and Excitement: Calc II Coord
082516 - PD Seminar Practice: John
Elaboration - Confidence
082516 - PD Seminar Practice: Dr. C
2
082516 - PD Seminar Practice: Dr. D
082516 - PD Seminar Practice: Edgar
082516 - PD Seminar Practice: Calc II Coord & Edgar
090716 - Megan Observation: Jeff
091616 - PD Course: Joe
091616 - PD Course: Megan
Elaboration - Loud Voice
2
091616 - PD Course: Adam
091616 - PD Course: Joe
091616 - PD Course: John
092216 - Edgar debrief: Justin
2
101416 - PD Course: Sheri
110416 - PD Course: Nancy
111716 - Week 12 Edgar: Justin

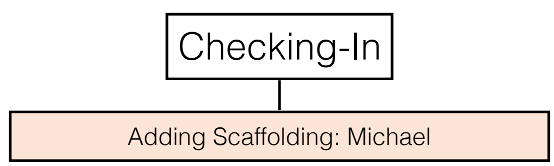

Attention
Stand Near Disruptive Group: Dr. D
2
082516 - PD Seminar Practice: Dr. C
Elaboration - Draw Attention to Student
082516 - PD Seminar Practice: Dr. C & Dr. D
090216 - PD Course: Megan
090216 - PD Course: Dr. D
Elaboration - Blanket Statement
091416 - Leilani debrief: Justin
Scare Students with Presenting
091416 - Leilani debrief: Justin
3
091416 - Leilani debrief: Leilani
091516 - Sheri debrief: Justin
091616 - PD Course: Justin
091616 - PD Course: Dr. D
2
091616 - PD Course: Tina
091616 - PD Course: Justin
092216 - David debrief: Justin
092216 - David debrief: Justin
101416 - PD Course: Tina
101416 - PD Course: Dr. D
101916 - Megan debrief: Jeff
102616 - Michael debrief: Jeff
110416 - PD Course: Dr. D
111016 - GTA Observation: Justin
111516 - Tina Observation: Adam
111816 - PD Course: Joe

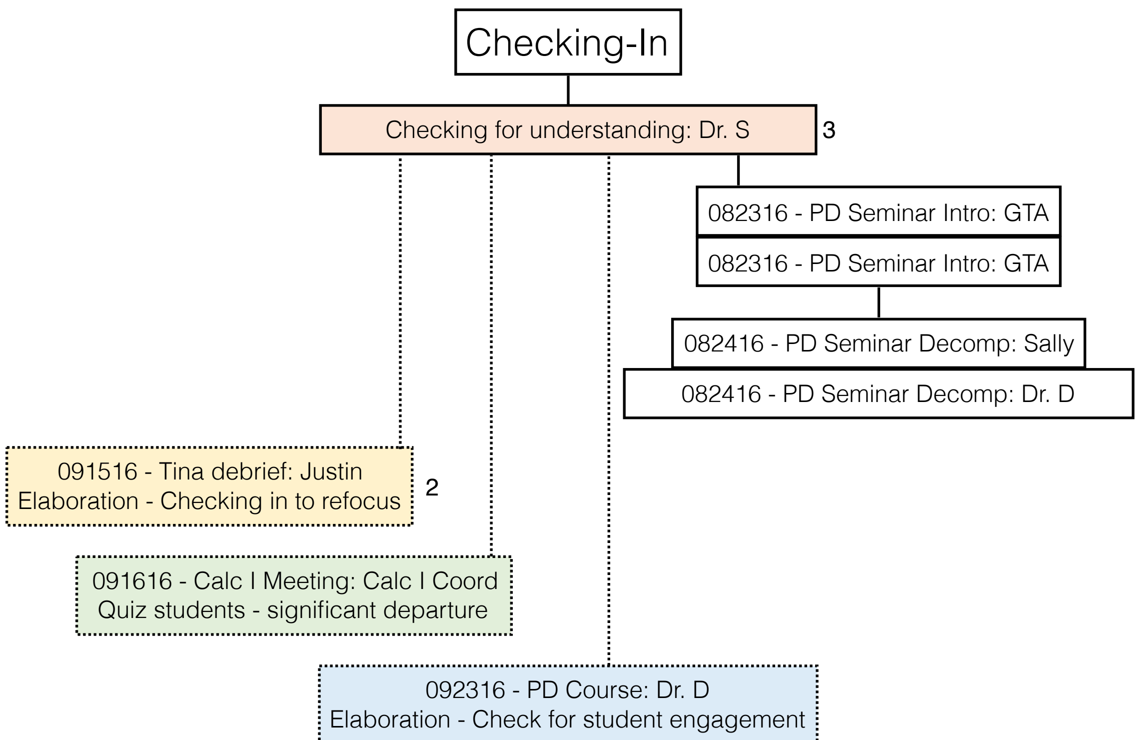

Body Position
Position with Groups: Dr. D
082516 - PD Seminar Practice: Calc II Coord Elaboration - Same Intellectual Level
082516 - PD Seminar Equity: Charlie
082516 - PD Seminar Practice: Dr. C
083116 - John debrief: Jeff
092816 - John debrief: Jeff
101416 - PD Course: Adam
101416 - PD Course: Nancy
101416 - PD Course: Dr. D
111816 - PD Course: Sheri
111816 - PD Course: Dr. D

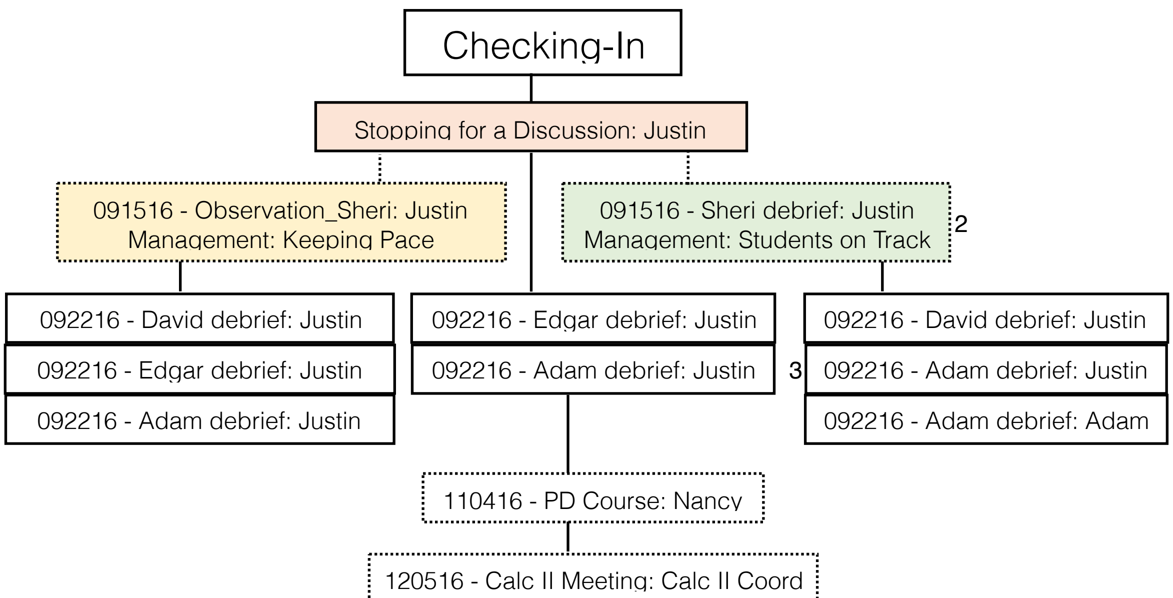

Body Position
Sitting with Students: Dr. D
091416 - Leilani debrief: Justin
Keep them on their toes
091616 - PD Course: Justin
092216 - David debrief: Justin
092316 - PD Course: Sheri
092316 - PD Course: Dr. D
111716 - Tina debrief: Justin
111716 - Tina debrief: Tina & Justin
111817 - PD Course: Dr. D
111816 - PD Course: David

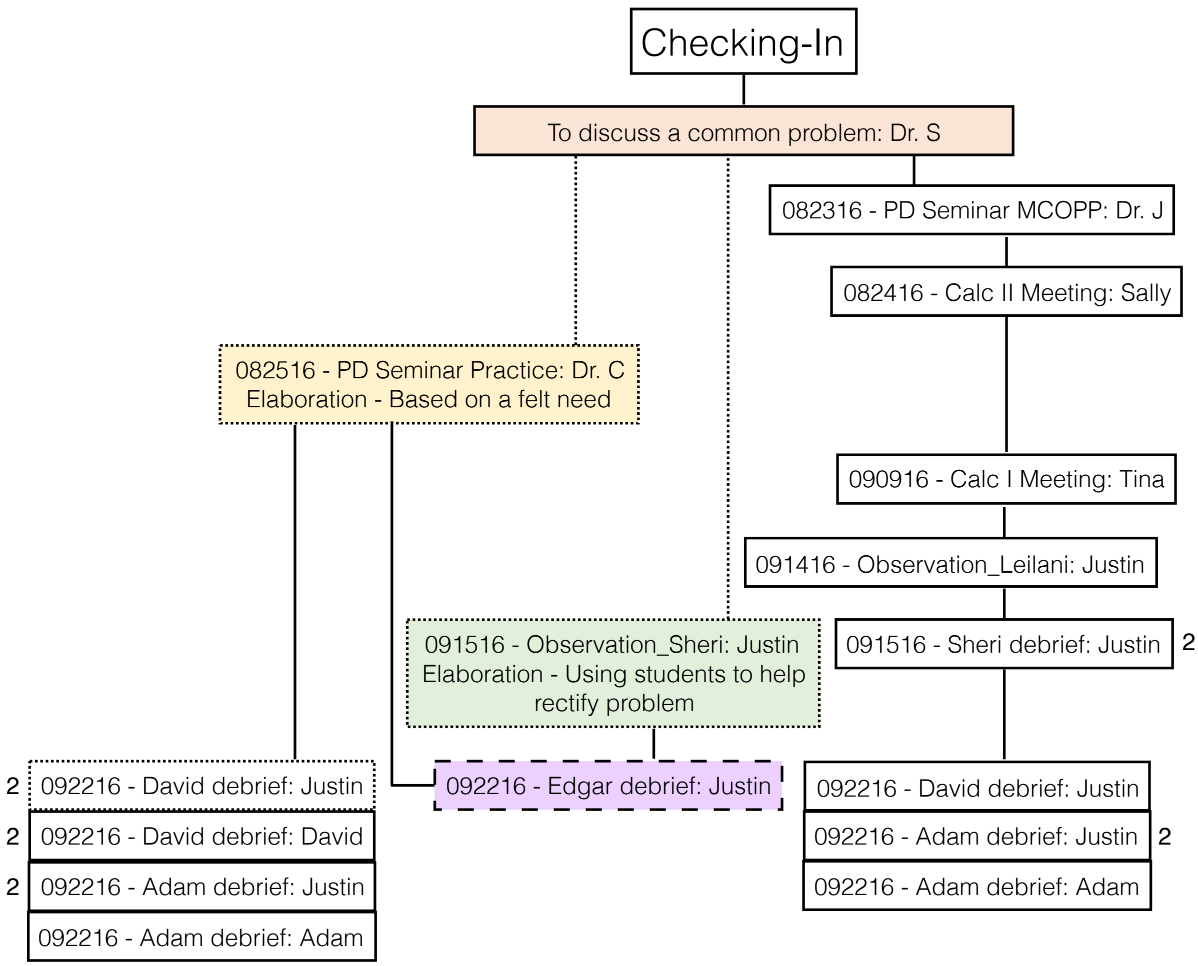

Body Position
Stand Next to Students for Attention: Dr. D
2
082516 - PD Seminar Practice: Dr. C & Dr. D
091416 - Leilani debrief: Justin
2
091616 - PD Course: Dr. D
2
091616 - PD Course: Tina
091616 - PD Course: Justin
101416 - PD Course: Dr. D
111816 - PD Course: Dr. D

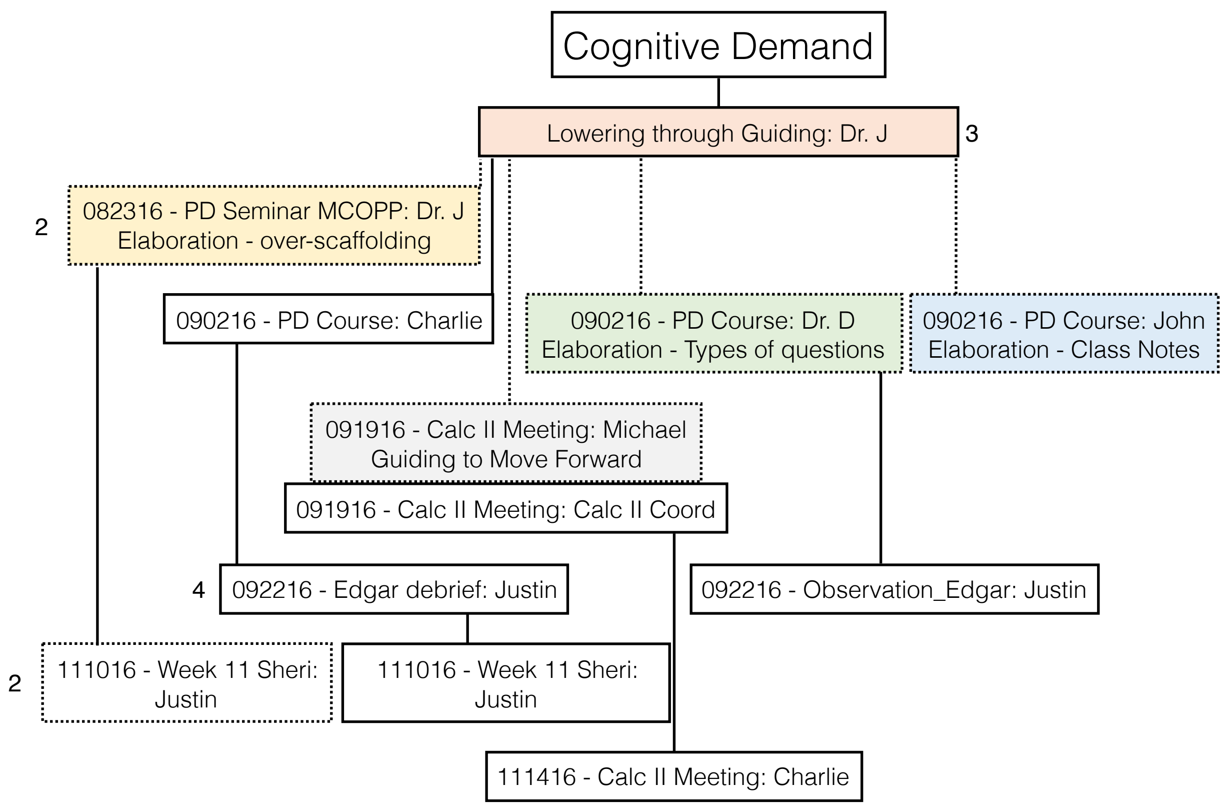

Body Position
TA Gaze: Adam
082416 - PD Seminar Decomp: Dr. C
Elaboration - Look at the Class
082516 - PD Seminar Practice: Calc II Coord & Dr. C
082516 - PD Seminar Practice: Calc II Coord
092216 - David debrief: Justin
2
082516 - PD Seminar Practice: Charlie
Elaboration - Utilize the Space
092216 - Adam debrief: Adam
082516 - PD Seminar Practice: Dr. C
Elaboration - Use Doc Camera
082516 - PD Seminar Practice: Calc II Coord
082516 - PD Seminar Practice: Charlie

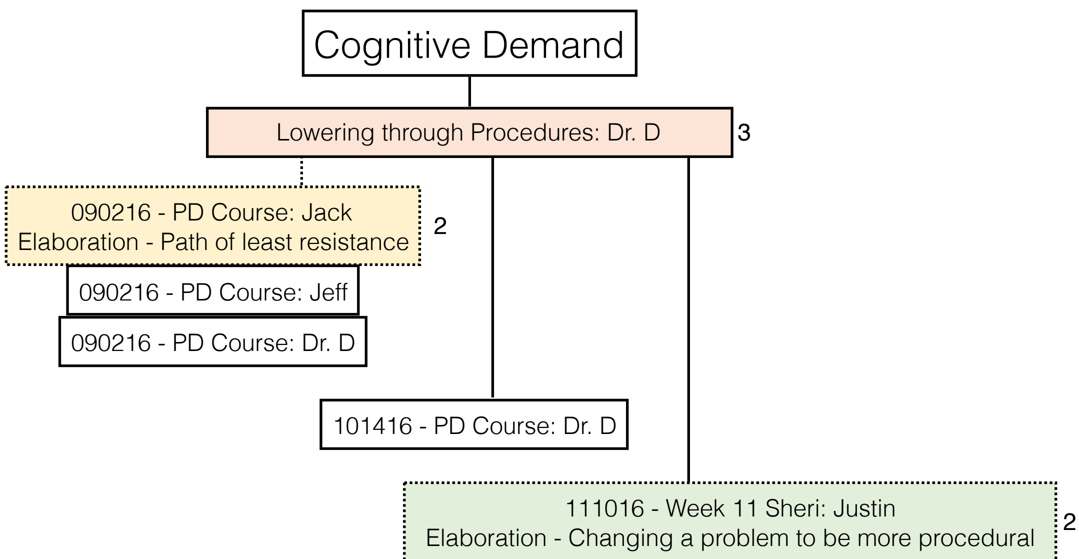

Checking-In
Adding Scaffolding: Michael

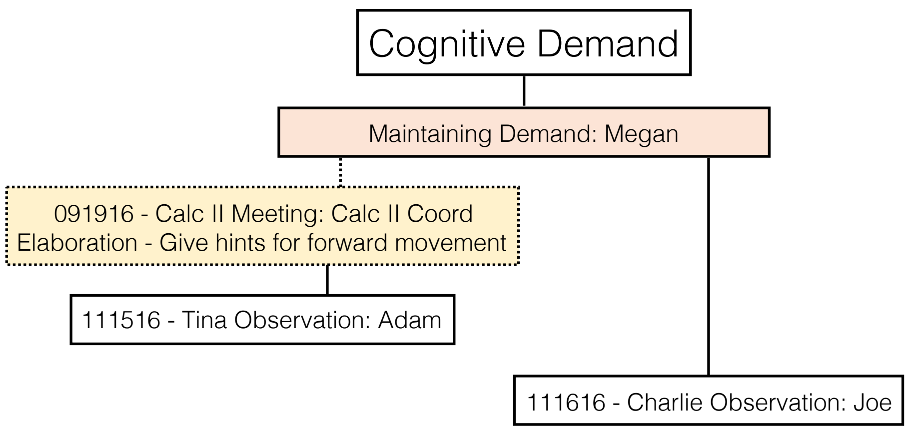

Checking-In
Checking for understanding: Dr. S
3
082316 - PD Seminar Intro: GTA
082316 - PD Seminar Intro: GTA
082416 - PD Seminar Decomp: Sally
082416 - PD Seminar Decomp: Dr. D
091516 - Tina debrief: Justin
Elaboration - Checking in to refocus
2
091616 - Calc I Meeting: Calc I Coord
Quiz students - significant departure
092316 - PD Course: Dr. D
Elaboration - Check for student engagement


Checking-In
Stopping for a Discussion: Justin
091516 - Observation_Sheri: Justin
Management: Keeping Pace
091516 - Sheri debrief: Justin
Management: Students on Track
2
092216 - David debrief: Justin
092216 - Edgar debrief: Justin
092216 - Adam debrief: Justin
092216 - Edgar debrief: Justin
092216 - Adam debrief: Justin
3
092216 - David debrief: Justin
092216 - Adam debrief: Justin
092216 - Adam debrief: Adam
110416 - PD Course: Nancy
120516 - Calc II Meeting: Calc II Coord

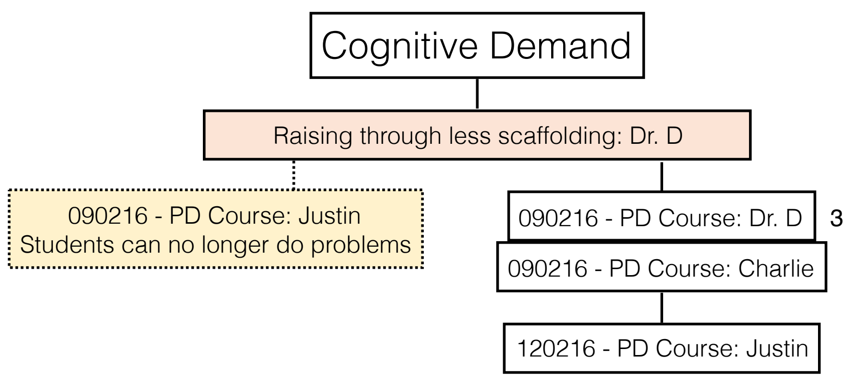

Checking-In
To discuss a common problem: Dr. S
082316 - PD Seminar MCOPP: Dr. J
082416 - Calc II Meeting: Sally
082516 - PD Seminar Practice: Dr. C
Elaboration - Based on a felt need
090916 - Calc I Meeting: Tina
091416 - Observation_Leilani: Justin
091516 - Observation_Sheri: Justin
Elaboration - Using students to help rectify problem
091516 - Sheri debrief: Justin
2
2
092216 - David debrief: Justin
2
092216 - David debrief: David
2
092216 - Adam debrief: Justin
092216 - Adam debrief: Adam
092216 - Edgar debrief: Justin
092216 - David debrief: Justin
092216 - Adam debrief: Justin
2
092216 - Adam debrief: Adam

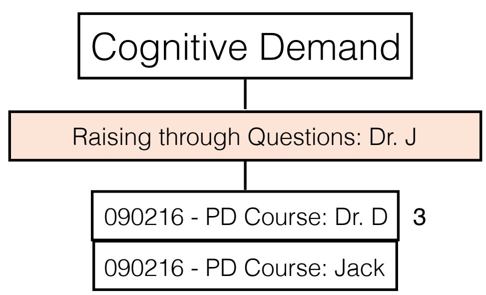

Cognitive Demand
Lowering through Guiding: Dr. J
3
2
082316 - PD Seminar MCOPP: Dr. J
Elaboration - over-scaffolding
090216 - PD Course: Charlie
090216 - PD Course: Dr. D
Elaboration - Types of questions
090216 - PD Course: John
Elaboration - Class Notes
091916 - Calc II Meeting: Michael
Guiding to Move Forward
091916 - Calc II Meeting: Calc II Coord
4
092216 - Edgar debrief: Justin
092216 - Observation_Edgar: Justin
2
111016 - Week 11 Sheri: Justin
111016 - Week 11 Sheri: Justin
111416 - Calc II Meeting: Charlie


Cognitive Demand
Lowering through Procedures: Dr. D
3
090216 - PD Course: Jack
Elaboration - Path of least resistance
2
090216 - PD Course: Jeff
090216 - PD Course: Dr. D
101416 - PD Course: Dr. D
111016 - Week 11 Sheri: Justin
Elaboration - Changing a problem to be more procedural
2



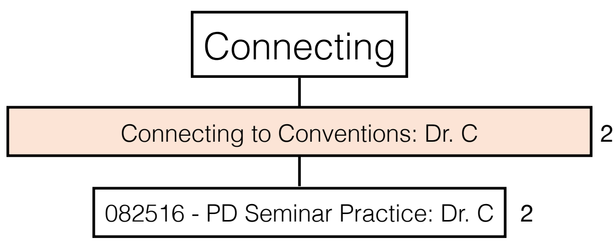
Cognitive Demand
Maintaining Demand: Megan
091916 - Calc II Meeting: Calc II Coord
Elaboration - Give hints for forward movement
111516 - Tina Observation: Adam
111616 - Charlie Observation: Joe

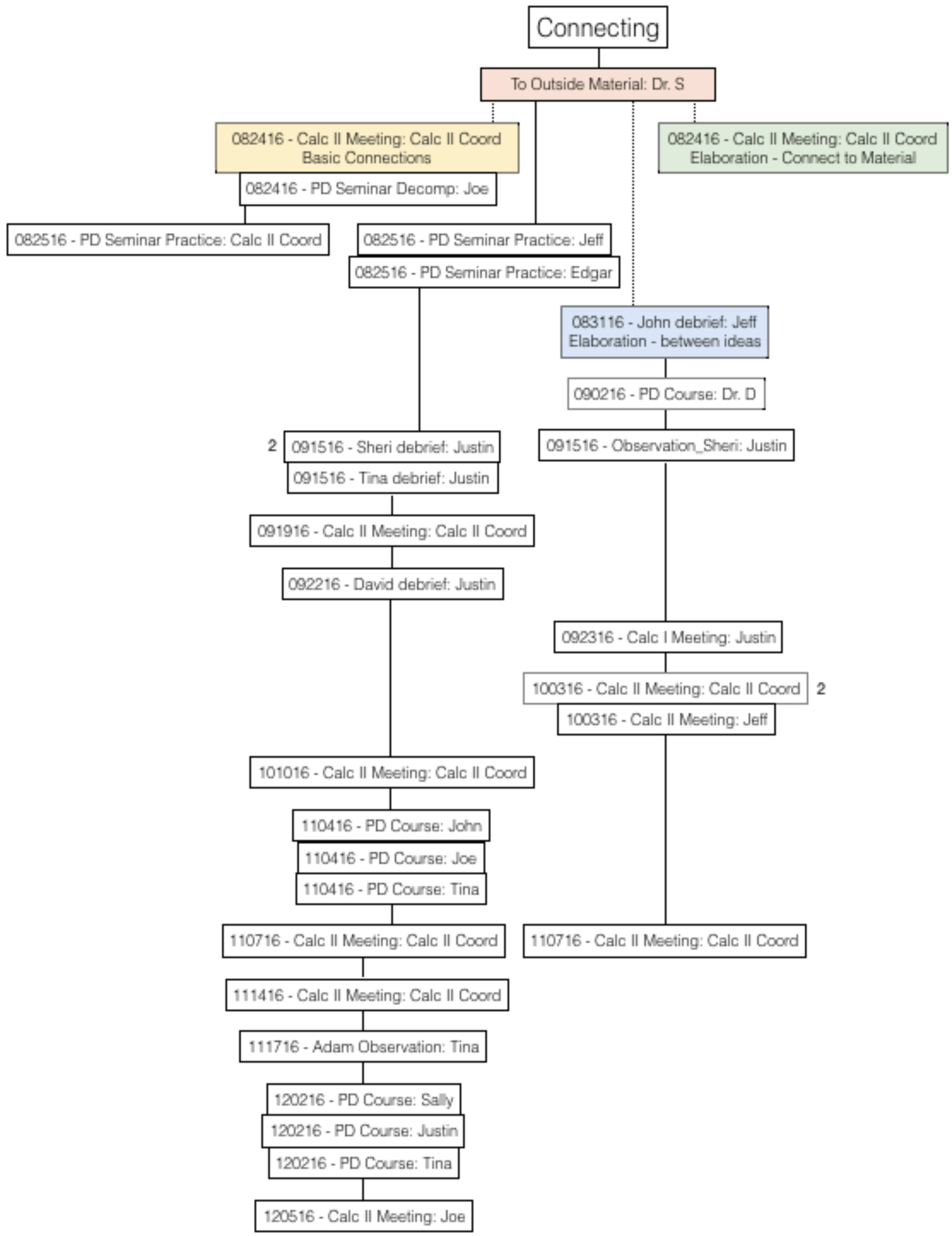

Cognitive Demand
Raising through less scaffolding: Dr. D
090216 - PD Course: Justin
Students can no longer do problems
090216 - PD Course: Dr. D
3
090216 - PD Course: Charlie
120216 - PD Course: Justin

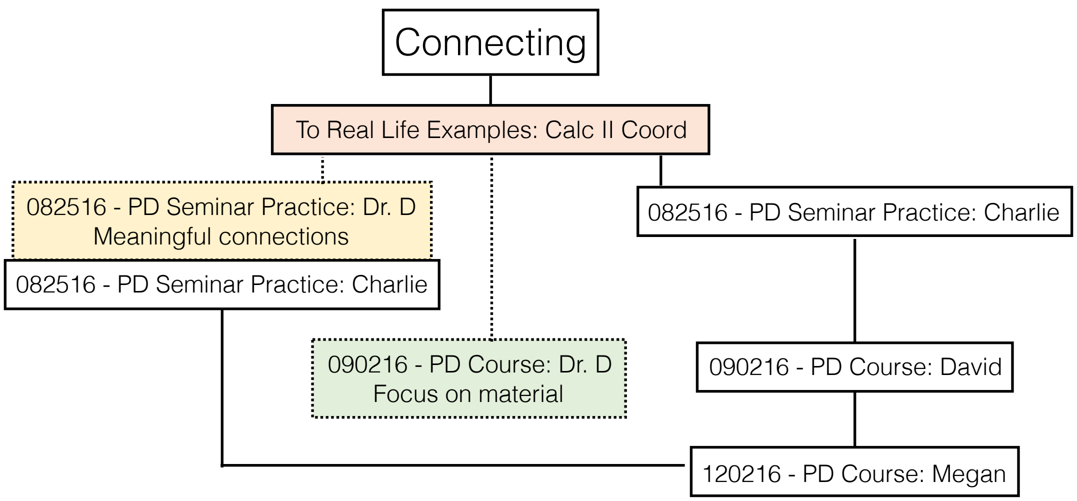

Cognitive Demand
Raising through Questions: Dr. J
090216 - PD Course: Dr. D
3
090216 - PD Course: Jack

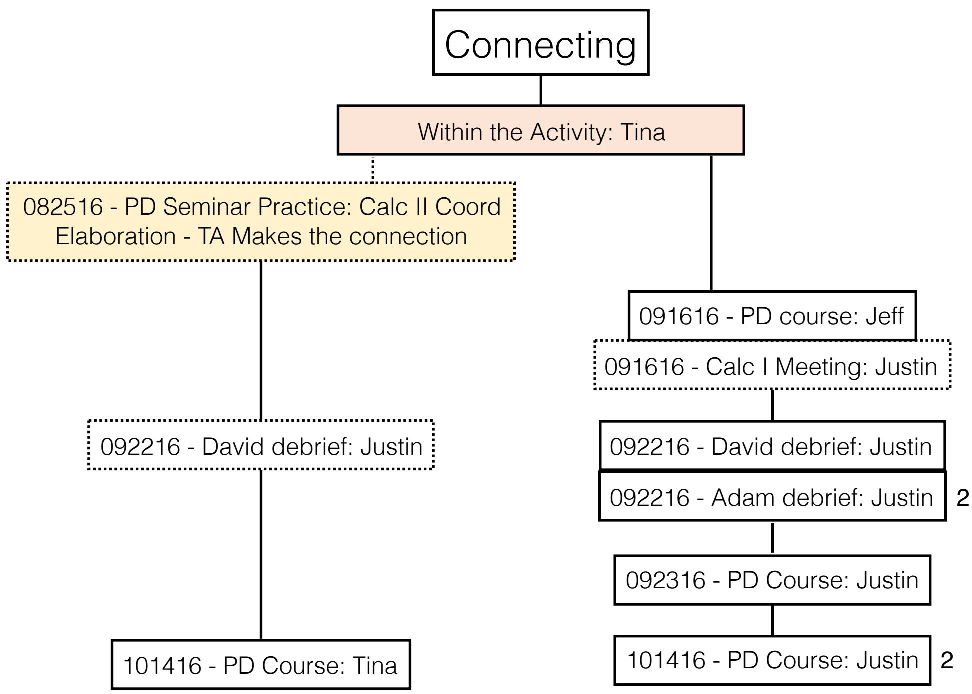
Connecting

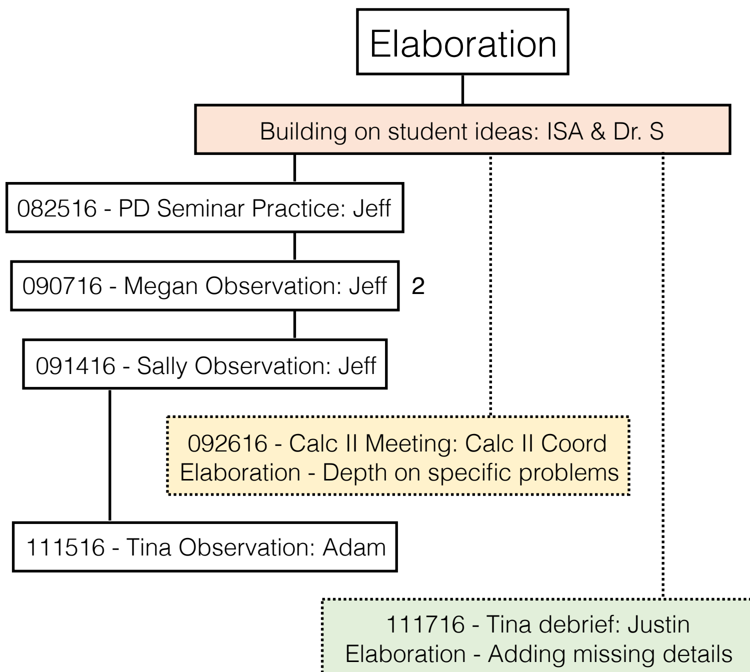
Connecting Across Students: Dr. D

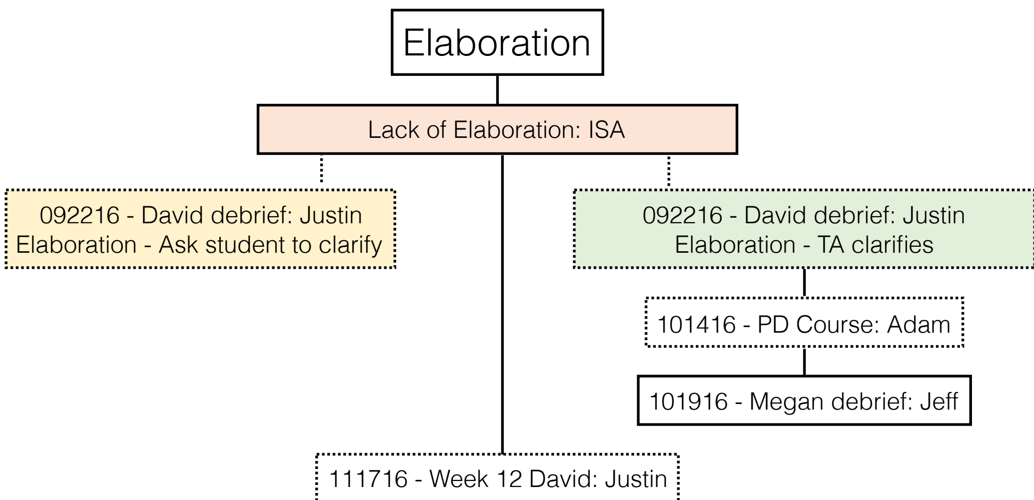

Connecting
Connecting to Conventions: Dr. C
2
082516 - PD Seminar Practice: Dr. C
2

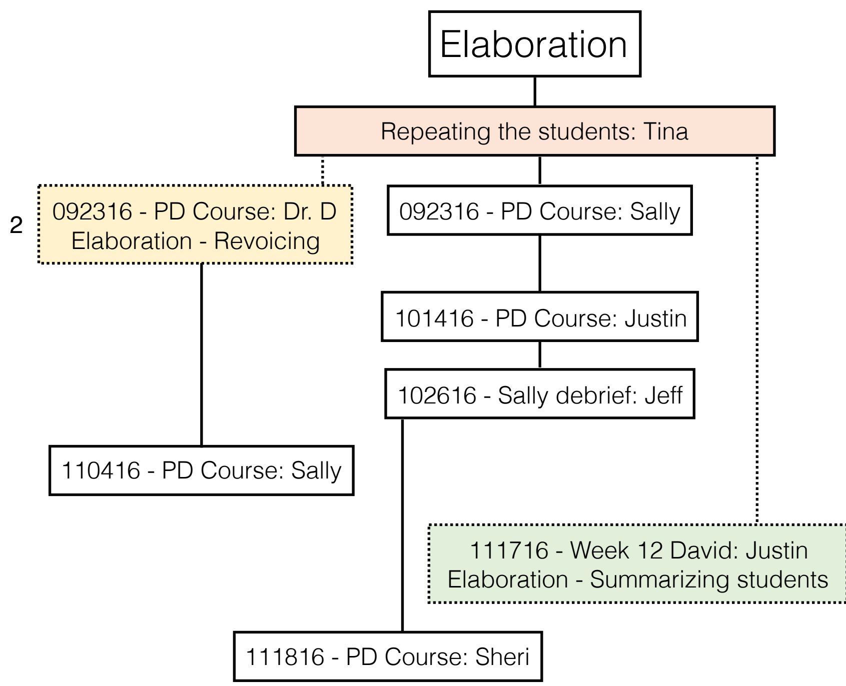

Connecting
To Outside Material: Dr. S
082416 - Calc II Meeting: Calc II Coord
Basic Connections
082416 - Calc II Meeting: Calc II Coord
Elaboration - Connect to Material
082416 - PD Seminar Decomp: Joe
082516 - PD Seminar Practice: Calc II Coord
082516 - PD Seminar Practice: Jeff
082516 - PD Seminar Practice: Edgar
083116 - John debrief: Jeff
Elaboration - between ideas
090216 - PD Course: Dr. D
2
091516 - Sheri debrief: Justin
091516 - Tina debrief: Justin
091516 - Observation_Sheri: Justin
091916 - Calc II Meeting: Calc II Coord
092216 - David debrief: Justin
092316 - Calc I Meeting: Justin
100316 - Calc II Meeting: Calc II Coord
2
100316 - Calc II Meeting: Jeff
101016 - Calc II Meeting: Calc II Coord
110416 - PD Course: John
110416 - PD Course: Joe
110416 - PD Course: Tina
110716 - Calc II Meeting: Calc II Coord
110716 - Calc II Meeting: Calc II Coord
111416 - Calc II Meeting: Calc II Coord
111716 - Adam Observation: Tina
120216 - PD Course: Sally
120216 - PD Course: Justin
120216 - PD Course: Tina
120516 - Calc II Meeting: Joe

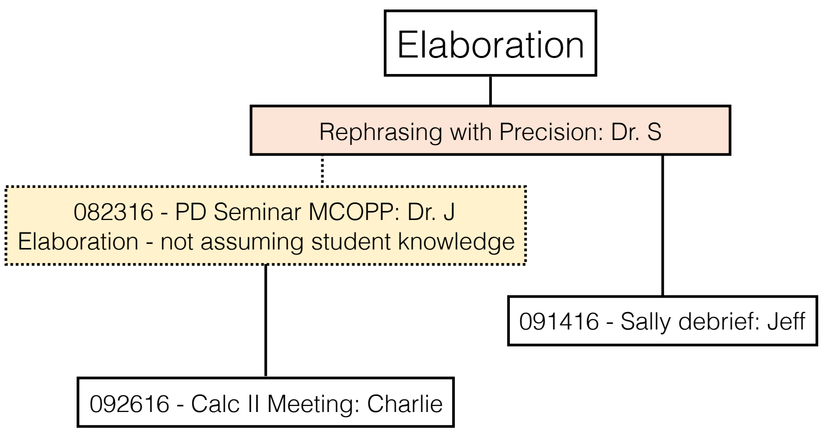

Connecting
To Real Life Examples: Calc II Coord
082516 - PD Seminar Practice: Dr. D
Meaningful connections
082516 - PD Seminar Practice: Charlie
090216 - PD Course: Dr. D
Focus on material
082516 - PD Seminar Practice: Charlie
090216 - PD Course: David
120216 - PD Course: Megan

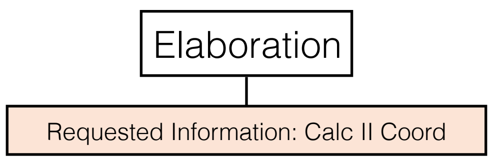

Connecting
Within the Activity: Tina
082516 - PD Seminar Practice: Calc II Coord
Elaboration - TA Makes the connection
092216 - David debrief: Justin
101416 - PD Course: Tina
091616 - PD course: Jeff
091616 - Calc I Meeting: Justin
092216 - David debrief: Justin
092216 - Adam debrief: Justin
2
092316 - PD Course: Justin
101416 - PD Course: Justin
2

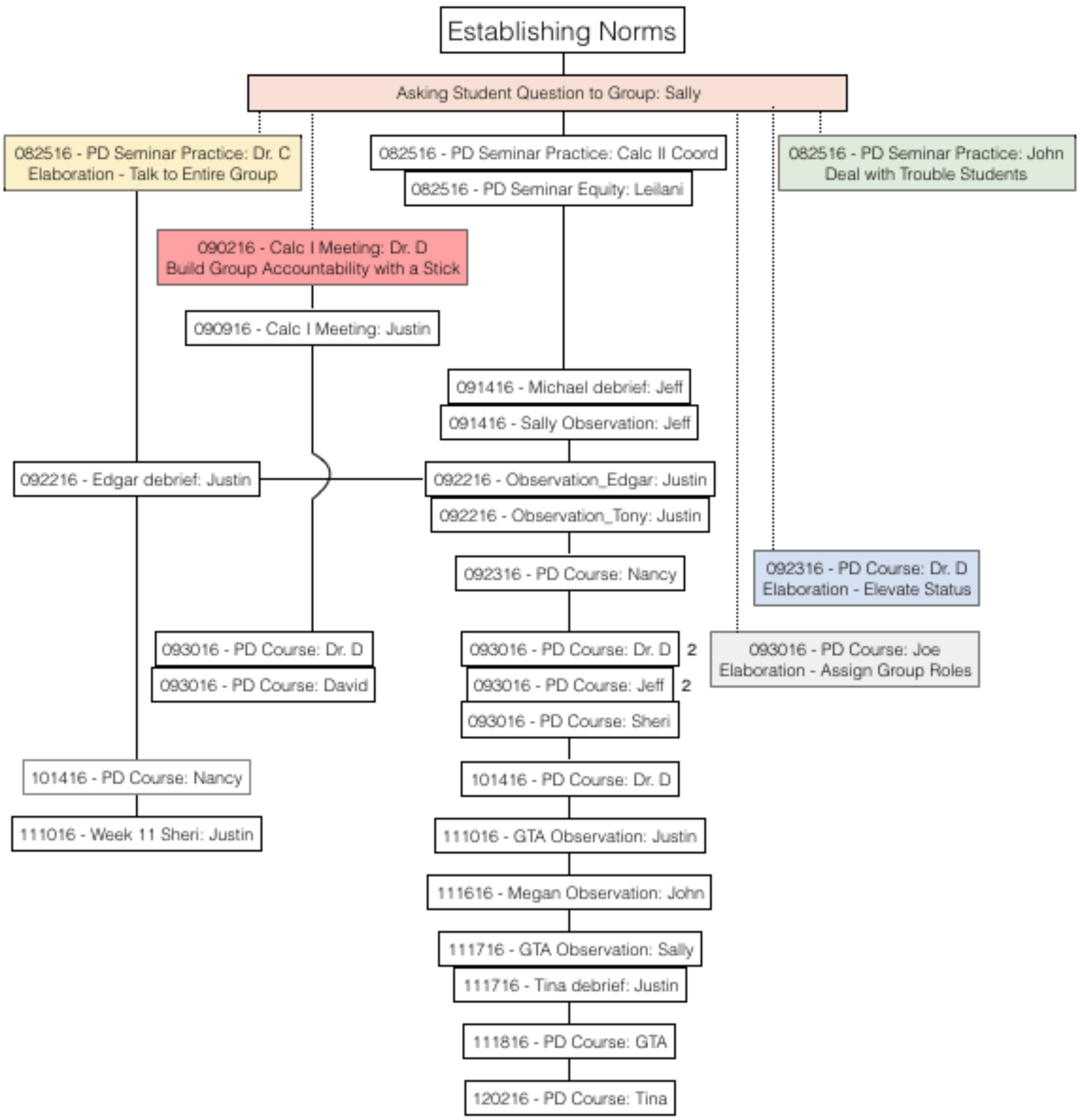

Elaboration
Building on student ideas: ISA & Dr. S
082516 - PD Seminar Practice: Jeff
090716 - Megan Observation: Jeff
2
091416 - Sally Observation: Jeff
092616 - Calc II Meeting: Calc II Coord
Elaboration - Depth on specific problems
111516 - Tina Observation: Adam
111716 - Tina debrief: Justin
Elaboration - Adding missing details

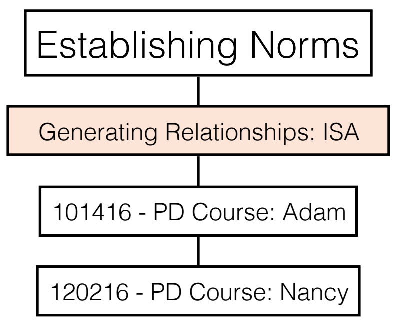

Elaboration
Lack of Elaboration: ISA
092216 - David debrief: Justin
Elaboration - Ask student to clarify
092216 - David debrief: Justin
Elaboration - TA clarifies
101416 - PD Course: Adam
101916 - Megan debrief: Jeff
111716 - Week 12 David: Justin


Elaboration
Repeating the students: Tina
2
092316 - PD Course: Dr. D
Elaboration - Revoicing
092316 - PD Course: Sally
101416 - PD Course: Justin
102616 - Sally debrief: Jeff
110416 - PD Course: Sally
111716 - Week 12 David: Justin
Elaboration - Summarizing students
111816 - PD Course: Sheri


Elaboration
Rephrasing with Precision: Dr. S
082316 - PD Seminar MCOPP: Dr. J
Elaboration - not assuming student knowledge
091416 - Sally debrief: Jeff
092616 - Calc II Meeting: Charlie

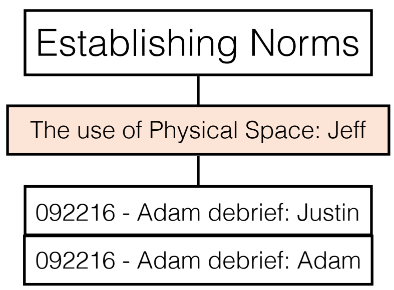

Elaboration
Requested Information: Calc II Coord

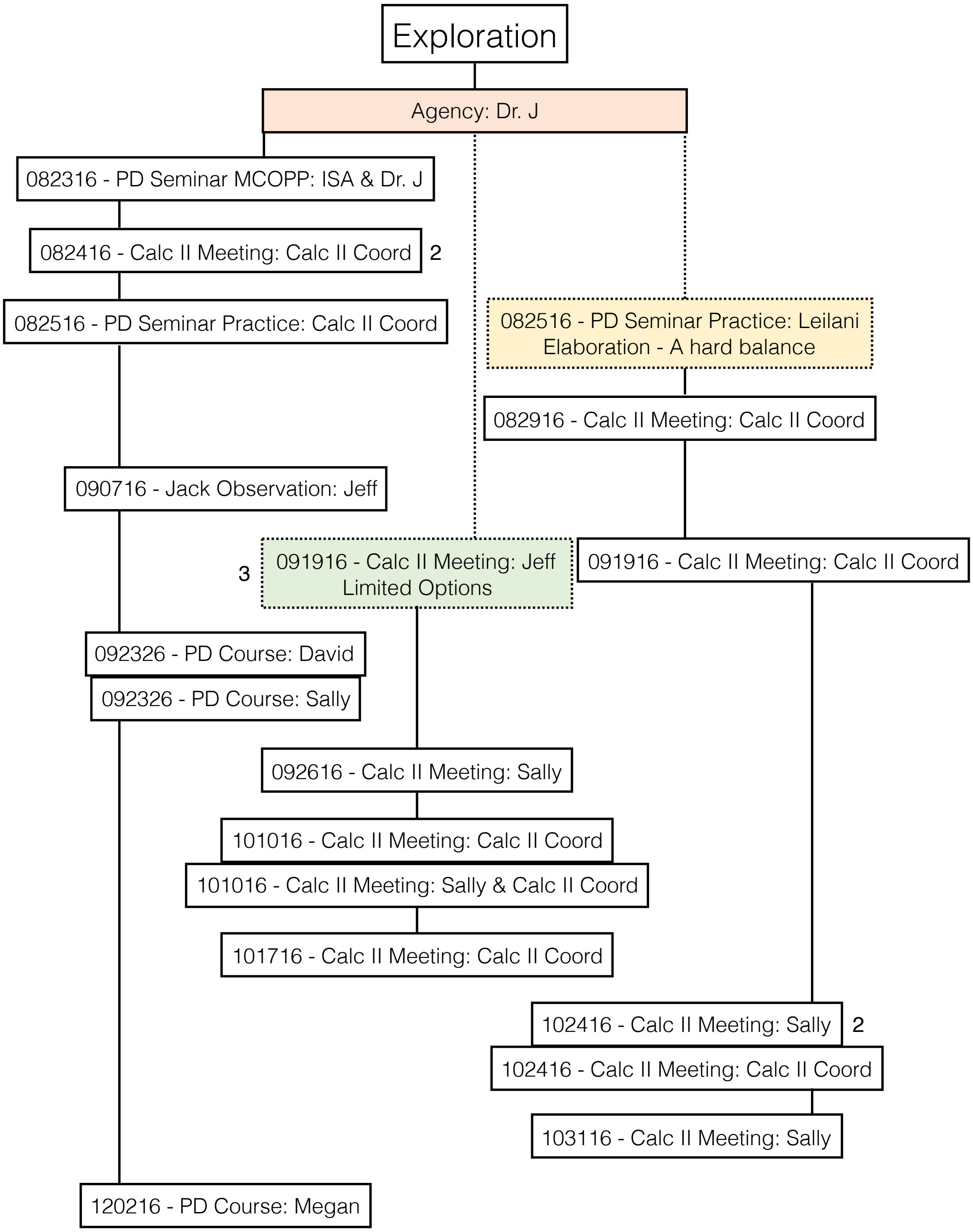

Establishing Norms
Asking Student Question to Group: Sally
082516 - PD Seminar Practice: Dr. C
Elaboration - Talk to Entire Group
082516 - PD Seminar Practice: Calc II Coord
082516 - PD Seminar Equity: Leilani
082516 - PD Seminar Practice: John
Deal with Trouble Students
090216 - Calc I Meeting: Dr. D
Build Group Accountability with a Stick
090916 - Calc I Meeting: Justin
091416 - Michael debrief: Jeff
091416 - Sally Observation: Jeff
092216 - Edgar debrief: Justin
092216 - Observation_Edgar: Justin
092216 - Observation_Tony: Justin
092316 - PD Course: Nancy
092316 - PD Course: Dr. D
Elaboration - Elevate Status
093016 - PD Course: Dr. D
093016 - PD Course: David
093016 - PD Course: Dr. D
2
093016 - PD Course: Jeff
2
093016 - PD Course: Sheri
093016 - PD Course: Joe
Elaboration - Assign Group Roles
101416 - PD Course: Nancy
111016 - Week 11 Sheri: Justin
101416 - PD Course: Dr. D
111016 - GTA Observation: Justin
111616 - Megan Observation: John
111716 - GTA Observation: Sally
111716 - Tina debrief: Justin
111816 - PD Course: GTA
120216 - PD Course: Tina


Establishing Norms
Generating Relationships: ISA
101416 - PD Course: Adam
120216 - PD Course: Nancy

Establishing Norms

Note Taking: Dr. D


Establishing Norms
The use of Physical Space: Jeff
092216 - Adam debrief: Justin
092216 - Adam debrief: Adam


Exploration
Agency: Dr. J
082316 - PD Seminar MCOPP: ISA & Dr. J
082416 - Calc II Meeting: Calc II Coord
2
082516 - PD Seminar Practice: Calc II Coord
082516 - PD Seminar Practice: Leilani
Elaboration - A hard balance
082916 - Calc II Meeting: Calc II Coord
090716 - Jack Observation: Jeff
3
091916 - Calc II Meeting: Jeff
Limited Options
091916 - Calc II Meeting: Calc II Coord
092326 - PD Course: David
092326 - PD Course: Sally
092616 - Calc II Meeting: Sally
101016 - Calc II Meeting: Calc II Coord
101016 - Calc II Meeting: Sally & Calc II Coord
101716 - Calc II Meeting: Calc II Coord
102416 - Calc II Meeting: Sally
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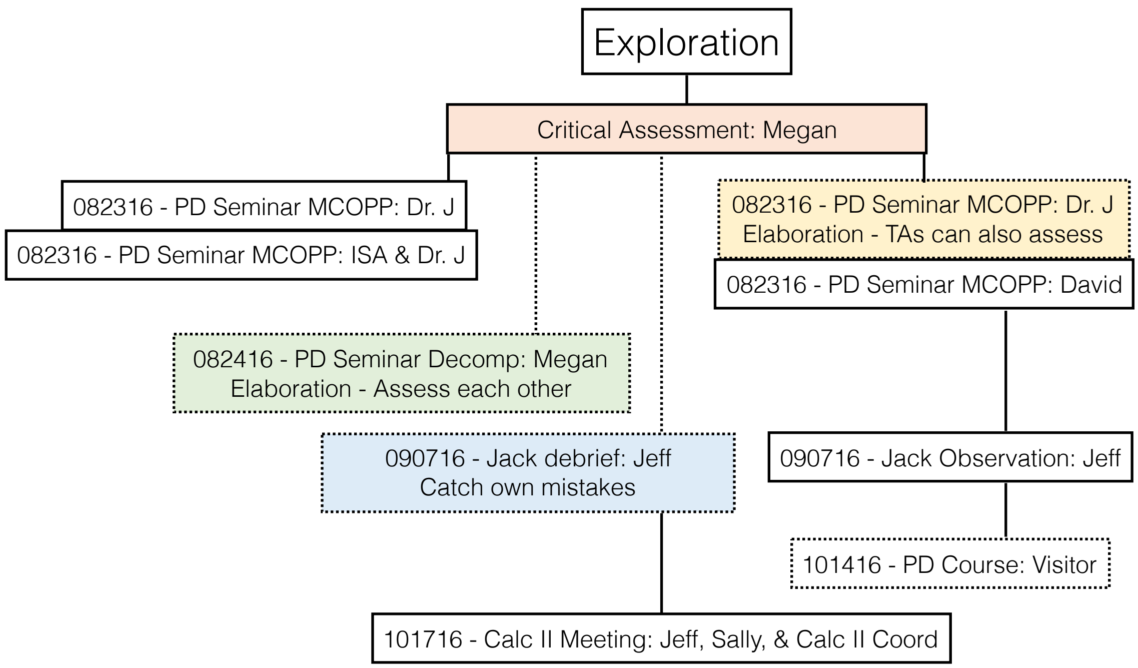
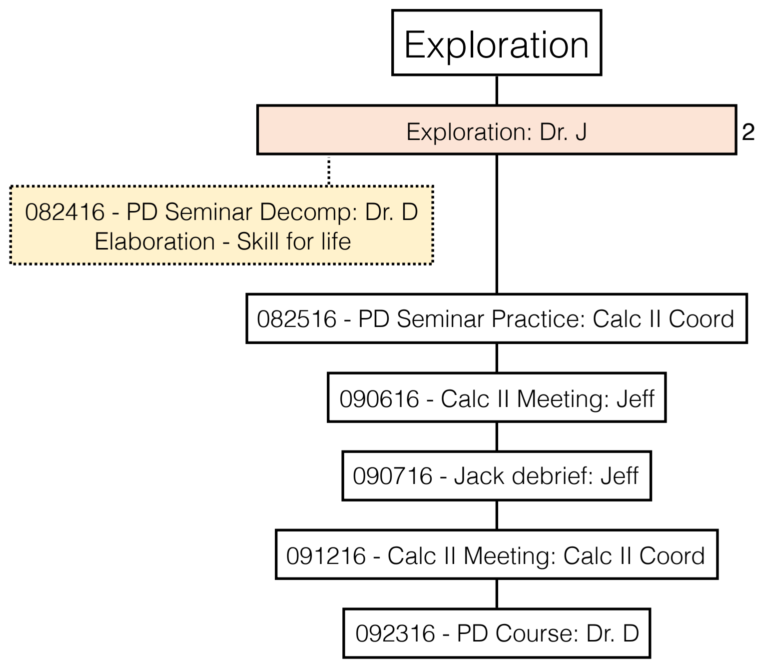
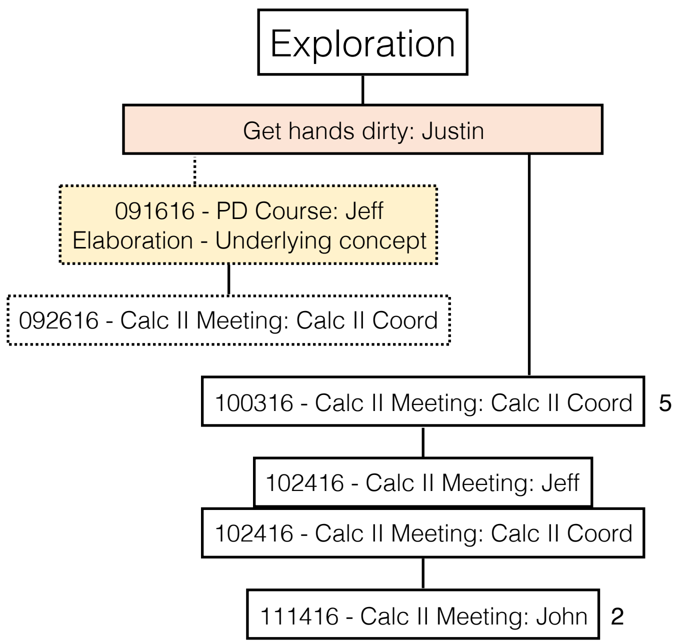
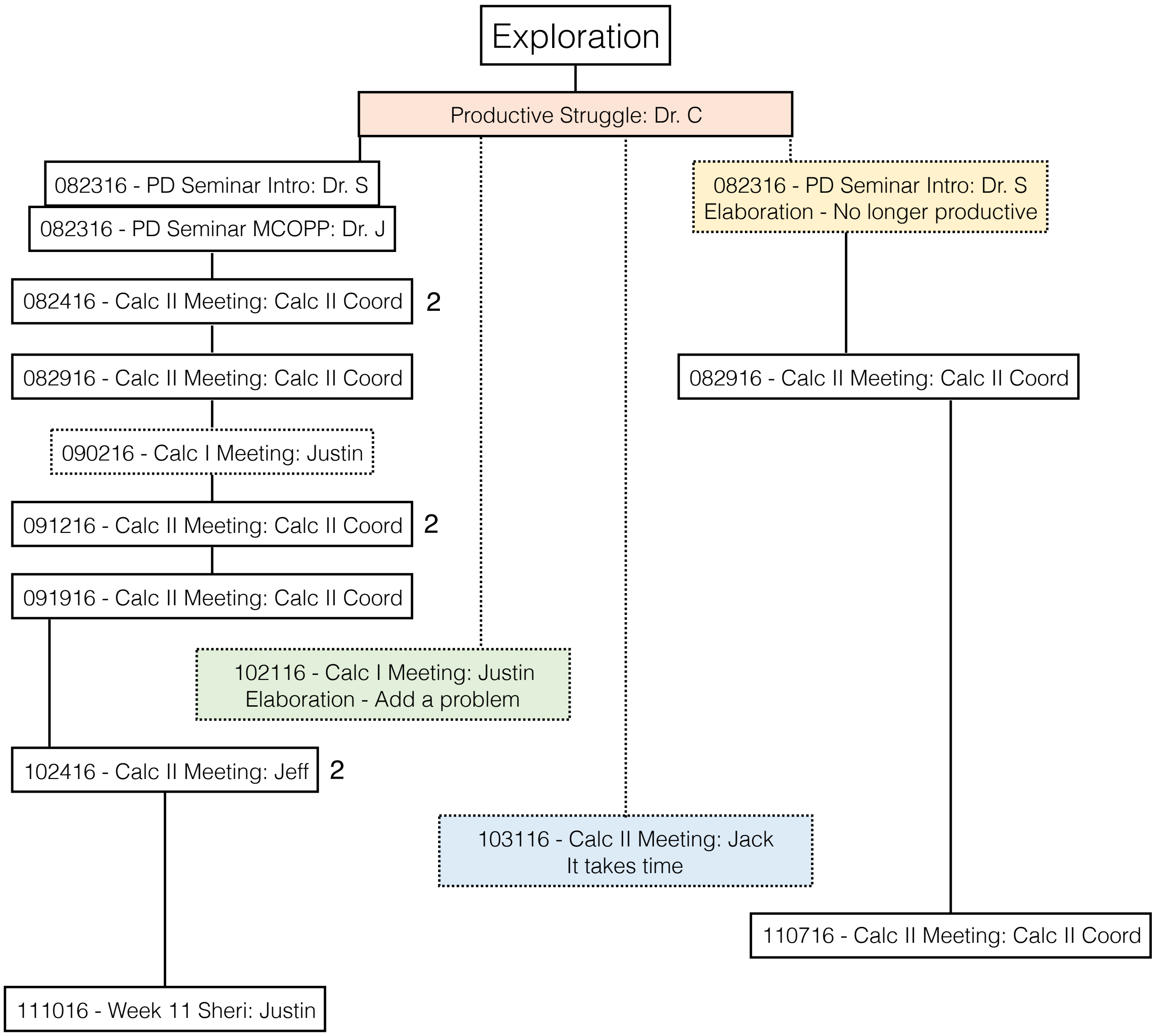
102416 - Calc II Meeting: Calc II Coord
103116 - Calc II Meeting: Sally
120216 - PD Course: Megan

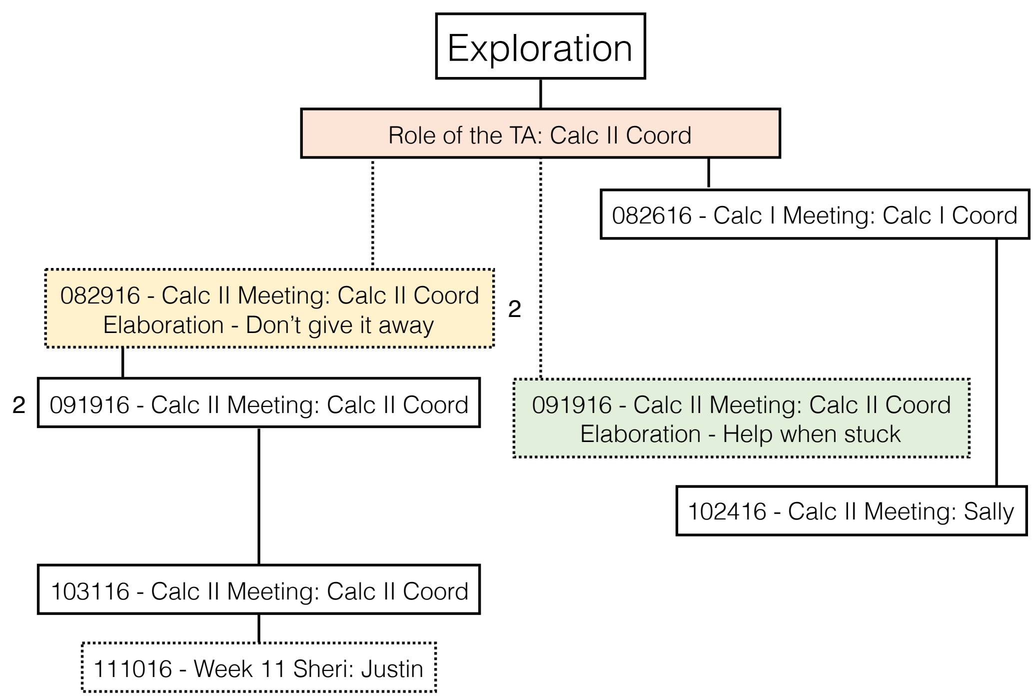

Exploration
Critical Assessment: Megan
082316 - PD Seminar MCOPP: Dr. J
082316 - PD Seminar MCOPP: ISA & Dr. J
082316 - PD Seminar MCOPP: Dr. J
Elaboration - TAs can also assess
082316 - PD Seminar MCOPP: David
082416 - PD Seminar Decomp: Megan
Elaboration - Assess each other
090716 - Jack debrief: Jeff
Catch own mistakes
090716 - Jack Observation: Jeff
101416 - PD Course: Visitor
101716 - Calc II Meeting: Jeff, Sally, & Calc II Coord

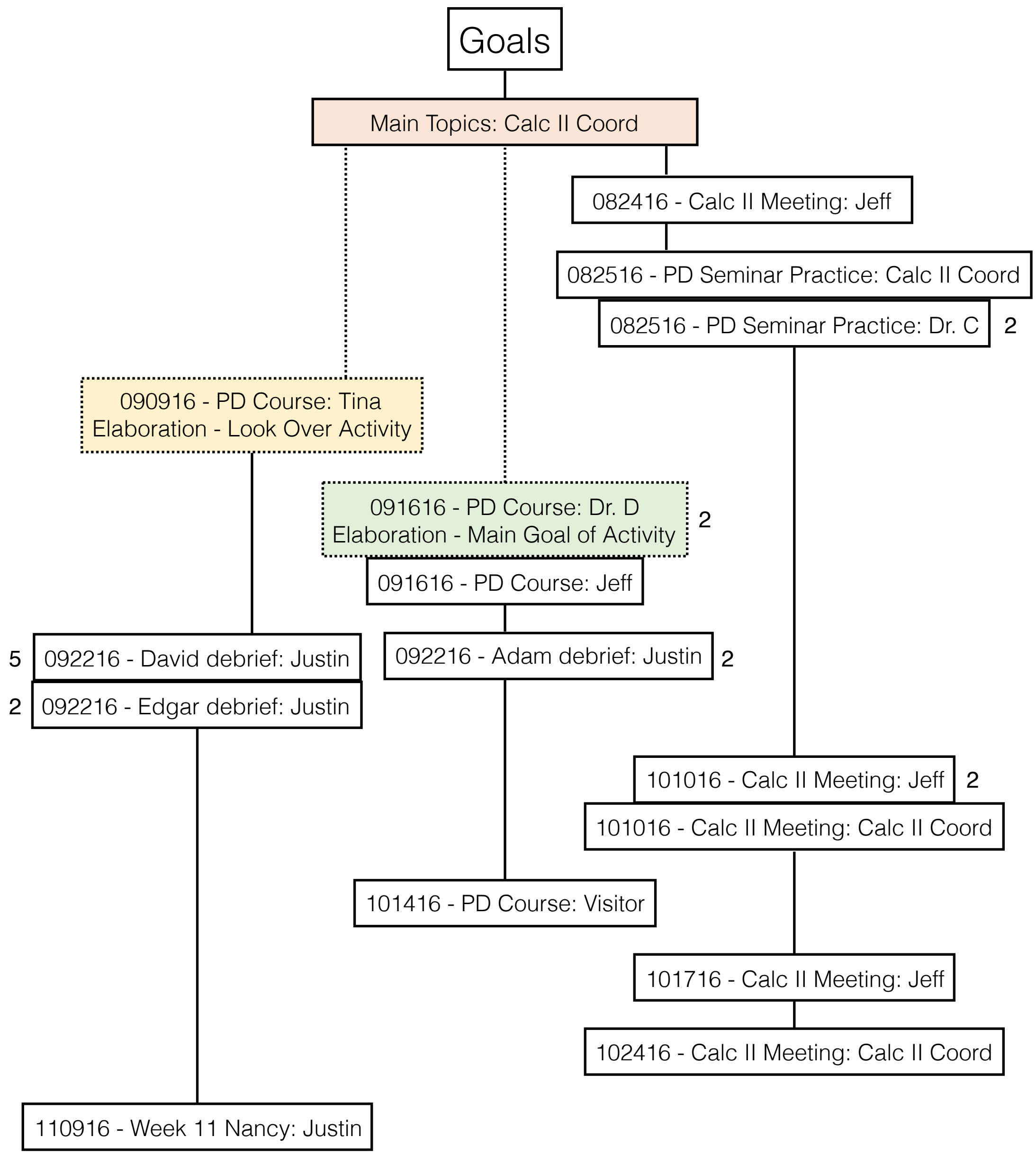

Exploration
Exploration: Dr. J
2
082416 - PD Seminar Decomp: Dr. D
Elaboration - Skill for life
082516 - PD Seminar Practice: Calc II Coord
090616 - Calc II Meeting: Jeff
090716 - Jack debrief: Jeff
091216 - Calc II Meeting: Calc II Coord
092316 - PD Course: Dr. D

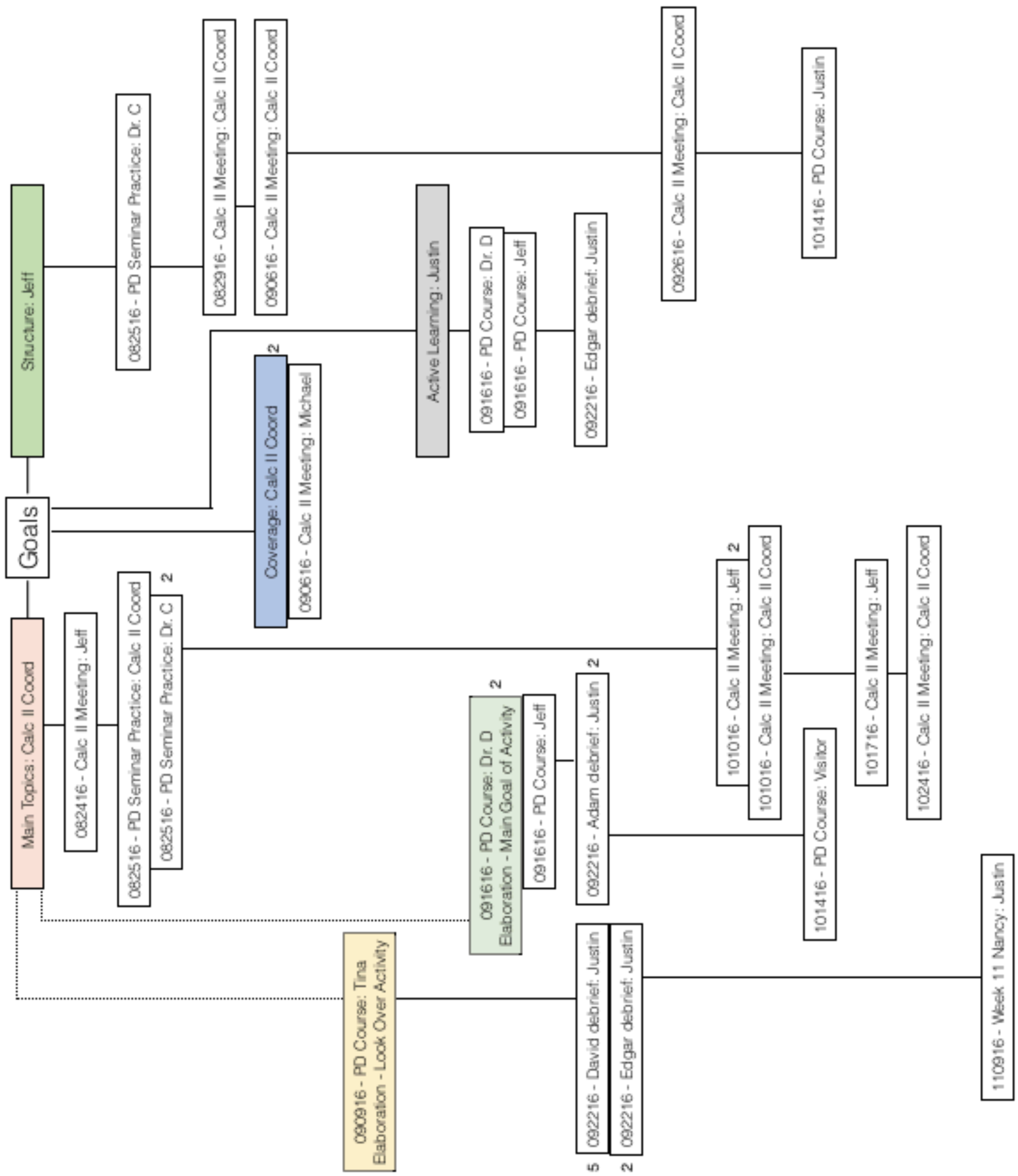

Exploration
Get hands dirty: Justin
091616 - PD Course: Jeff
Elaboration - Underlying concept
092616 - Calc II Meeting: Calc II Coord
100316 - Calc II Meeting: Calc II Coord
5
102416 - Calc II Meeting: Jeff
102416 - Calc II Meeting: Calc II Coord
111416 - Calc II Meeting: John
2

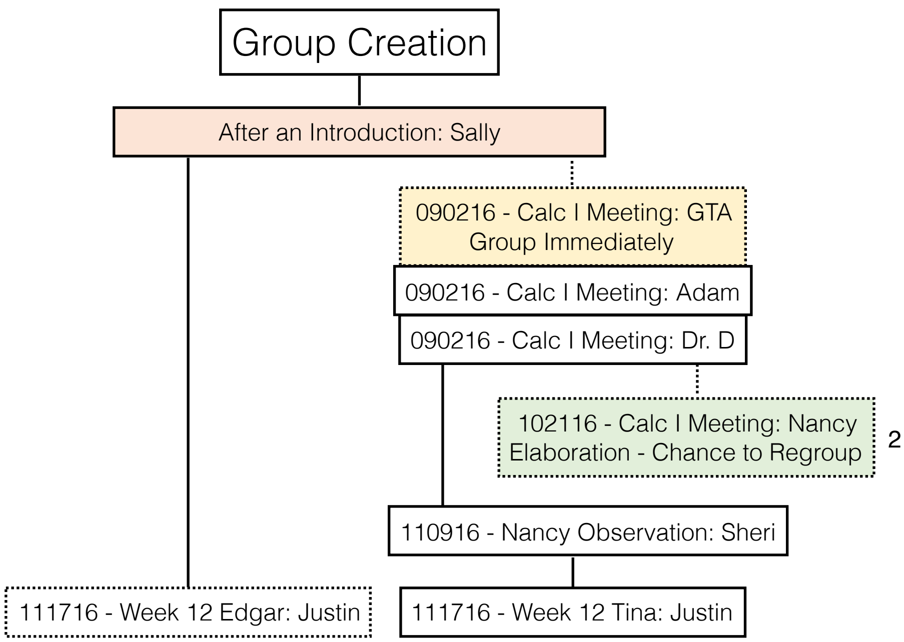


Exploration
Productive Struggle: Dr. C
082316 - PD Seminar Intro: Dr. S
082316 - PD Seminar MCOPP: Dr. J
082416 - Calc II Meeting: Calc II Coord
2
082916 - Calc II Meeting: Calc II Coord
090216 - Calc I Meeting: Justin
091216 - Calc II Meeting: Calc II Coord
2
091916 - Calc II Meeting: Calc II Coord
102116 - Calc I Meeting: Justin
Elaboration - Add a problem
102416 - Calc II Meeting: Jeff
2
111016 - Week 11 Sheri: Justin
103116 - Calc II Meeting: Jack
It takes time
082316 - PD Seminar Intro: Dr. S
Elaboration - No longer productive
082916 - Calc II Meeting: Calc II Coord
110716 - Calc II Meeting: Calc II Coord

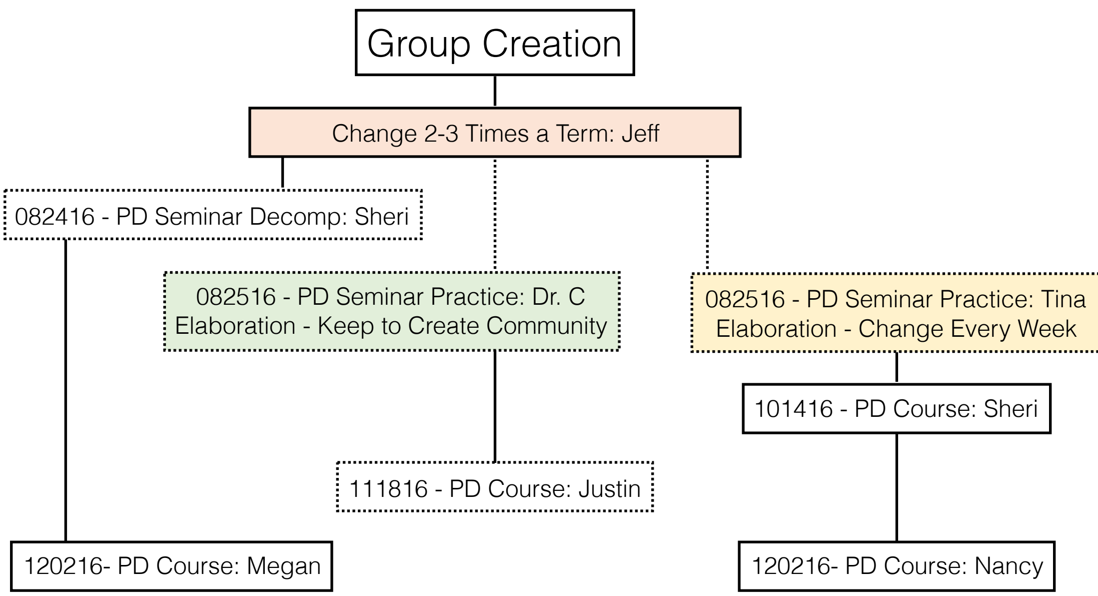

Exploration
Role of the TA: Calc II Coord
082616 - Calc I Meeting: Calc I Coord
082916 - Calc II Meeting: Calc II Coord
Elaboration - Don't give it away
2
2
091916 - Calc II Meeting: Calc II Coord
091916 - Calc II Meeting: Calc II Coord
Elaboration - Help when stuck
102416 - Calc II Meeting: Sally
103116 - Calc II Meeting: Calc II Coord
111016 - Week 11 Sheri: Justin

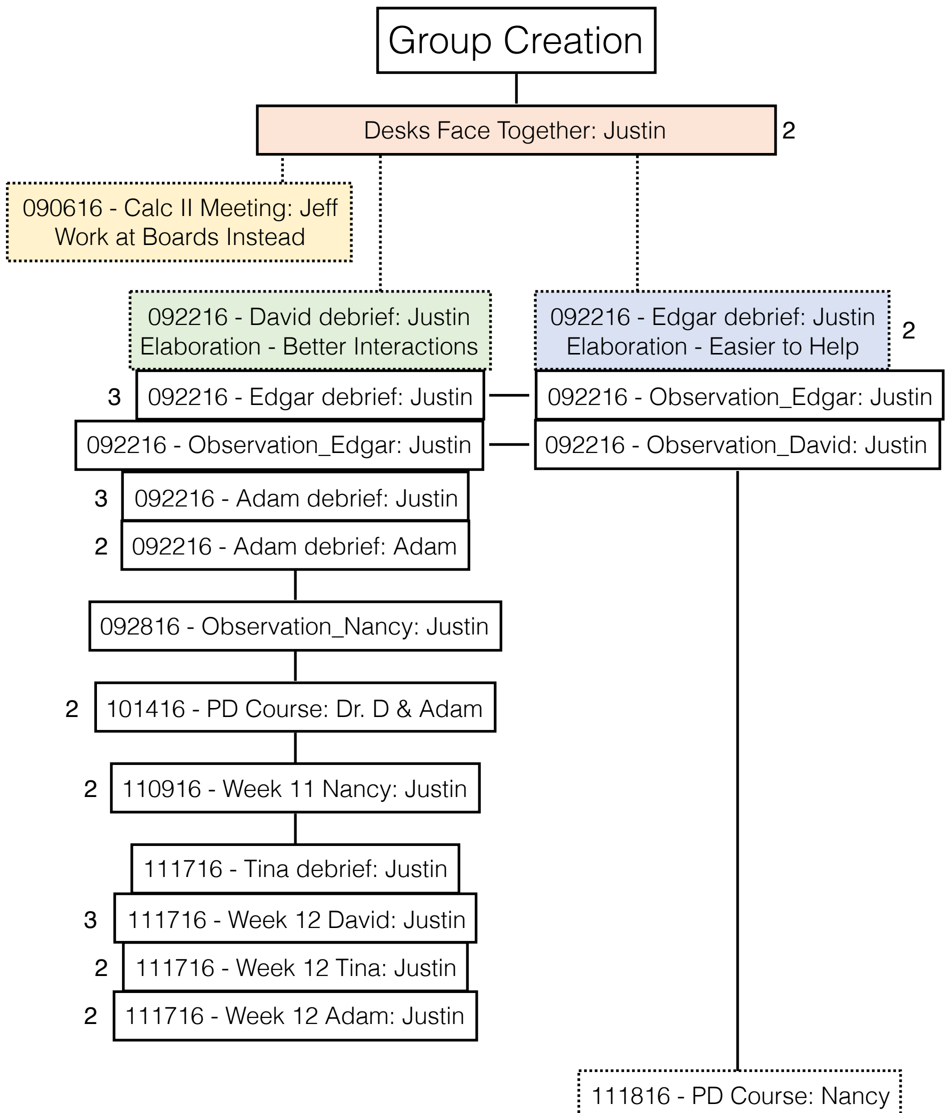

Goals
Main Topics: Calc II Coord
082416 - Calc II Meeting: Jeff
082516 - PD Seminar Practice: Calc II Coord
082516 - PD Seminar Practice: Dr. C
2
090916 - PD Course: Tina
Elaboration - Look Over Activity
091616 - PD Course: Dr. D
Elaboration - Main Goal of Activity
2
091616 - PD Course: Jeff
5
092216 - David debrief: Justin
2
092216 - Edgar debrief: Justin
092216 - Adam debrief: Justin
2
101016 - Calc II Meeting: Jeff
2
101016 - Calc II Meeting: Calc II Coord
101416 - PD Course: Visitor
101716 - Calc II Meeting: Jeff
102416 - Calc II Meeting: Calc II Coord
110916 - Week 11 Nancy: Justin

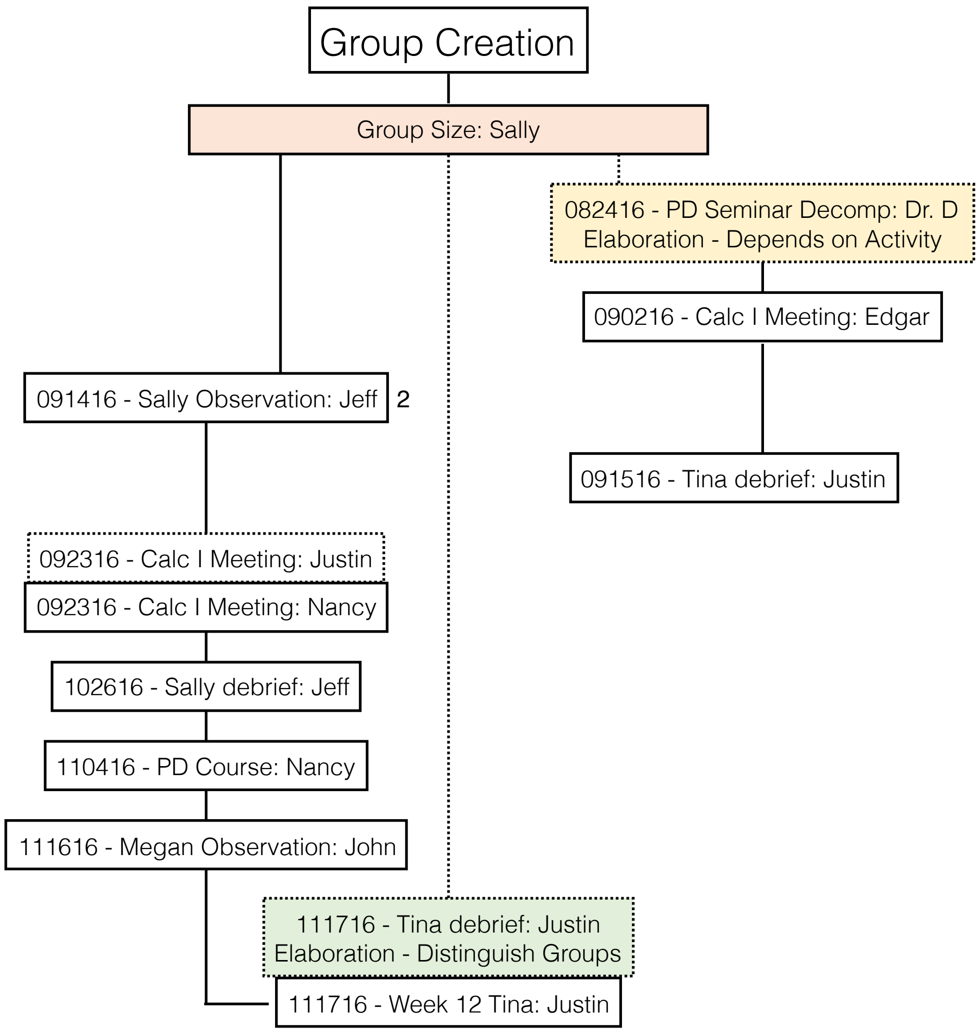

Goals
Structure: Jeff
082516 - PD Seminar Practice: Dr. C
082916 - Calc II Meeting: Calc II Coord
090616 - Calc II Meeting: Calc II Coord
092616 - Calc II Meeting: Calc II Coord
101416 - PD Course: Justin
Active Learning: Justin
091616 - PD Course: Dr. D
091616 - PD Course: Jeff
092216 - Edgar debrief: Justin
Coverage: Calc II Coord
2
090616 - Calc II Meeting: Michael
Main Topics: Calc II Coord
082416 - Calc II Meeting: Jeff
082516 - PD Seminar Practice: Calc II Coord
082516 - PD Seminar Practice: Dr. C
2
101016 - Calc II Meeting: Jeff
2
101016 - Calc II Meeting: Calc II Coord
101716 - Calc II Meeting: Jeff
102416 - Calc II Meeting: Calc II Coord
091616 - PD Course: Dr. D
Elaboration - Main Goal of Activity
2
091616 - PD Course: Jeff
092216 - Adam debrief: Justin
2
101416 - PD Course: Visitor
090916 - PD Course: Tina
Elaboration - Look Over Activity
092216 - David debrief: Justin
5
092216 - Edgar debrief: Justin
2
110916 - Week 11 Nancy: Justin

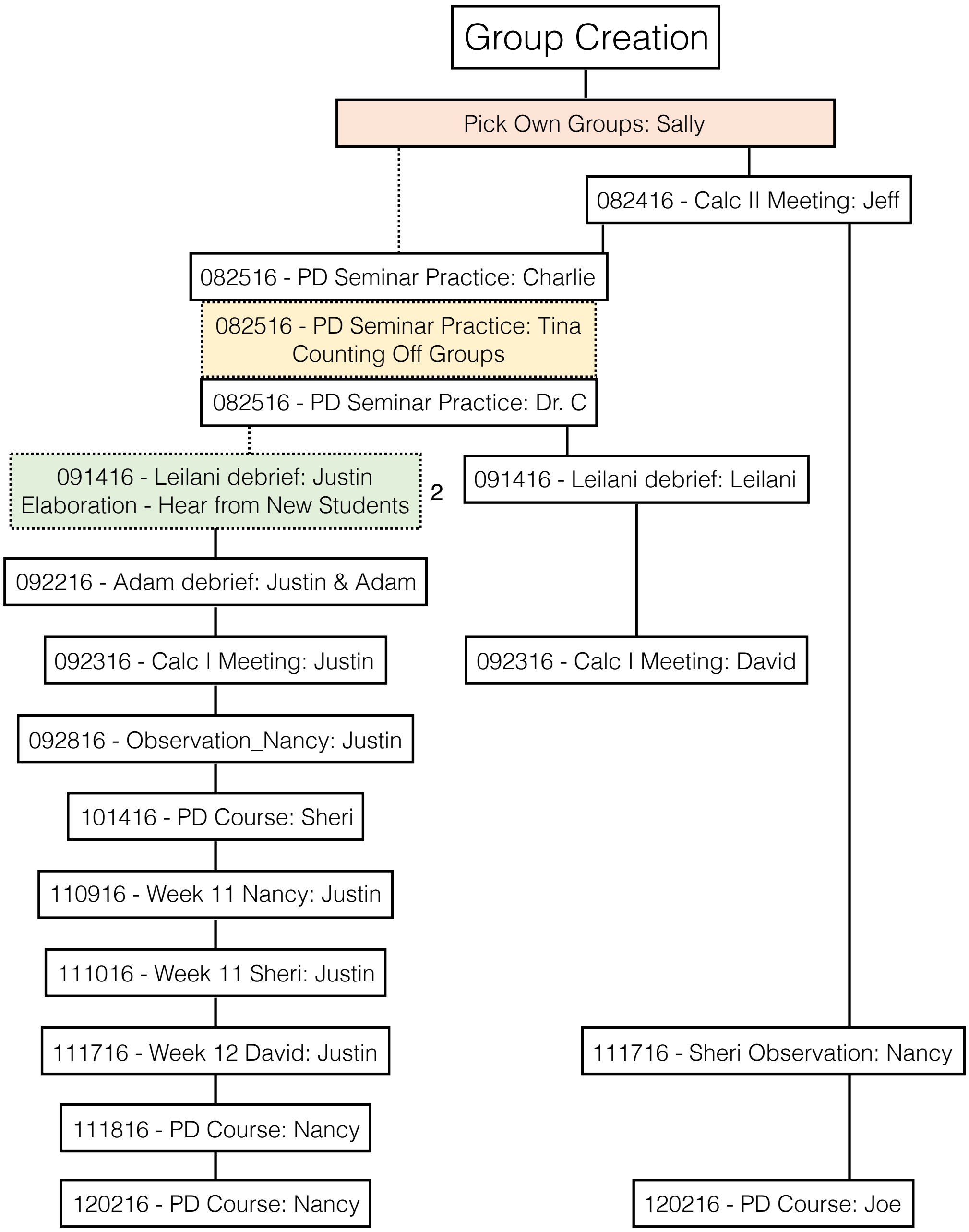


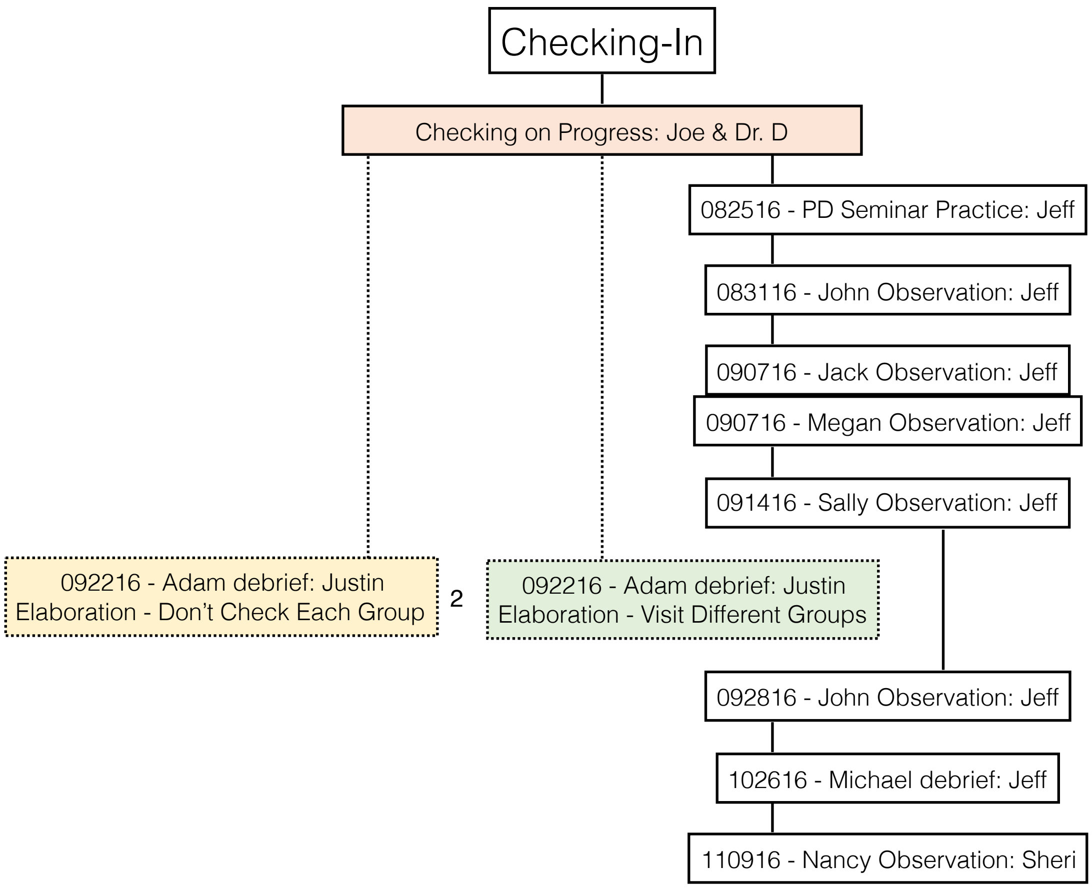
Group Creation
After an Introduction: Sally
090216 - Calc I Meeting: GTA Group Immediately
090216 - Calc I Meeting: Adam
090216 - Calc I Meeting: Dr. D
102116 - Calc I Meeting: Nancy Elaboration - Chance to Regroup
2
110916 - Nancy Observation: Sheri
111716 - Week 12 Edgar: Justin
111716 - Week 12 Tina: Justin

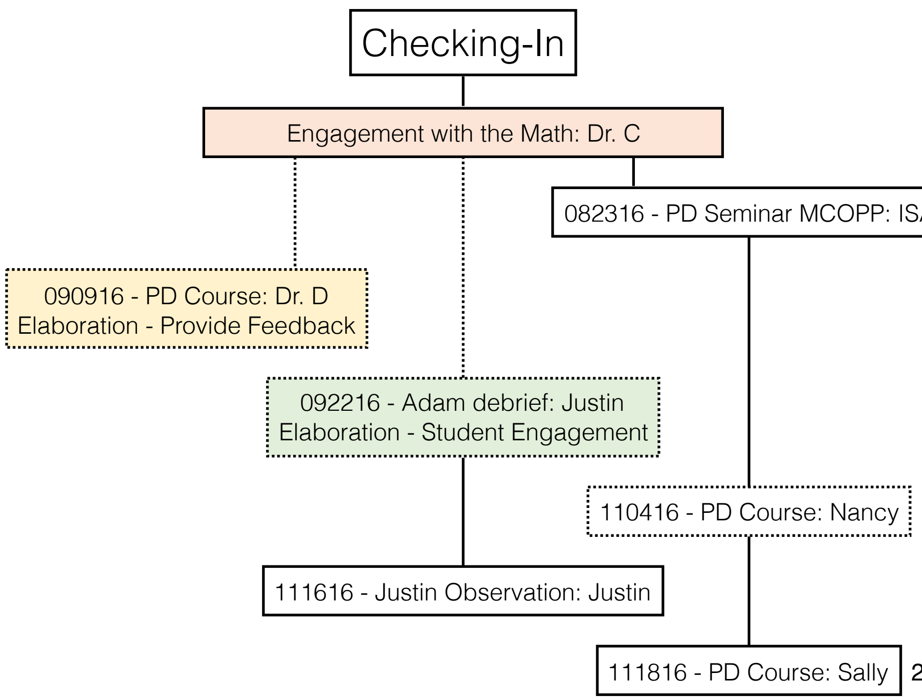

Group Creation
Change 2-3 Times a Term: Jeff
082416 - PD Seminar Decomp: Sheri
082516 - PD Seminar Practice: Dr. C
Elaboration - Keep to Create Community
082516 - PD Seminar Practice: Tina
Elaboration - Change Every Week
101416 - PD Course: Sheri
111816 - PD Course: Justin
120216- PD Course: Megan
120216- PD Course: Nancy

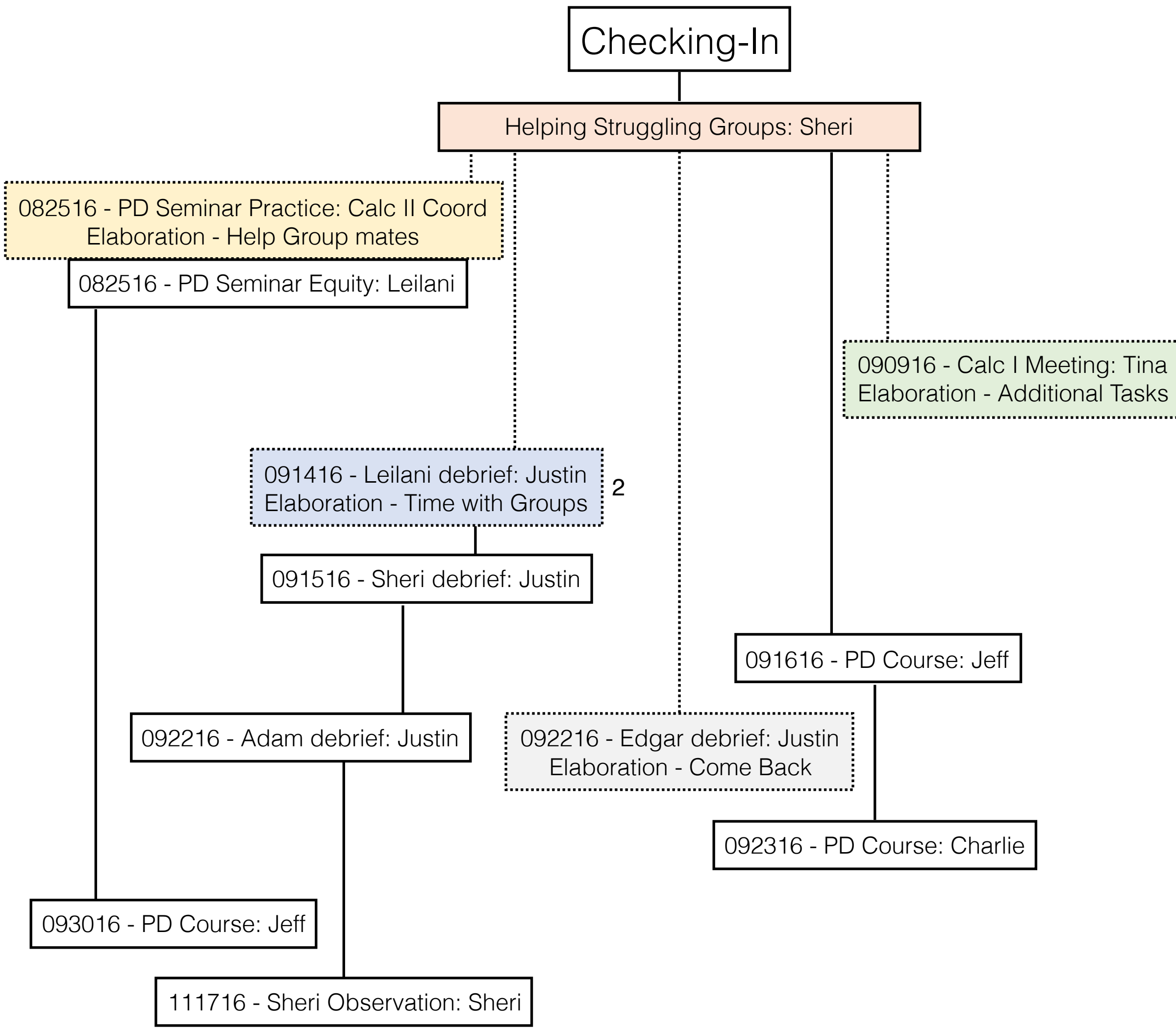

Group Creation
Desks Face Together: Justin
2
090616 - Calc II Meeting: Jeff
Work at Boards Instead
092216 - David debrief: Justin
Elaboration - Better Interactions
092216 - Edgar debrief: Justin
Elaboration - Easier to Help
2
3
092216 - Edgar debrief: Justin
092216 - Observation_Edgar: Justin
092216 - Observation_Edgar: Justin
092216 - Observation_David: Justin
3
092216 - Adam debrief: Justin
2
092216 - Adam debrief: Adam
092816 - Observation_Nancy: Justin
2
101416 - PD Course: Dr. D & Adam
2
110916 - Week 11 Nancy: Justin
111716 - Tina debrief: Justin
3
111716 - Week 12 David: Justin
2
111716 - Week 12 Tina: Justin
2
111716 - Week 12 Adam: Justin
111816 - PD Course: Nancy


Group Creation
Group Size: Sally
082416 - PD Seminar Decomp: Dr. D
Elaboration - Depends on Activity
090216 - Calc I Meeting: Edgar
091416 - Sally Observation: Jeff
2
091516 - Tina debrief: Justin
092316 - Calc I Meeting: Justin
092316 - Calc I Meeting: Nancy
102616 - Sally debrief: Jeff
110416 - PD Course: Nancy
111616 - Megan Observation: John
111716 - Tina debrief: Justin
Elaboration - Distinguish Groups
111716 - Week 12 Tina: Justin

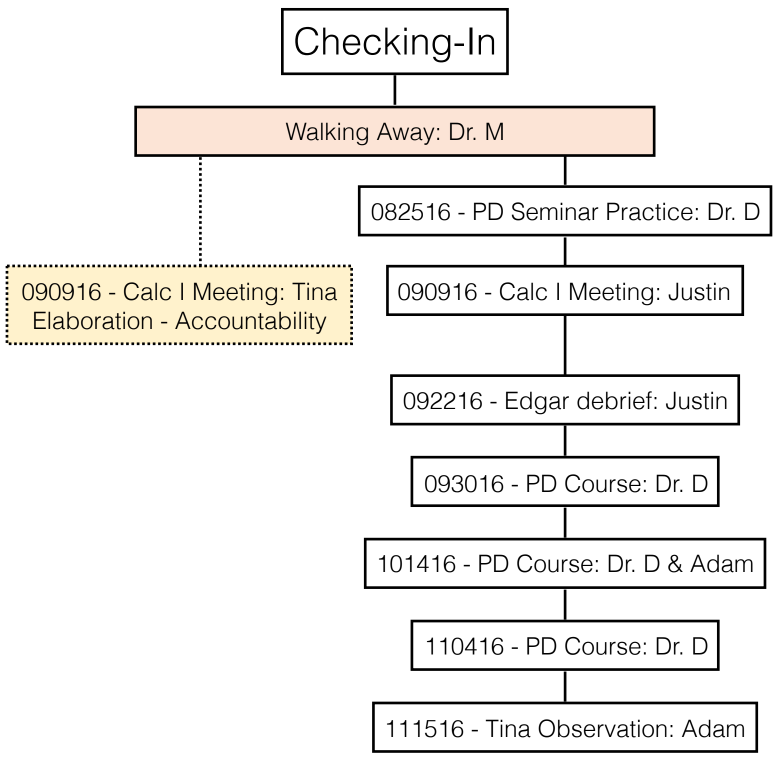

Group Creation
Pick Own Groups: Sally
082416 - Calc II Meeting: Jeff
082516 - PD Seminar Practice: Charlie
082516 - PD Seminar Practice: Tina
Counting Off Groups
082516 - PD Seminar Practice: Dr. C
091416 - Leilani debrief: Justin
Elaboration - Hear from New Students
2
091416 - Leilani debrief: Leilani
092216 - Adam debrief: Justin & Adam
092316 - Calc I Meeting: Justin
092316 - Calc I Meeting: David
092816 - Observation_Nancy: Justin
101416 - PD Course: Sheri
110916 - Week 11 Nancy: Justin
111016 - Week 11 Sheri: Justin
111716 - Week 12 David: Justin
111716 - Sheri Observation: Nancy
111816 - PD Course: Nancy
120216 - PD Course: Nancy
120216 - PD Course: Joe

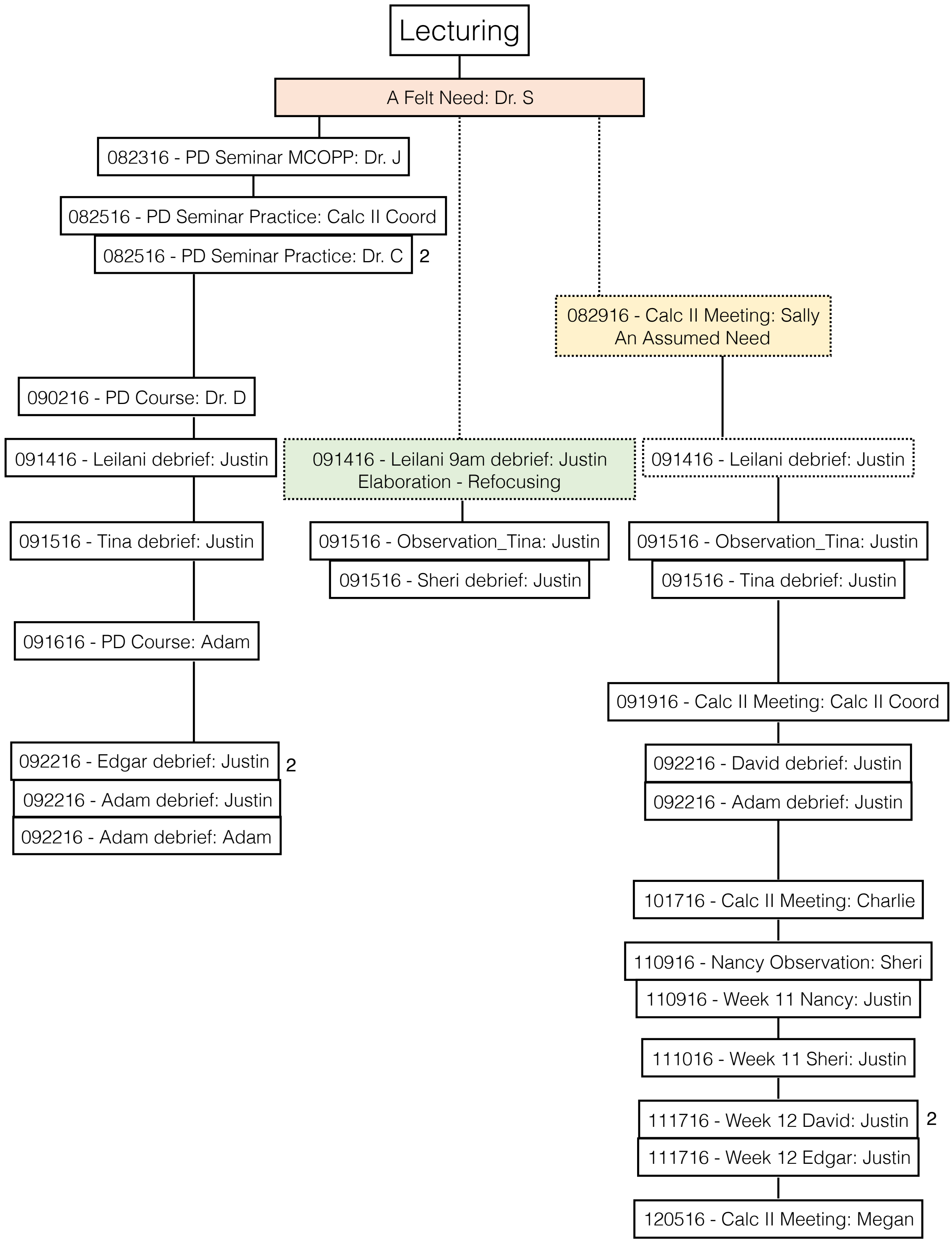

Checking-In
Checking on Progress: Joe & Dr. D
082516 - PD Seminar Practice: Jeff
083116 - John Observation: Jeff
090716 - Jack Observation: Jeff
090716 - Megan Observation: Jeff
091416 - Sally Observation: Jeff
092216 - Adam debrief: Justin
Elaboration - Don’t Check Each Group
2
092216 - Adam debrief: Justin
Elaboration - Visit Different Groups
092816 - John Observation: Jeff
102616 - Michael debrief: Jeff
110916 - Nancy Observation: Sheri

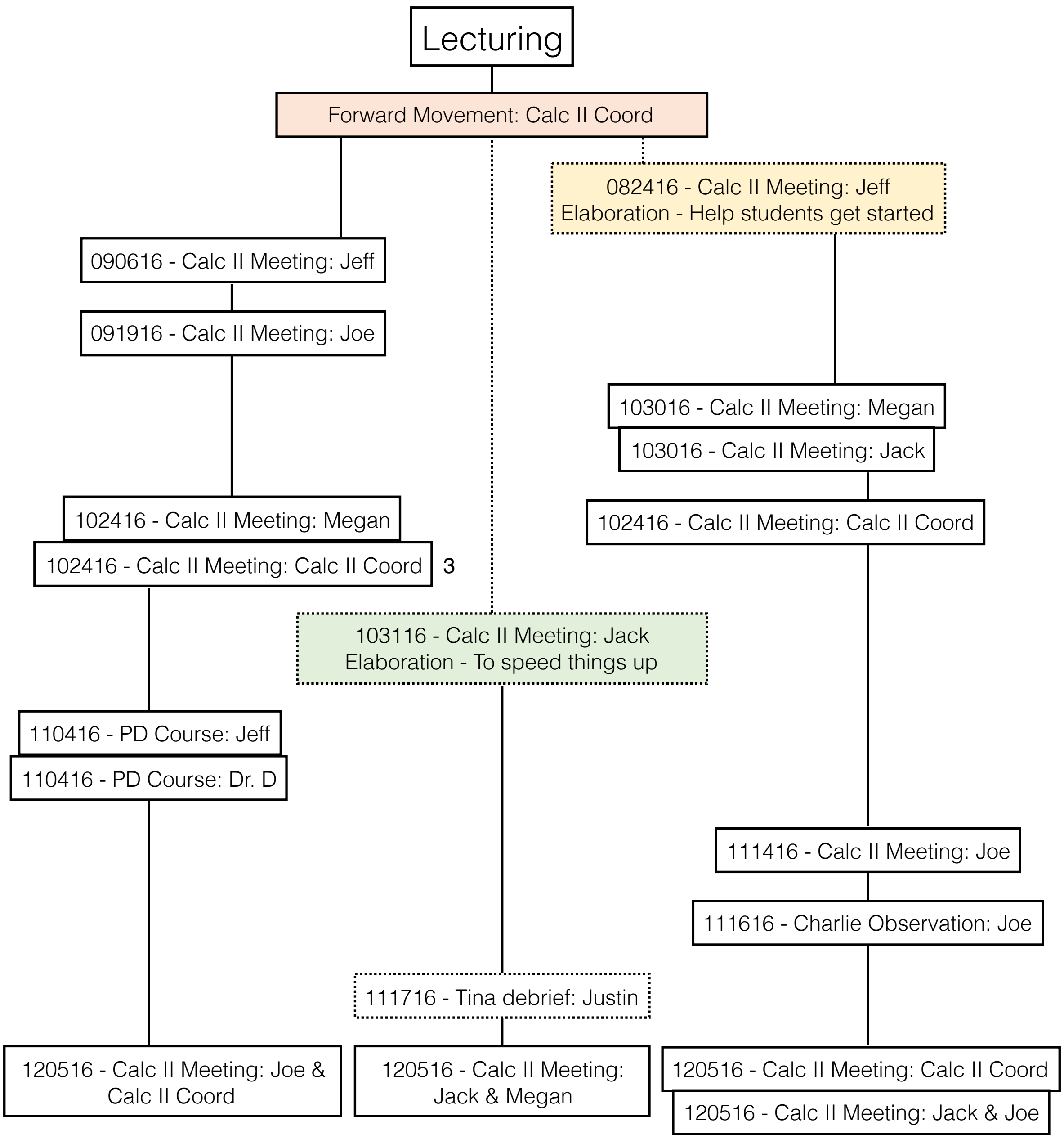

Checking-In
Engagement with the Math: Dr. C
082316 - PD Seminar MCOPP: ISA
090916 - PD Course: Dr. D
Elaboration - Provide Feedback
092216 - Adam debrief: Justin
Elaboration - Student Engagement
110416 - PD Course: Nancy
111616 - Justin Observation: Justin
111816 - PD Course: Sally
2

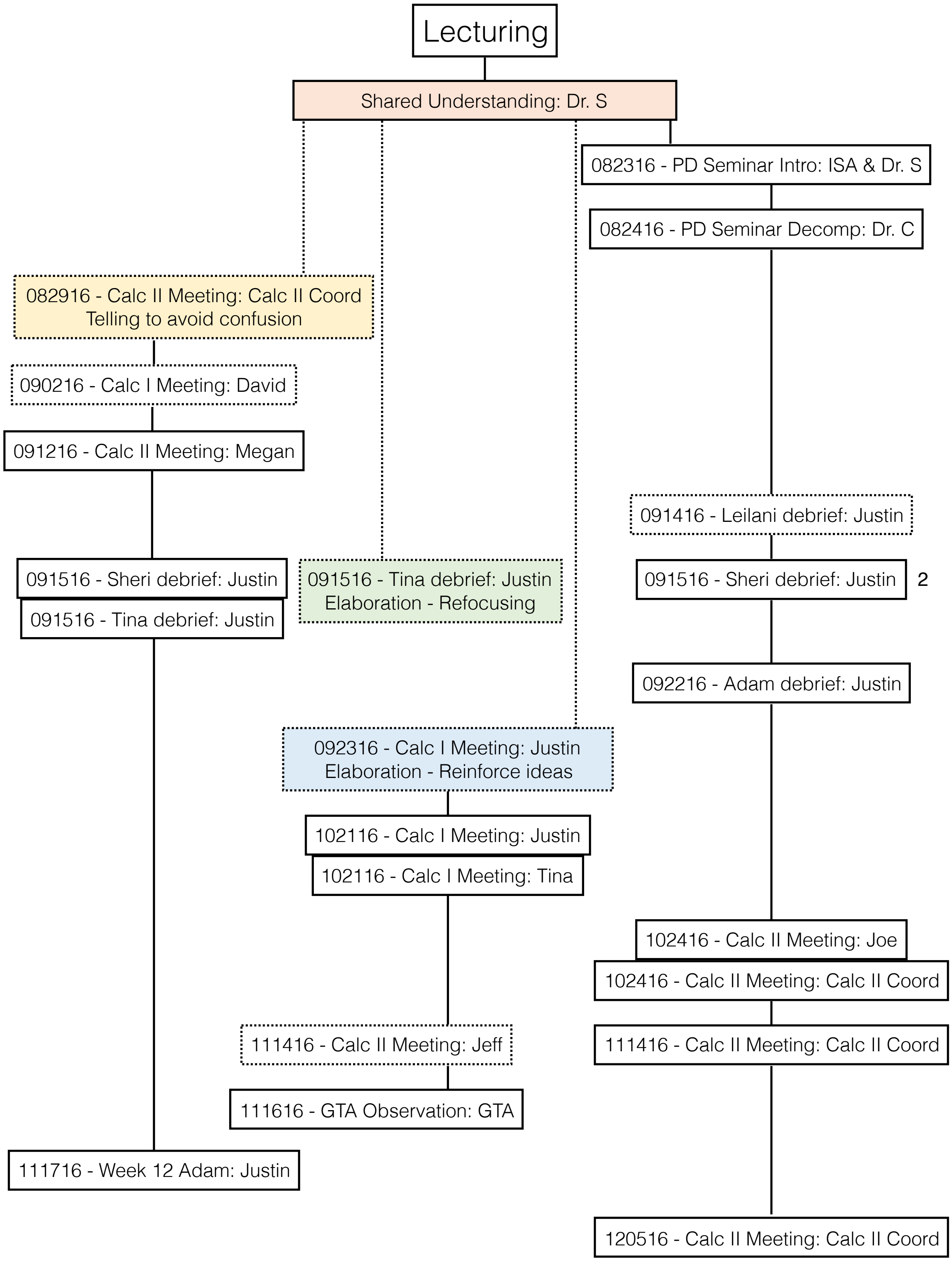


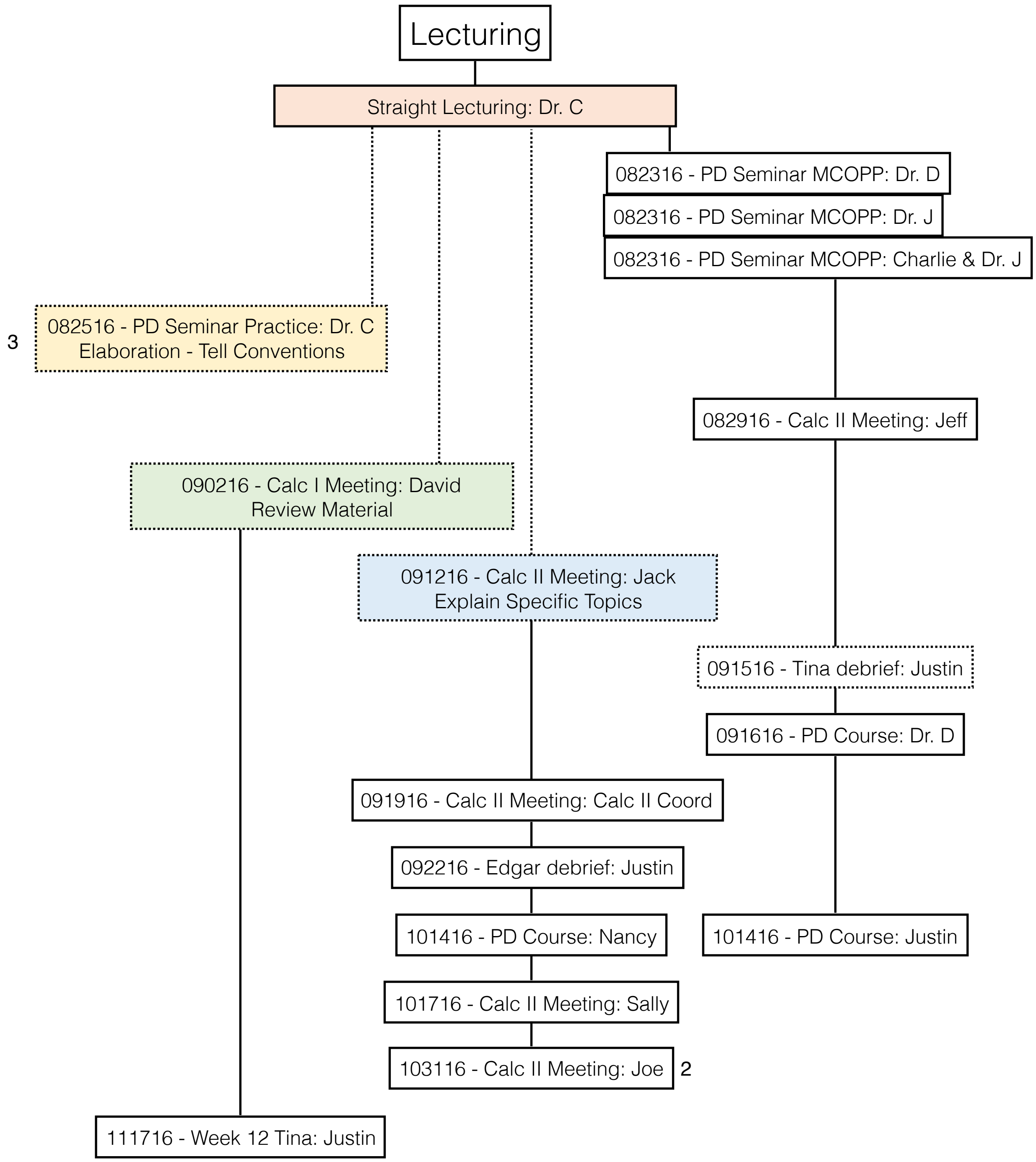
Checking-In
Helping Struggling Groups: Sheri
082516 - PD Seminar Practice: Calc II Coord
Elaboration - Help Group mates
082516 - PD Seminar Equity: Leilani
090916 - Calc I Meeting: Tina
Elaboration - Additional Tasks
091416 - Leilani debrief: Justin
Elaboration - Time with Groups
2
091516 - Sheri debrief: Justin
091616 - PD Course: Jeff
092216 - Adam debrief: Justin
092216 - Edgar debrief: Justin
Elaboration - Come Back
092316 - PD Course: Charlie
093016 - PD Course: Jeff
111716 - Sheri Observation: Sheri


Checking-In
Walking Away: Dr. M
082516 - PD Seminar Practice: Dr. D
090916 - Calc I Meeting: Tina
Elaboration - Accountability
090916 - Calc I Meeting: Justin
092216 - Edgar debrief: Justin
093016 - PD Course: Dr. D
101416 - PD Course: Dr. D & Adam
110416 - PD Course: Dr. D
111516 - Tina Observation: Adam

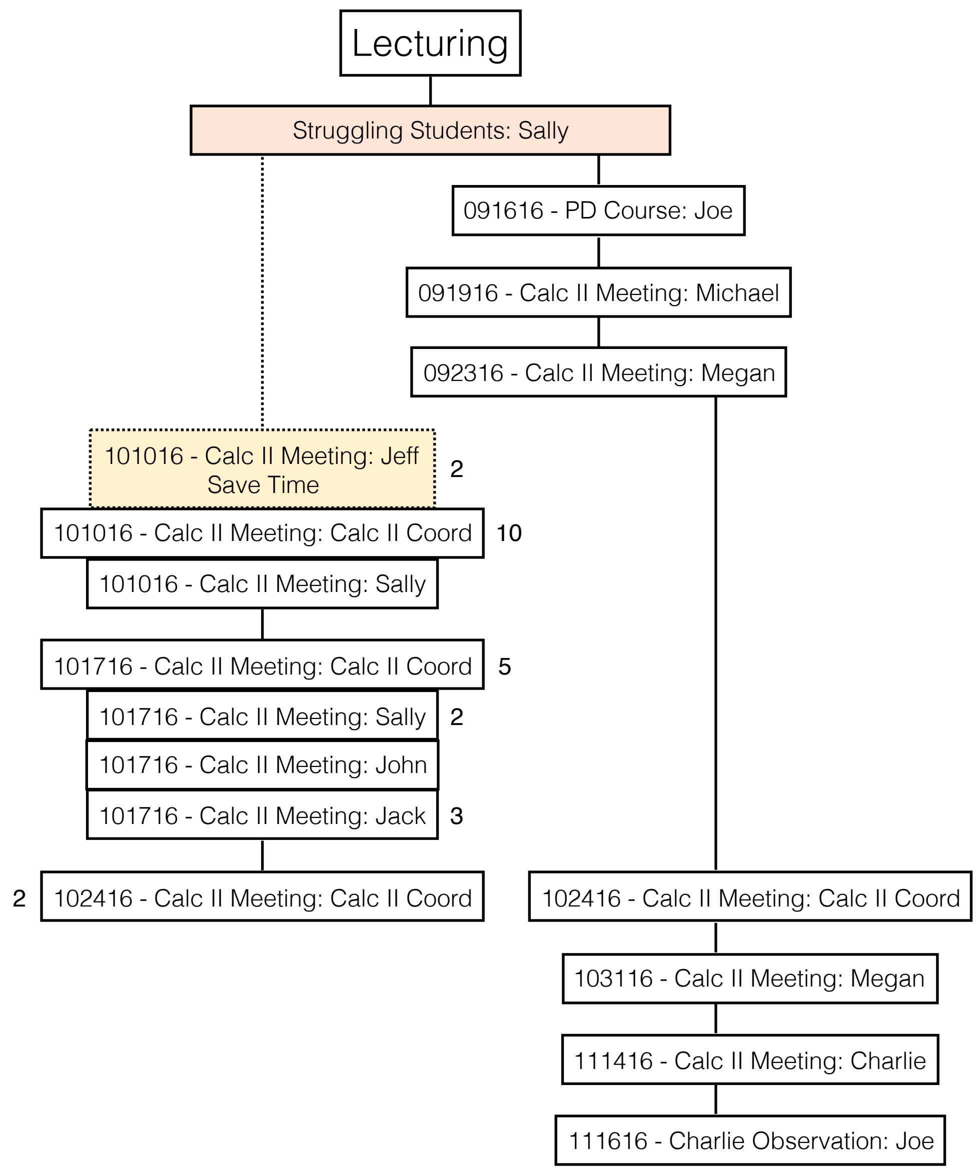

Lecturing
A Felt Need: Dr. S
082316 - PD Seminar MCOPP: Dr. J
082516 - PD Seminar Practice: Calc II Coord
082516 - PD Seminar Practice: Dr. C
2
082916 - Calc II Meeting: Sally
An Assumed Need
090216 - PD Course: Dr. D
091416 - Leilani debrief: Justin
091416 - Leilani 9am debrief: Justin
Elaboration - Refocusing
091416 - Leilani debrief: Justin
091516 - Tina debrief: Justin
091516 - Observation_Tina: Justin
091516 - Sheri debrief: Justin
091516 - Observation_Tina: Justin
091516 - Tina debrief: Justin
091616 - PD Course: Adam
091916 - Calc II Meeting: Calc II Coord
092216 - Edgar debrief: Justin
2
092216 - Adam debrief: Justin
092216 - Adam debrief: Adam
092216 - David debrief: Justin
092216 - Adam debrief: Justin
101716 - Calc II Meeting: Charlie
110916 - Nancy Observation: Sheri
110916 - Week 11 Nancy: Justin
111016 - Week 11 Sheri: Justin
111716 - Week 12 David: Justin
2
111716 - Week 12 Edgar: Justin
120516 - Calc II Meeting: Megan

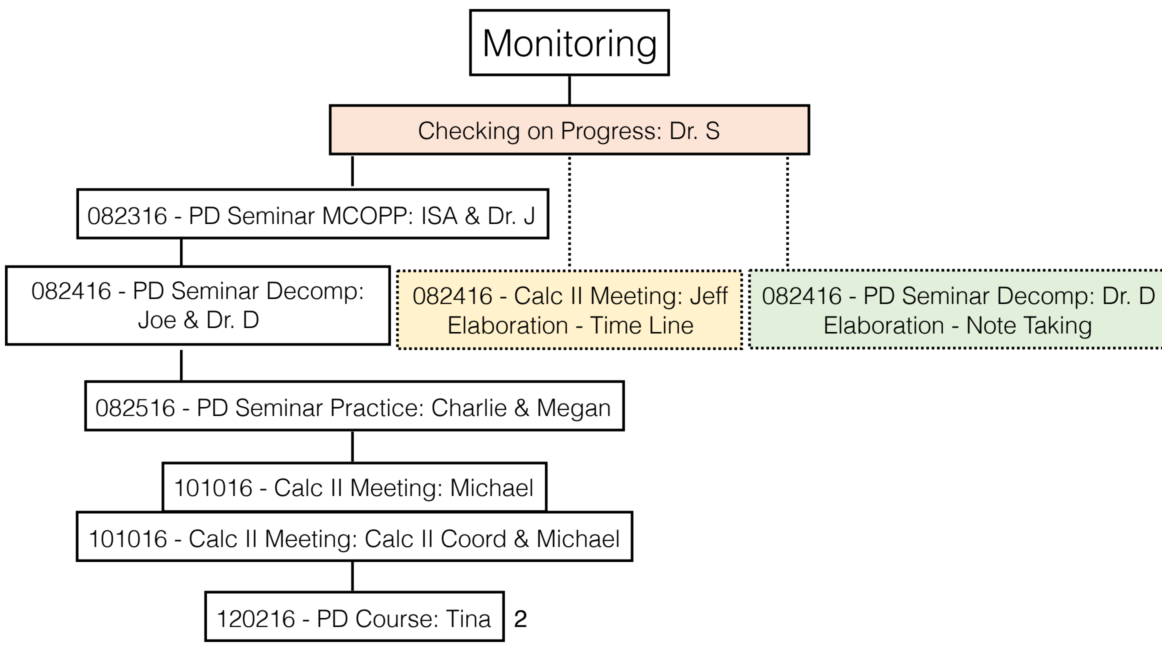

Lecturing
Forward Movement: Calc II Coord
082416 - Calc II Meeting: Jeff
Elaboration - Help students get started
090616 - Calc II Meeting: Jeff
091916 - Calc II Meeting: Joe
103016 - Calc II Meeting: Megan
103016 - Calc II Meeting: Jack
102416 - Calc II Meeting: Megan
102416 - Calc II Meeting: Calc II Coord
3
102416 - Calc II Meeting: Calc II Coord
103116 - Calc II Meeting: Jack
Elaboration - To speed things up
110416 - PD Course: Jeff
110416 - PD Course: Dr. D
111416 - Calc II Meeting: Joe
111616 - Charlie Observation: Joe
111716 - Tina debrief: Justin
120516 - Calc II Meeting: Joe &
Calc II Coord
120516 - Calc II Meeting:
Jack & Megan
120516 - Calc II Meeting: Calc II Coord
120516 - Calc II Meeting: Jack & Joe

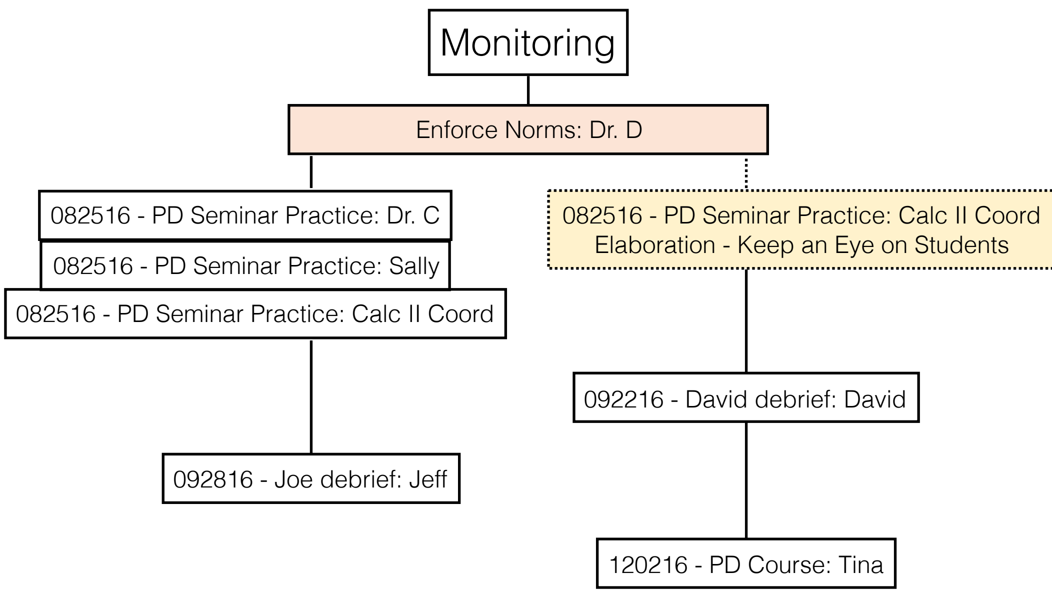

Lecturing
Shared Understanding: Dr. S
082316 - PD Seminar Intro: ISA & Dr. S
082416 - PD Seminar Decomp: Dr. C
082916 - Calc II Meeting: Calc II Coord
Telling to avoid confusion
090216 - Calc I Meeting: David
091216 - Calc II Meeting: Megan
091416 - Leilani debrief: Justin
091516 - Sheri debrief: Justin
091516 - Tina debrief: Justin
091516 - Tina debrief: Justin
Elaboration - Refocusing
091516 - Sheri debrief: Justin
2
092216 - Adam debrief: Justin
092316 - Calc I Meeting: Justin
Elaboration - Reinforce ideas
102116 - Calc I Meeting: Justin
102116 - Calc I Meeting: Tina
102416 - Calc II Meeting: Joe
102416 - Calc II Meeting: Calc II Coord
111416 - Calc II Meeting: Jeff
111416 - Calc II Meeting: Calc II Coord
111616 - GTA Observation: GTA
111716 - Week 12 Adam: Justin
120516 - Calc II Meeting: Calc II Coord

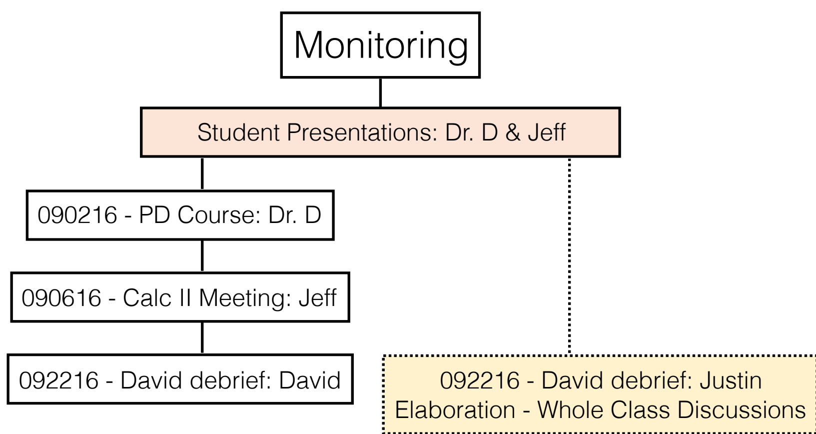


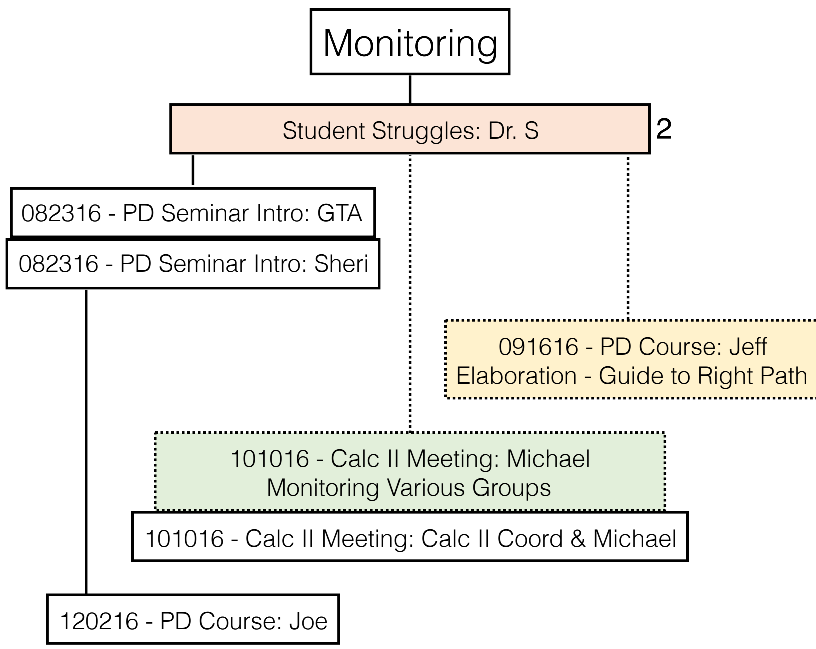
Lecturing
Straight Lecturing: Dr. C
082316 - PD Seminar MCOPP: Dr. D
082316 - PD Seminar MCOPP: Dr. J
082316 - PD Seminar MCOPP: Charlie & Dr. J
3
082516 - PD Seminar Practice: Dr. C
Elaboration - Tell Conventions
082916 - Calc II Meeting: Jeff
090216 - Calc I Meeting: David
Review Material
091216 - Calc II Meeting: Jack
Explain Specific Topics
091516 - Tina debrief: Justin
091616 - PD Course: Dr. D
091916 - Calc II Meeting: Calc II Coord
092216 - Edgar debrief: Justin
101416 - PD Course: Nancy
101416 - PD Course: Justin
101716 - Calc II Meeting: Sally
103116 - Calc II Meeting: Joe
2
111716 - Week 12 Tina: Justin


Lecturing
Struggling Students: Sally
091616 - PD Course: Joe
091916 - Calc II Meeting: Michael
092316 - Calc II Meeting: Megan
101016 - Calc II Meeting: Jeff
Save Time
2
101016 - Calc II Meeting: Calc II Coord
10
101016 - Calc II Meeting: Sally
101716 - Calc II Meeting: Calc II Coord
5
101716 - Calc II Meeting: Sally
2
101716 - Calc II Meeting: John
101716 - Calc II Meeting: Jack
3
2
102416 - Calc II Meeting: Calc II Coord
102416 - Calc II Meeting: Calc II Coord
103116 - Calc II Meeting: Megan
111416 - Calc II Meeting: Charlie
111616 - Charlie Observation: Joe

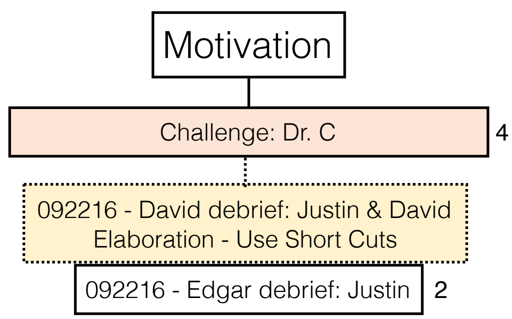

Monitoring
Checking on Progress: Dr. S
082316 - PD Seminar MCOPP: ISA & Dr. J
082416 - PD Seminar Decomp: Joe & Dr. D
082416 - Calc II Meeting: Jeff Elaboration - Time Line
082416 - PD Seminar Decomp: Dr. D Elaboration - Note Taking
082516 - PD Seminar Practice: Charlie & Megan
101016 - Calc II Meeting: Michael
101016 - Calc II Meeting: Calc II Coord & Michael
120216 - PD Course: Tina
2

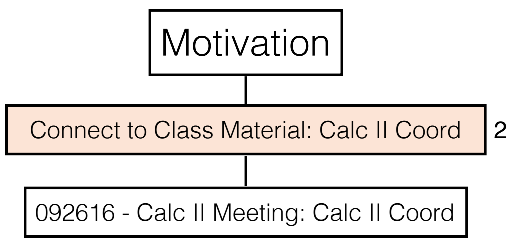

Monitoring
Enforce Norms: Dr. D
082516 - PD Seminar Practice: Dr. C
082516 - PD Seminar Practice: Sally
082516 - PD Seminar Practice: Calc II Coord
092816 - Joe debrief: Jeff
082516 - PD Seminar Practice: Calc II Coord
Elaboration - Keep an Eye on Students
092216 - David debrief: David
120216 - PD Course: Tina

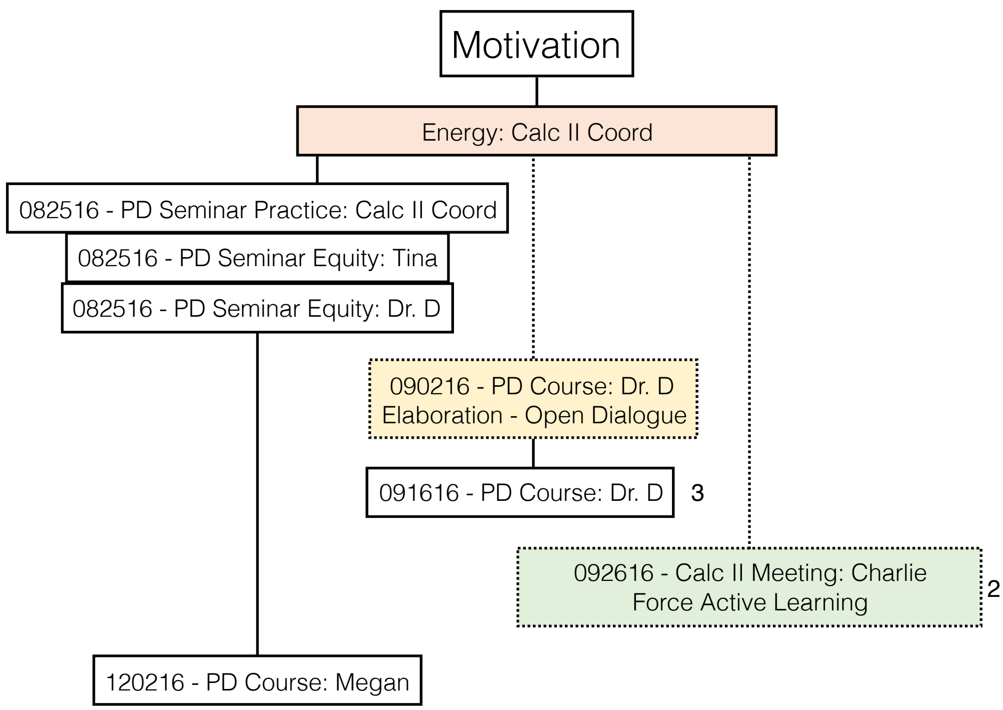

Monitoring
Student Presentations: Dr. D & Jeff
090216 - PD Course: Dr. D
090616 - Calc II Meeting: Jeff
092216 - David debrief: David
092216 - David debrief: Justin
Elaboration - Whole Class Discussions

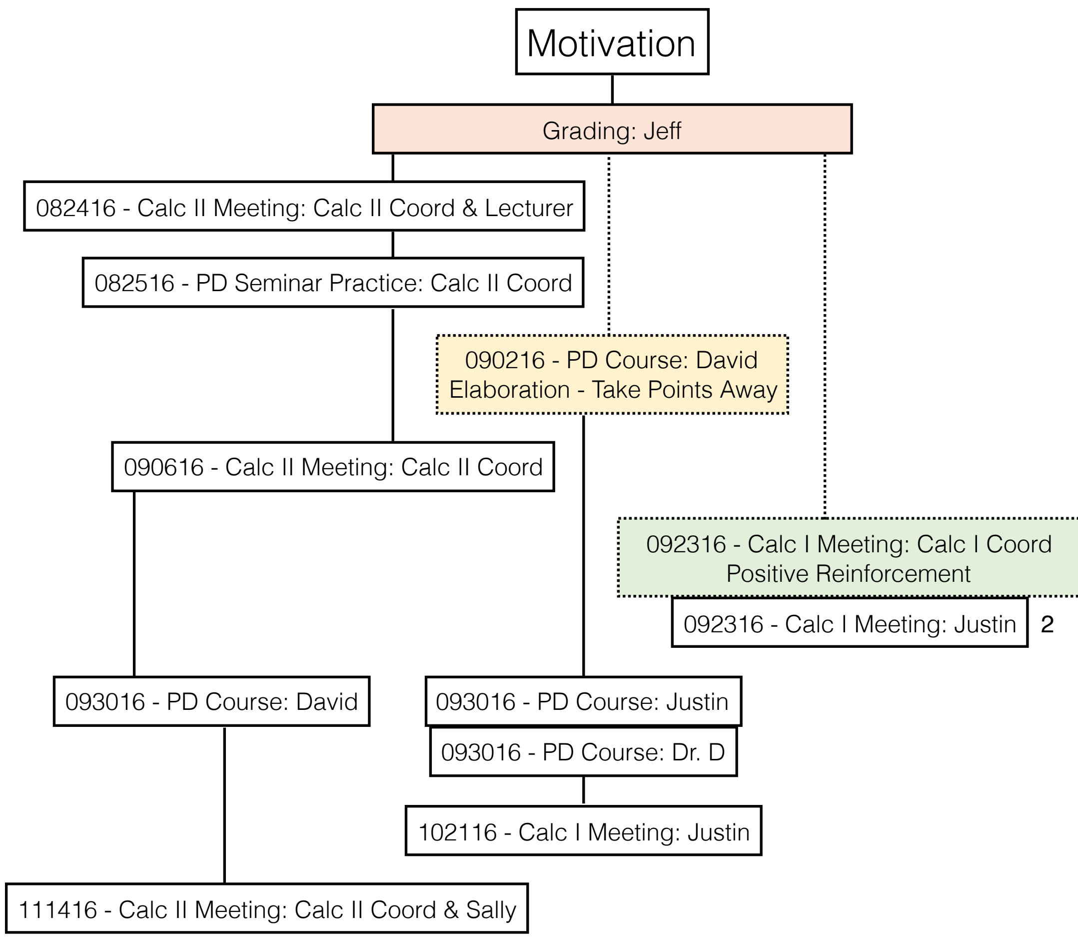


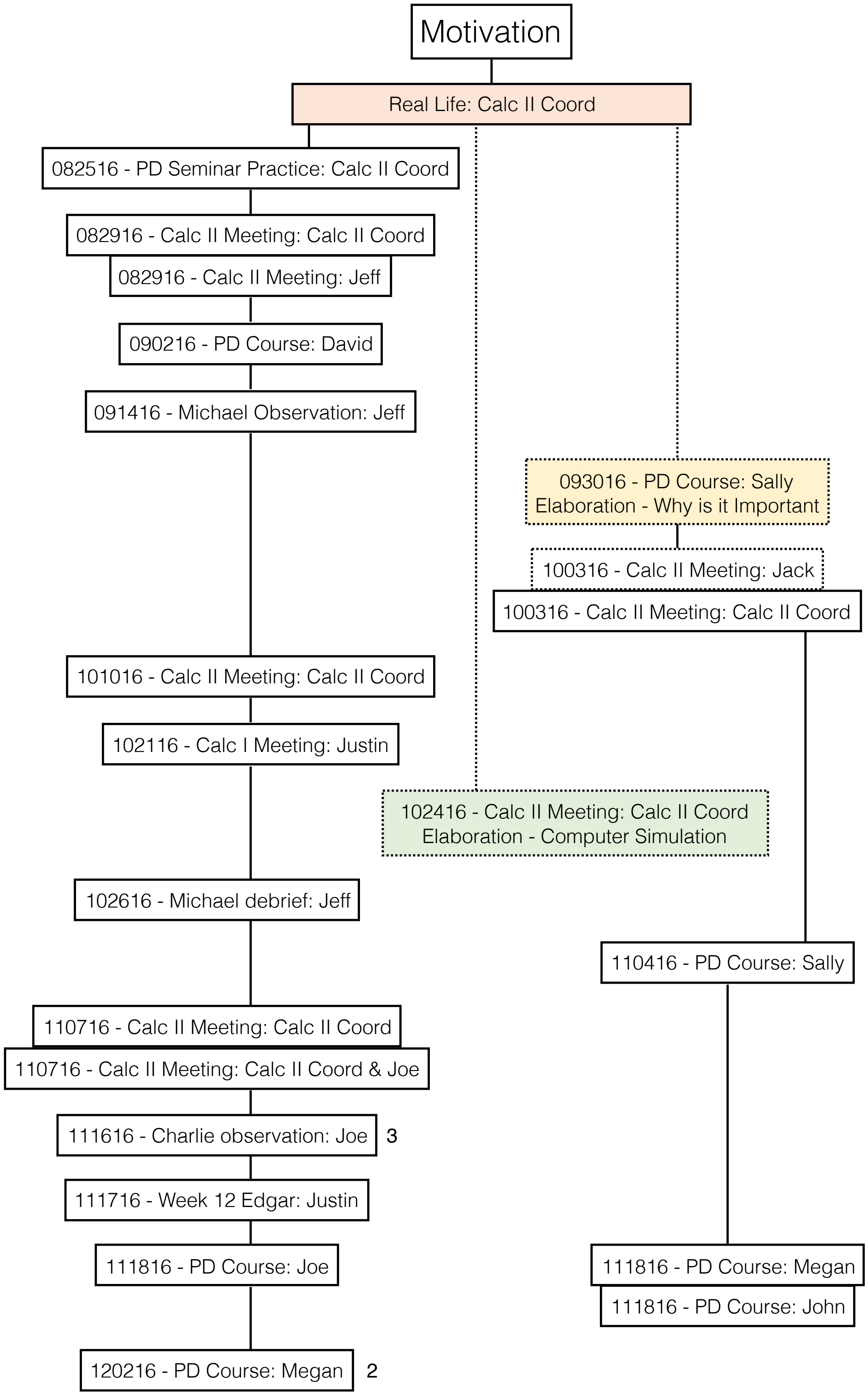
Monitoring
Student Struggles: Dr. S
2
082316 - PD Seminar Intro: GTA
082316 - PD Seminar Intro: Sheri
091616 - PD Course: Jeff
Elaboration - Guide to Right Path
101016 - Calc II Meeting: Michael
Monitoring Various Groups
101016 - Calc II Meeting: Calc II Coord & Michael
120216 - PD Course: Joe

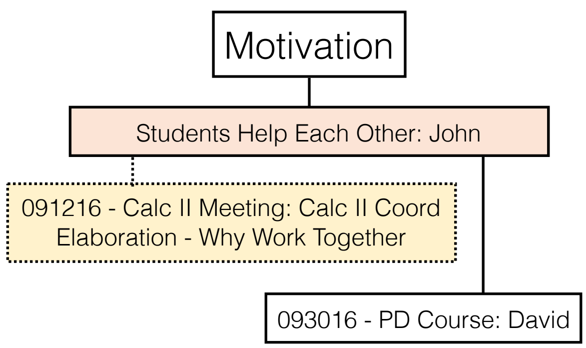

Motivation
Challenge: Dr. C
4
092216 - David debrief: Justin & David
Elaboration - Use Short Cuts
092216 - Edgar debrief: Justin
2

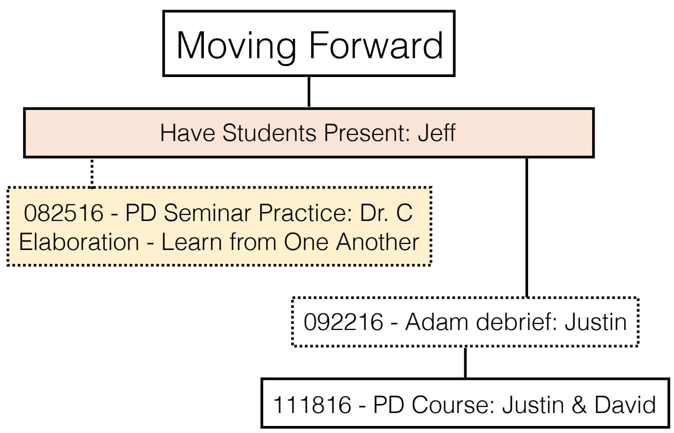

Motivation
Connect to Class Material: Calc II Coord
2
092616 - Calc II Meeting: Calc II Coord


Motivation
Energy: Calc II Coord
082516 - PD Seminar Practice: Calc II Coord
082516 - PD Seminar Equity: Tina
082516 - PD Seminar Equity: Dr. D
090216 - PD Course: Dr. D
Elaboration - Open Dialogue
091616 - PD Course: Dr. D
3
092616 - Calc II Meeting: Charlie
Force Active Learning
2
120216 - PD Course: Megan


Motivation
Grading: Jeff
082416 - Calc II Meeting: Calc II Coord & Lecturer
082516 - PD Seminar Practice: Calc II Coord
090216 - PD Course: David
Elaboration - Take Points Away
090616 - Calc II Meeting: Calc II Coord
092316 - Calc I Meeting: Calc I Coord
Positive Reinforcement
092316 - Calc I Meeting: Justin
2
093016 - PD Course: David
093016 - PD Course: Justin
093016 - PD Course: Dr. D
102116 - Calc I Meeting: Justin
111416 - Calc II Meeting: Calc II Coord & Sally

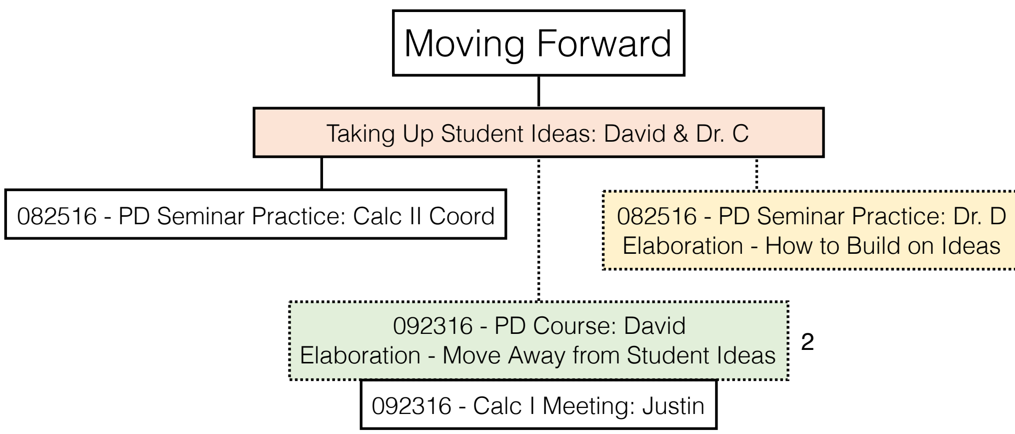

Motivation
Real Life: Calc II Coord
082516 - PD Seminar Practice: Calc II Coord
082916 - Calc II Meeting: Calc II Coord
082916 - Calc II Meeting: Jeff
090216 - PD Course: David
091416 - Michael Observation: Jeff
093016 - PD Course: Sally
Elaboration - Why is it Important
100316 - Calc II Meeting: Jack
100316 - Calc II Meeting: Calc II Coord
101016 - Calc II Meeting: Calc II Coord
102116 - Calc I Meeting: Justin
102416 - Calc II Meeting: Calc II Coord
Elaboration - Computer Simulation
102616 - Michael debrief: Jeff
110416 - PD Course: Sally
110716 - Calc II Meeting: Calc II Coord
110716 - Calc II Meeting: Calc II Coord & Joe
111616 - Charlie observation: Joe
3
111716 - Week 12 Edgar: Justin
111816 - PD Course: Joe
111816 - PD Course: Megan
111816 - PD Course: John
120216 - PD Course: Megan
2

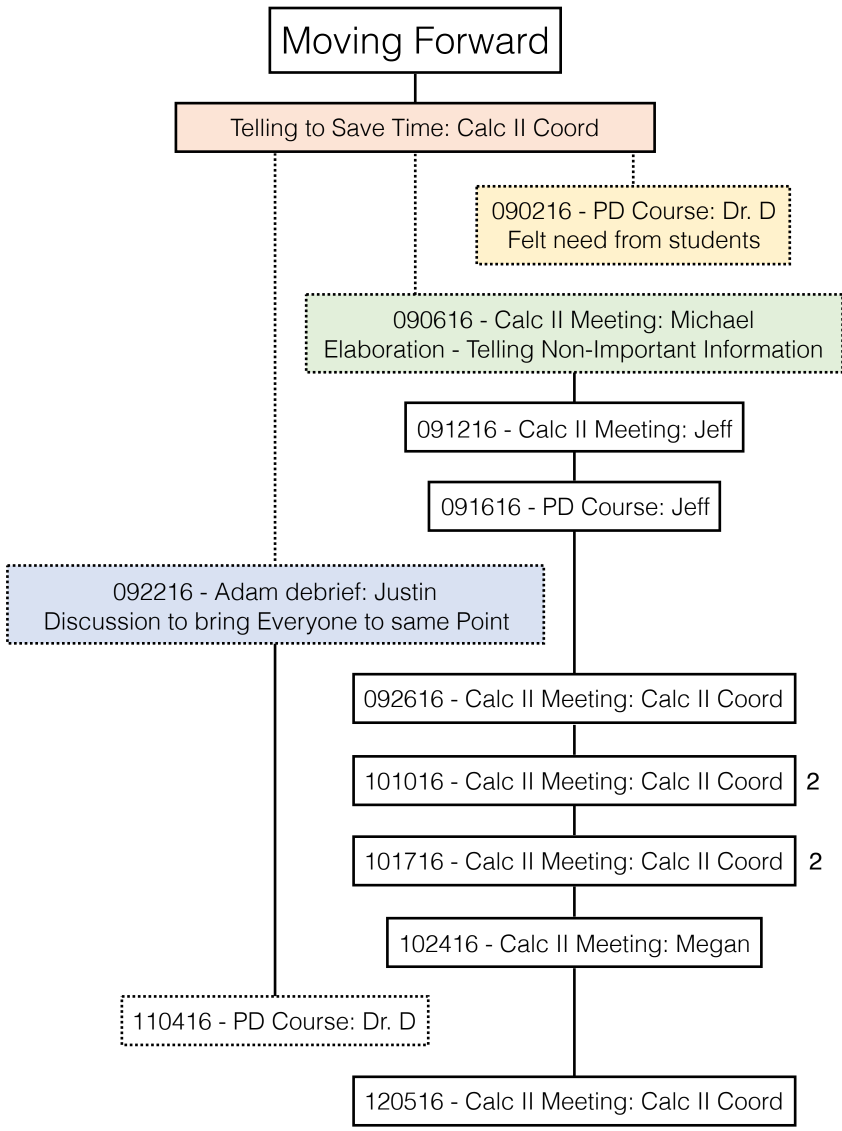

Motivation
Students Help Each Other: John
091216 - Calc II Meeting: Calc II Coord
Elaboration - Why Work Together
093016 - PD Course: David


Moving Forward
Have Students Present: Jeff
082516 - PD Seminar Practice: Dr. C
Elaboration - Learn from One Another
092216 - Adam debrief: Justin
111816 - PD Course: Justin & David

Moving Forward

Move Forward with their Attention: Dr. D


Moving Forward
Taking Up Student Ideas: David & Dr. C
082516 - PD Seminar Practice: Calc II Coord
082516 - PD Seminar Practice: Dr. D
Elaboration - How to Build on Ideas
092316 - PD Course: David
Elaboration - Move Away from Student Ideas
2
092316 - Calc I Meeting: Justin


Moving Forward
Telling to Save Time: Calc II Coord
090216 - PD Course: Dr. D
Felt need from students
090616 - Calc II Meeting: Michael
Elaboration - Telling Non-Important Information
091216 - Calc II Meeting: Jeff
091616 - PD Course: Jeff
092216 - Adam debrief: Justin
Discussion to bring Everyone to same Point
092616 - Calc II Meeting: Calc II Coord
101016 - Calc II Meeting: Calc II Coord
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101716 - Calc II Meeting: Calc II Coord
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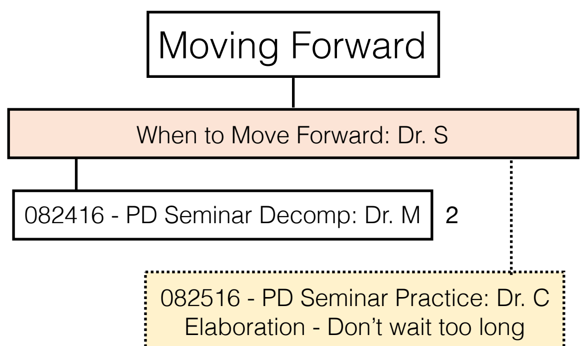
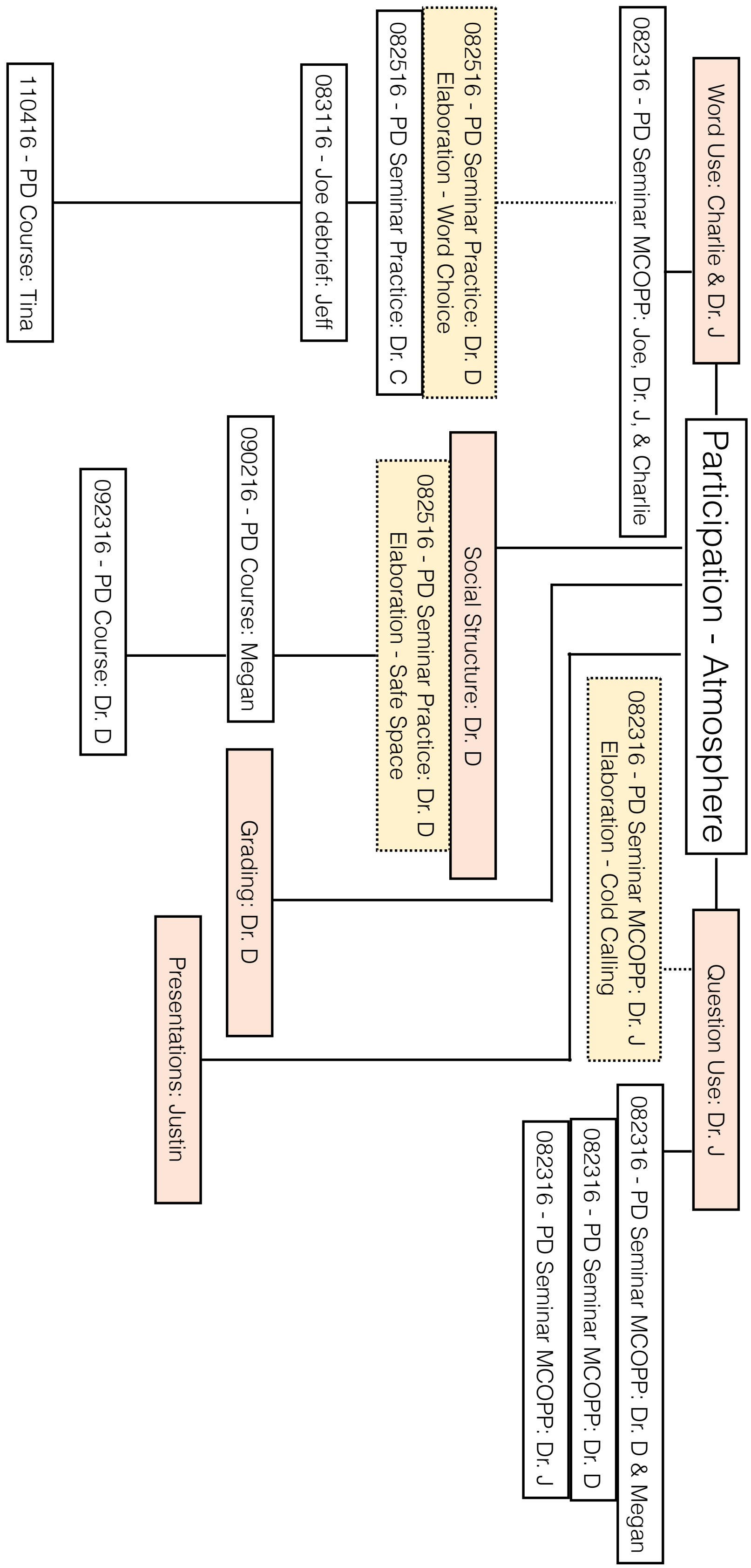
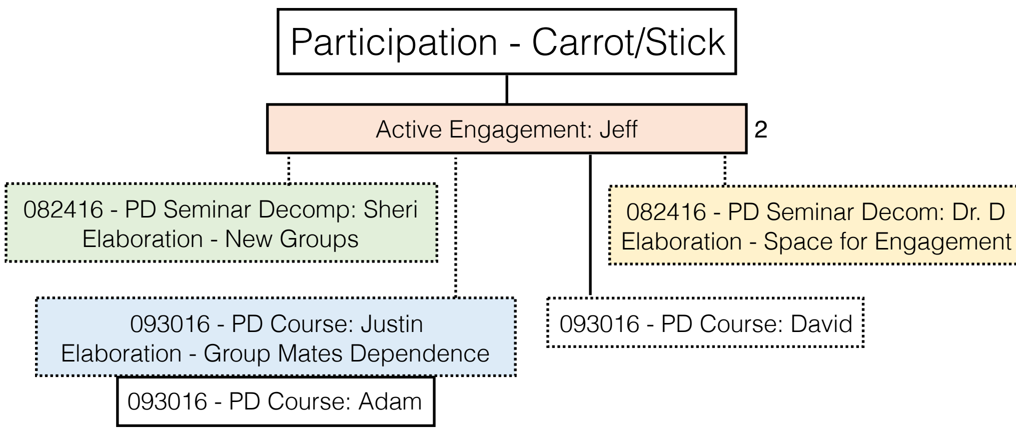
102416 - Calc II Meeting: Megan
110416 - PD Course: Dr. D
120516 - Calc II Meeting: Calc II Coord

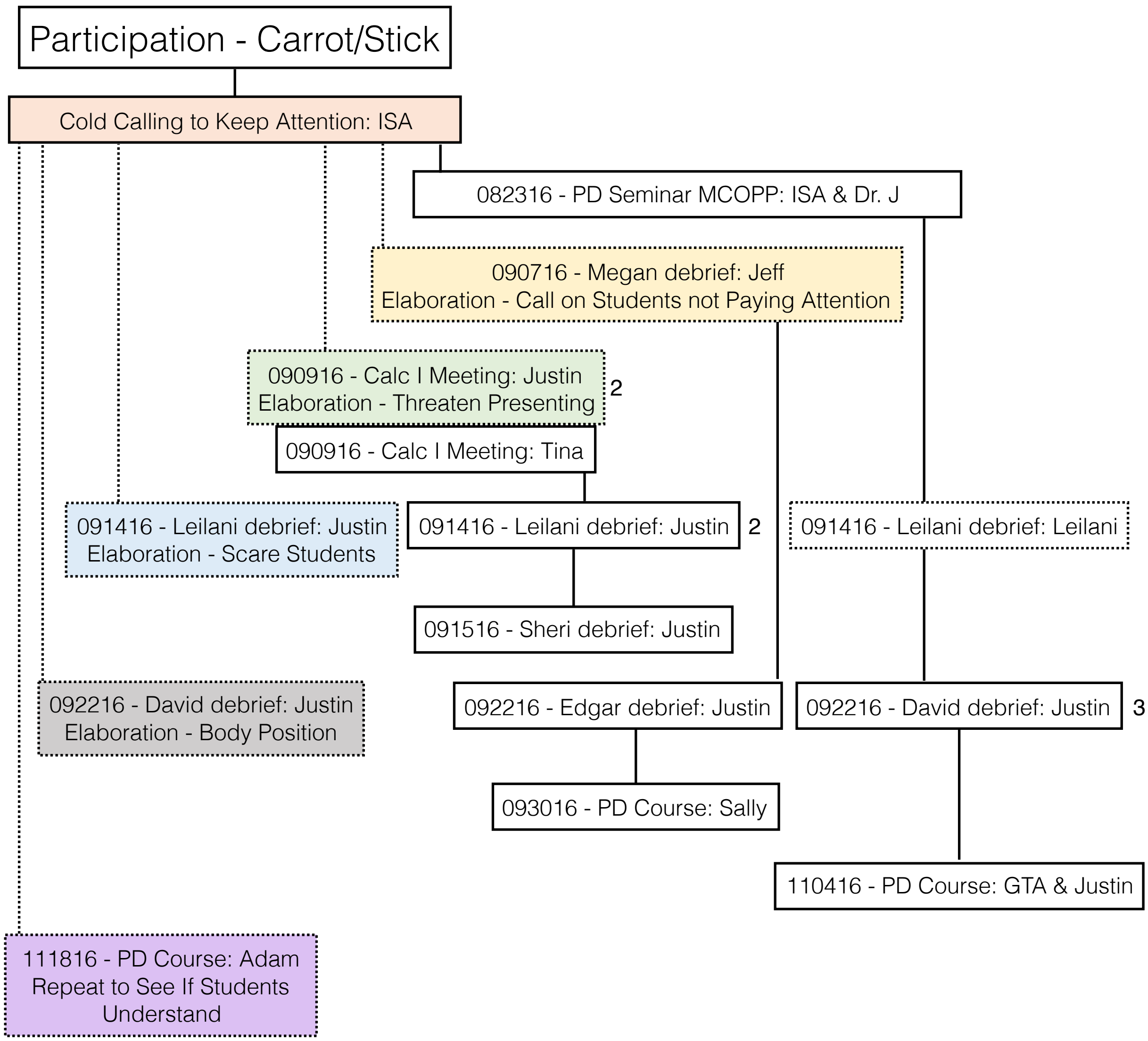

Moving Forward
When to Move Forward: Dr. S
082416 - PD Seminar Decomp: Dr. M
2
082516 - PD Seminar Practice: Dr. C
Elaboration - Don't wait too long

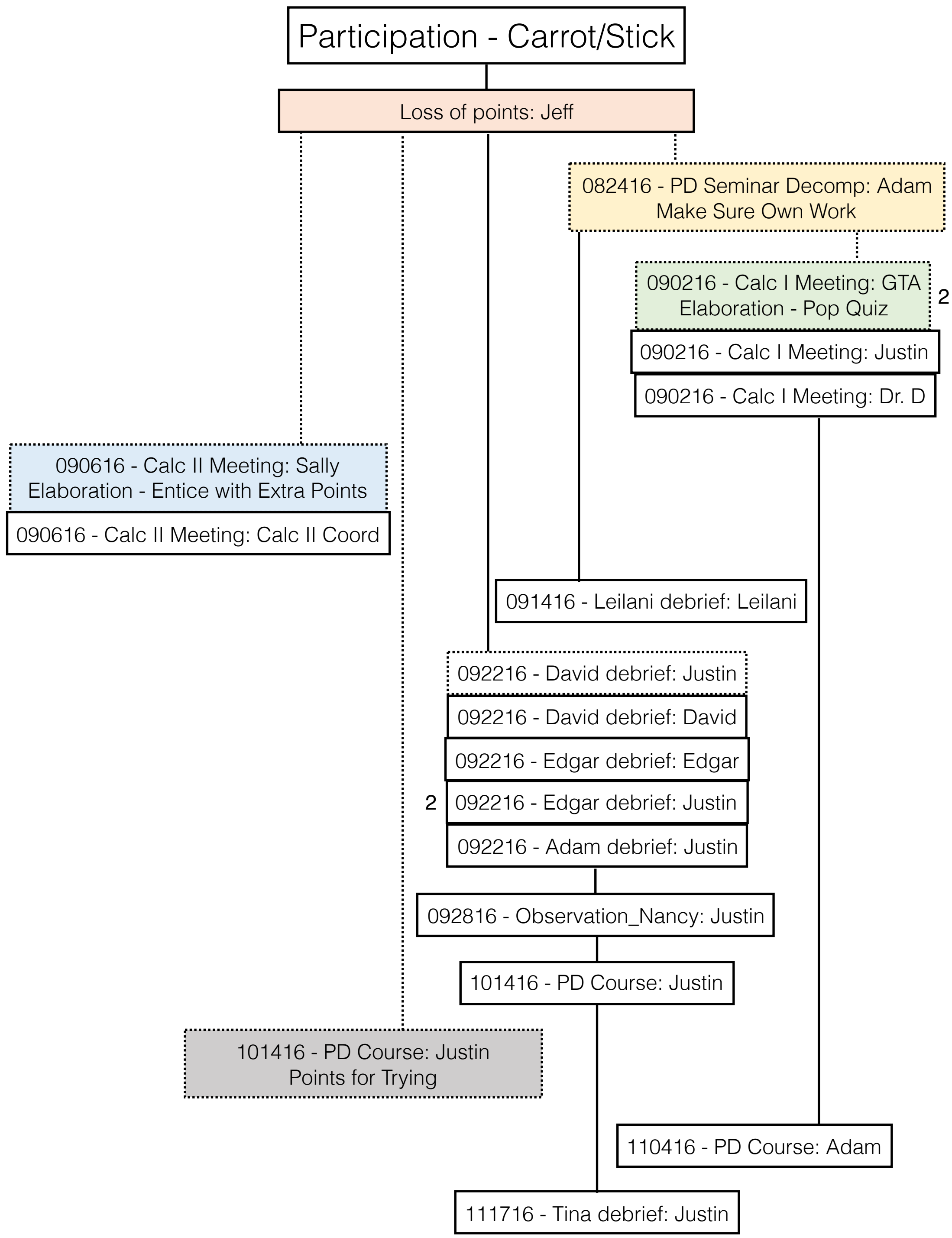


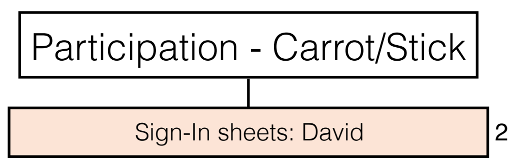
Participation - Atmosphere
Word Use: Charlie & Dr. J
082316 - PD Seminar MCOPP: Joe, Dr. J, & Charlie
082516 - PD Seminar Practice: Dr. D
Elaboration - Word Choice
082516 - PD Seminar Practice: Dr. C
083116 - Joe debrief: Jeff
110416 - PD Course: Tina
Social Structure: Dr. D
082516 - PD Seminar Practice: Dr. D
Elaboration - Safe Space
090216 - PD Course: Megan
092316 - PD Course: Dr. D
Grading: Dr. D
Presentations: Justin
Question Use: Dr. J
082316 - PD Seminar MCOPP: Dr. J
Elaboration - Cold Calling
082316 - PD Seminar MCOPP: Dr. D & Megan
082316 - PD Seminar MCOPP: Dr. D
082316 - PD Seminar MCOPP: Dr. J

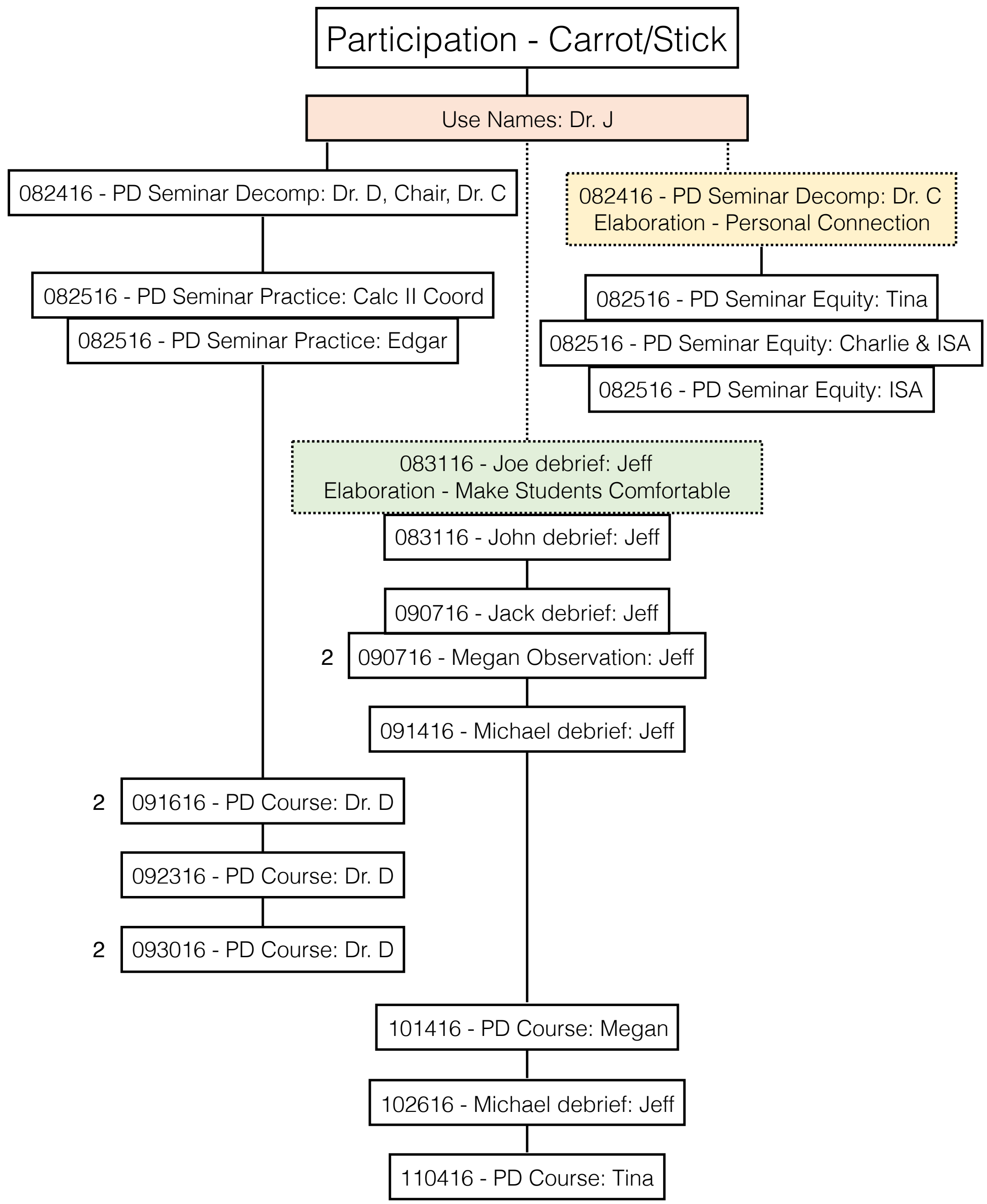


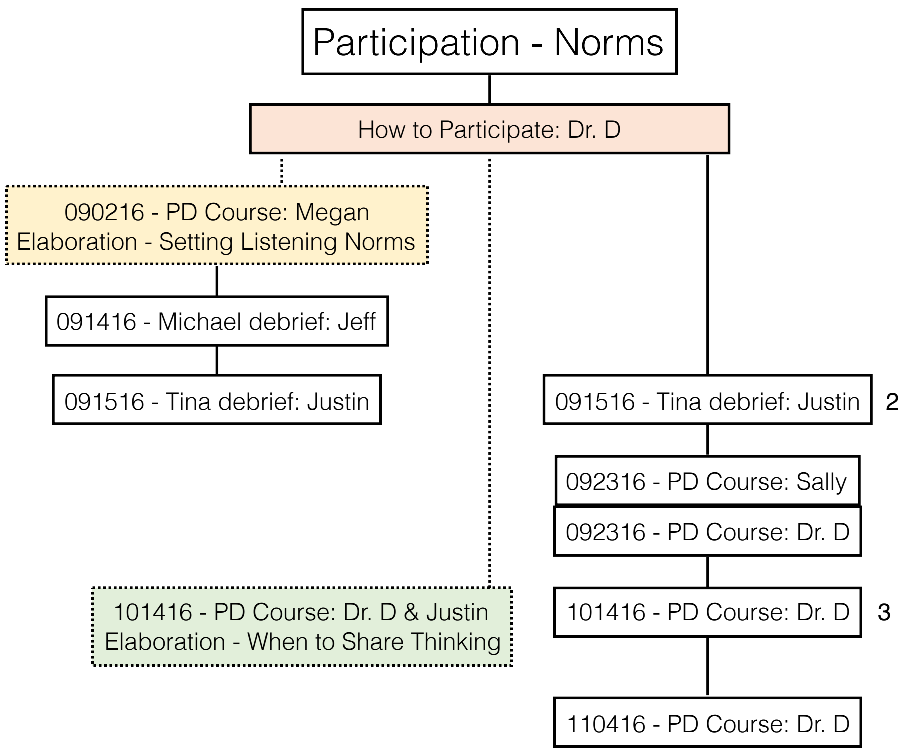
Participation - Carrot/Stick
Active Engagement: Jeff
2
082416 - PD Seminar Decomp: Sheri
Elaboration - New Groups
082416 - PD Seminar Decom: Dr. D
Elaboration - Space for Engagement
093016 - PD Course: Justin
Elaboration - Group Mates Dependence
093016 - PD Course: David
093016 - PD Course: Adam

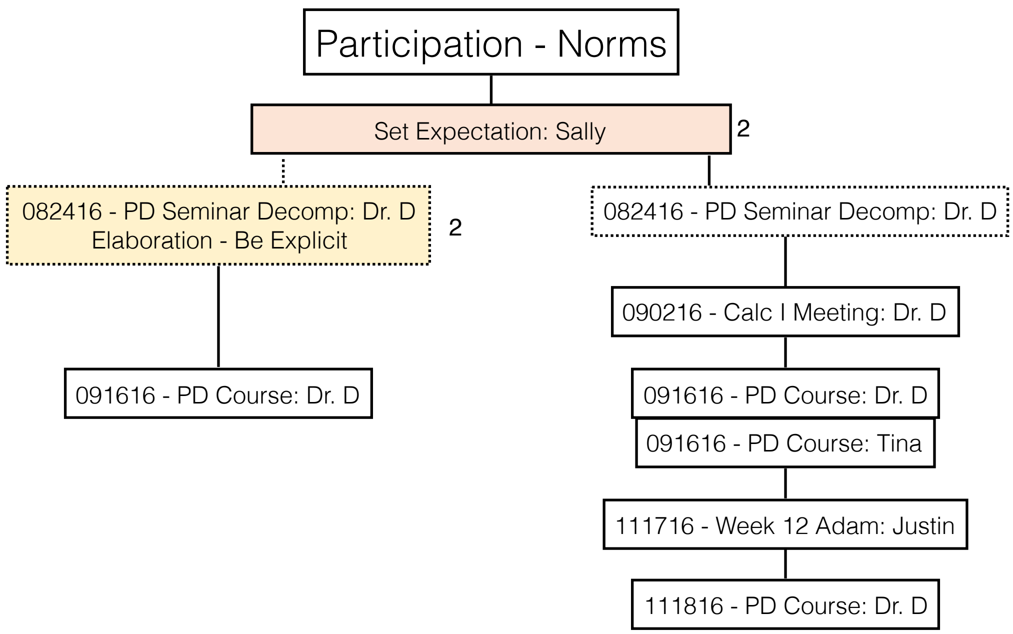

Participation - Carrot/Stick
Cold Calling to Keep Attention: ISA
082316 - PD Seminar MCOPP: ISA & Dr. J
090716 - Megan debrief: Jeff
Elaboration - Call on Students not Paying Attention
090916 - Calc I Meeting: Justin
Elaboration - Threaten Presenting
2
090916 - Calc I Meeting: Tina
091416 - Leilani debrief: Justin
Elaboration - Scare Students
091416 - Leilani debrief: Justin
2
091416 - Leilani debrief: Leilani
091516 - Sheri debrief: Justin
092216 - David debrief: Justin
Elaboration - Body Position
092216 - Edgar debrief: Justin
092216 - David debrief: Justin
3
093016 - PD Course: Sally
110416 - PD Course: GTA & Justin
111816 - PD Course: Adam
Repeat to See If Students
Understand

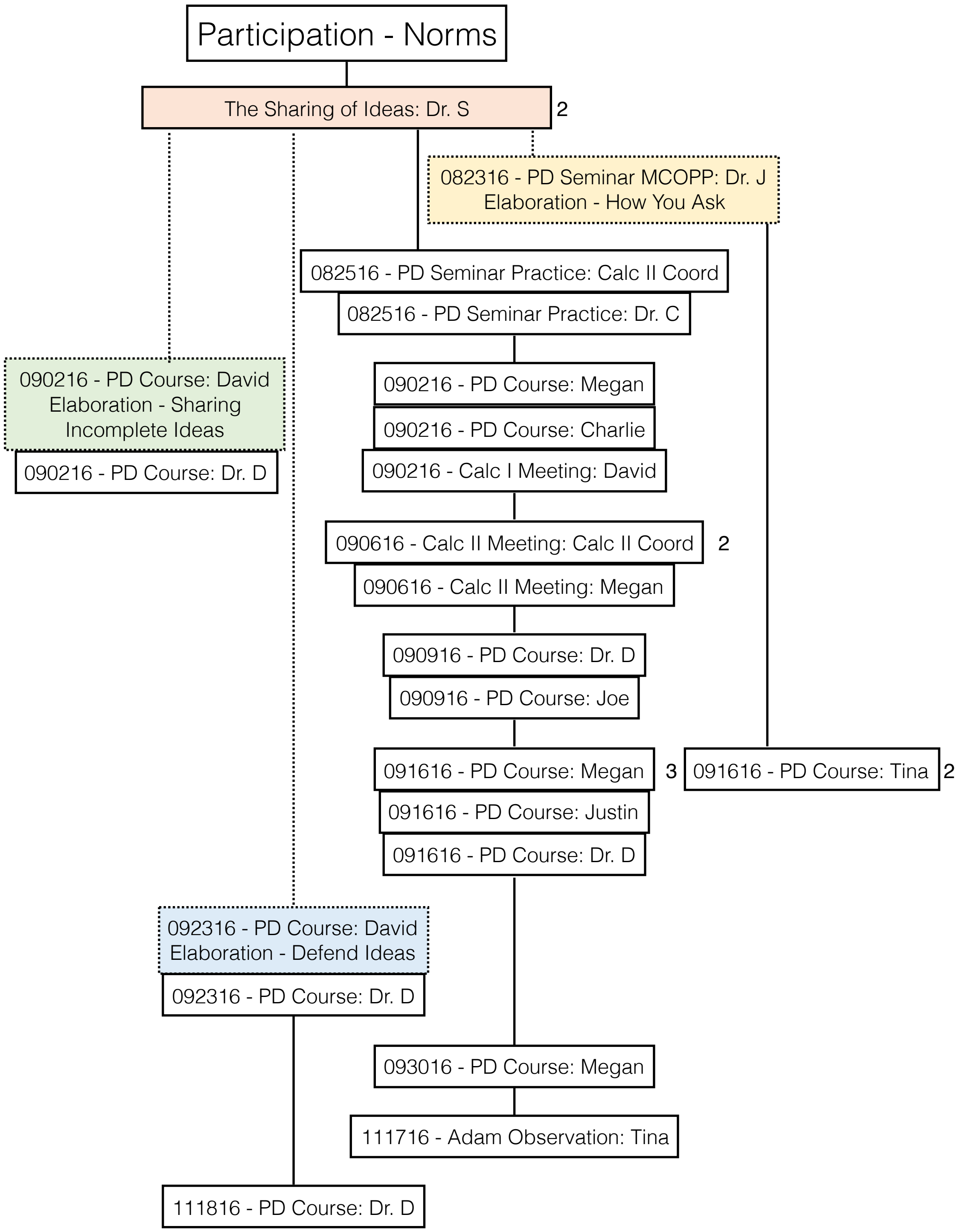

Participation - Carrot/Stick
Loss of points: Jeff
082416 - PD Seminar Decomp: Adam
Make Sure Own Work
090216 - Calc I Meeting: GTA
Elaboration - Pop Quiz
2
090216 - Calc I Meeting: Justin
090216 - Calc I Meeting: Dr. D
090616 - Calc II Meeting: Sally
Elaboration - Entice with Extra Points
090616 - Calc II Meeting: Calc II Coord
091416 - Leilani debrief: Leilani
092216 - David debrief: Justin
092216 - David debrief: David
092216 - Edgar debrief: Edgar
2
092216 - Edgar debrief: Justin
092216 - Adam debrief: Justin
092816 - Observation_Nancy: Justin
101416 - PD Course: Justin
101416 - PD Course: Justin
Points for Trying
110416 - PD Course: Adam
111716 - Tina debrief: Justin

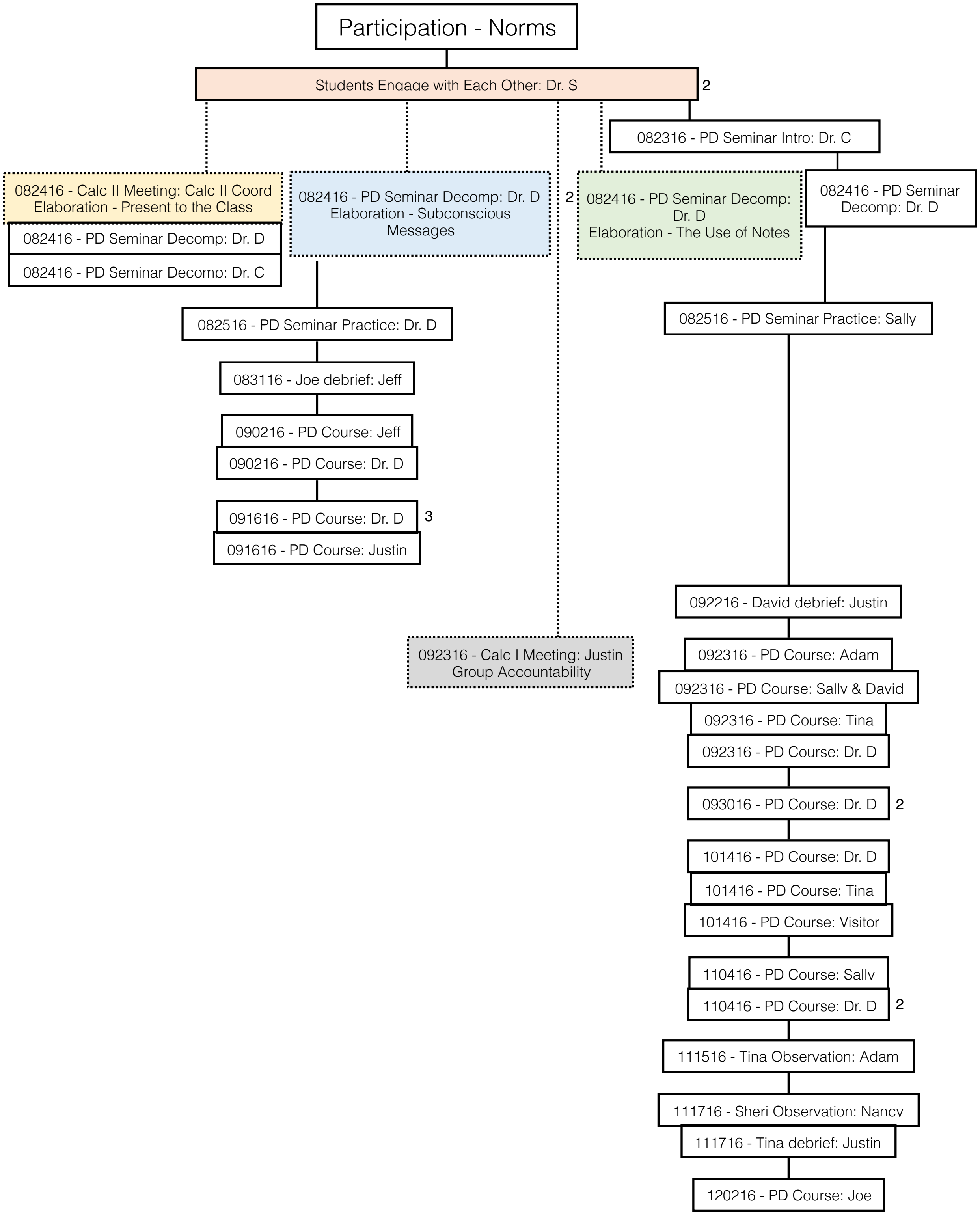

Participation - Carrot/Stick
Sign-In sheets: David
2


Participation - Carrot/Stick
Use Names: Dr. J
082416 - PD Seminar Decomp: Dr. D, Chair, Dr. C
082416 - PD Seminar Decomp: Dr. C
Elaboration - Personal Connection
082516 - PD Seminar Practice: Calc II Coord
082516 - PD Seminar Practice: Edgar
082516 - PD Seminar Equity: Tina
082516 - PD Seminar Equity: Charlie & ISA
082516 - PD Seminar Equity: ISA
083116 - Joe debrief: Jeff
Elaboration - Make Students Comfortable
083116 - John debrief: Jeff
090716 - Jack debrief: Jeff
2
090716 - Megan Observation: Jeff
091416 - Michael debrief: Jeff
2
091616 - PD Course: Dr. D
092316 - PD Course: Dr. D
2
093016 - PD Course: Dr. D
101416 - PD Course: Megan
102616 - Michael debrief: Jeff
110416 - PD Course: Tina


Participation - Norms
How to Participate: Dr. D
090216 - PD Course: Megan
Elaboration - Setting Listening Norms
091416 - Michael debrief: Jeff
091516 - Tina debrief: Justin
091516 - Tina debrief: Justin
2
092316 - PD Course: Sally
092316 - PD Course: Dr. D
101416 - PD Course: Dr. D & Justin
Elaboration - When to Share Thinking
101416 - PD Course: Dr. D
3
110416 - PD Course: Dr. D


Participation - Norms
Set Expectation: Sally
2
082416 - PD Seminar Decomp: Dr. D
Elaboration - Be Explicit
2
082416 - PD Seminar Decomp: Dr. D
090216 - Calc I Meeting: Dr. D
091616 - PD Course: Dr. D
091616 - PD Course: Dr. D
091616 - PD Course: Tina
111716 - Week 12 Adam: Justin
111816 - PD Course: Dr. D


Participation - Norms
The Sharing of Ideas: Dr. S
2
082316 - PD Seminar MCOPP: Dr. J
Elaboration - How You Ask
082516 - PD Seminar Practice: Calc II Coord
082516 - PD Seminar Practice: Dr. C
090216 - PD Course: David
Elaboration - Sharing
Incomplete Ideas
090216 - PD Course: Dr. D
090216 - PD Course: Megan
090216 - PD Course: Charlie
090216 - Calc I Meeting: David
090616 - Calc II Meeting: Calc II Coord
2
090616 - Calc II Meeting: Megan
090916 - PD Course: Dr. D
090916 - PD Course: Joe
091616 - PD Course: Megan
3
091616 - PD Course: Tina
2
091616 - PD Course: Justin
091616 - PD Course: Dr. D
092316 - PD Course: David
Elaboration - Defend Ideas
092316 - PD Course: Dr. D
093016 - PD Course: Megan
111716 - Adam Observation: Tina
111816 - PD Course: Dr. D


Participation - Norms
Students Engage with Each Other: Dr. S
2
082416 - Calc II Meeting: Calc II Coord Elaboration - Present to the Class
082416 - PD Seminar Decomp: Dr. D
082416 - PD Seminar Decomp: Dr. C
082416 - PD Seminar Decomp: Dr. D Elaboration - Subconscious Messages
2
082416 - PD Seminar Decomp: Dr. D Elaboration - The Use of Notes
082316 - PD Seminar Intro: Dr. C
082416 - PD Seminar Decomp: Dr. D
082516 - PD Seminar Practice: Dr. D
083116 - Joe debrief: Jeff
090216 - PD Course: Jeff
090216 - PD Course: Dr. D
091616 - PD Course: Dr. D
3
091616 - PD Course: Justin
082516 - PD Seminar Practice: Sally
092216 - David debrief: Justin
092316 - Calc I Meeting: Justin Group Accountability
092316 - PD Course: Adam
092316 - PD Course: Sally & David
092316 - PD Course: Tina
092316 - PD Course: Dr. D
093016 - PD Course: Dr. D
2
101416 - PD Course: Dr. D
101416 - PD Course: Tina
101416 - PD Course: Visitor
110416 - PD Course: Sally
110416 - PD Course: Dr. D
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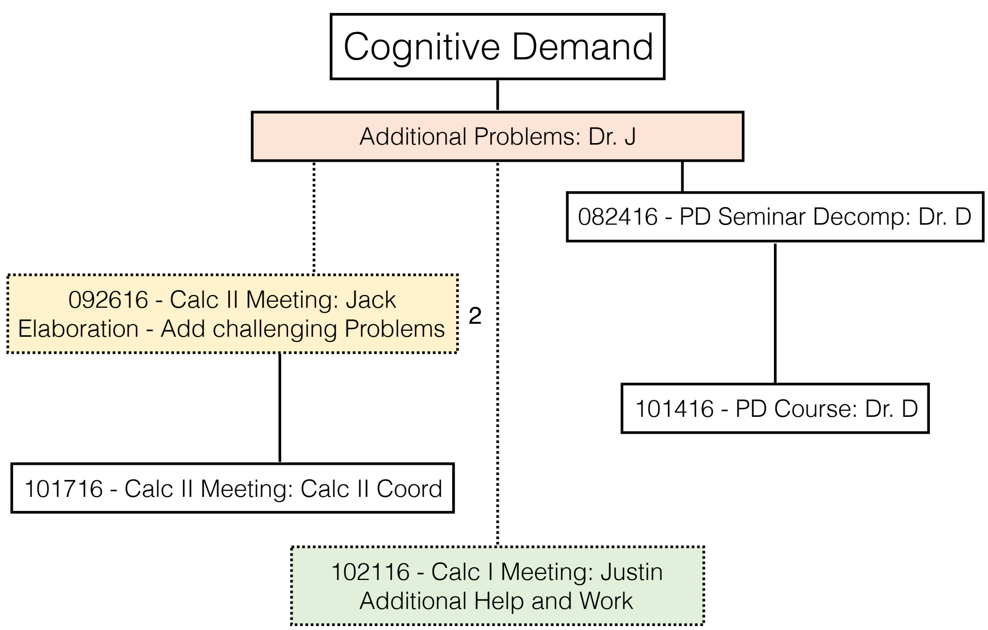
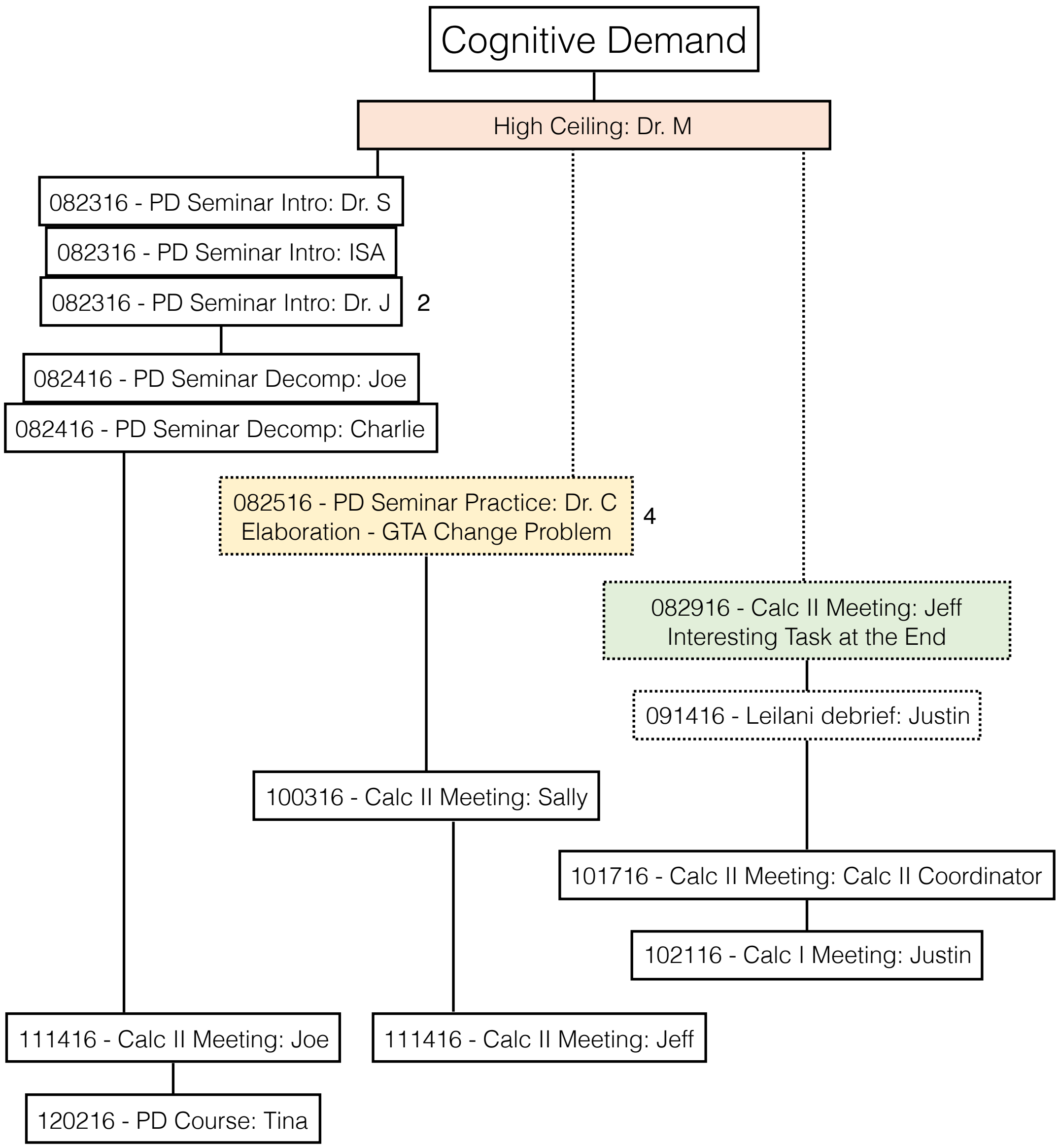
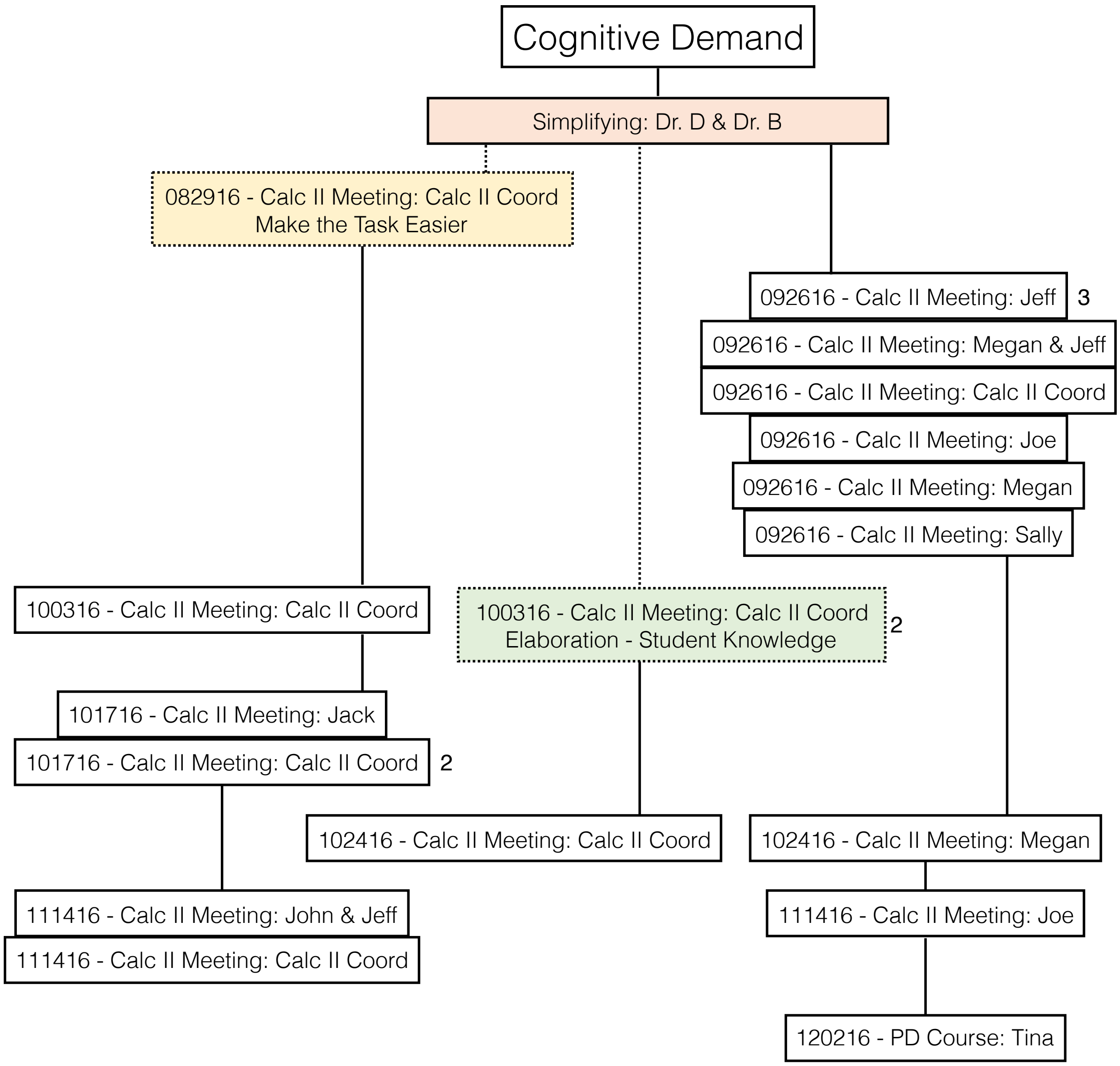
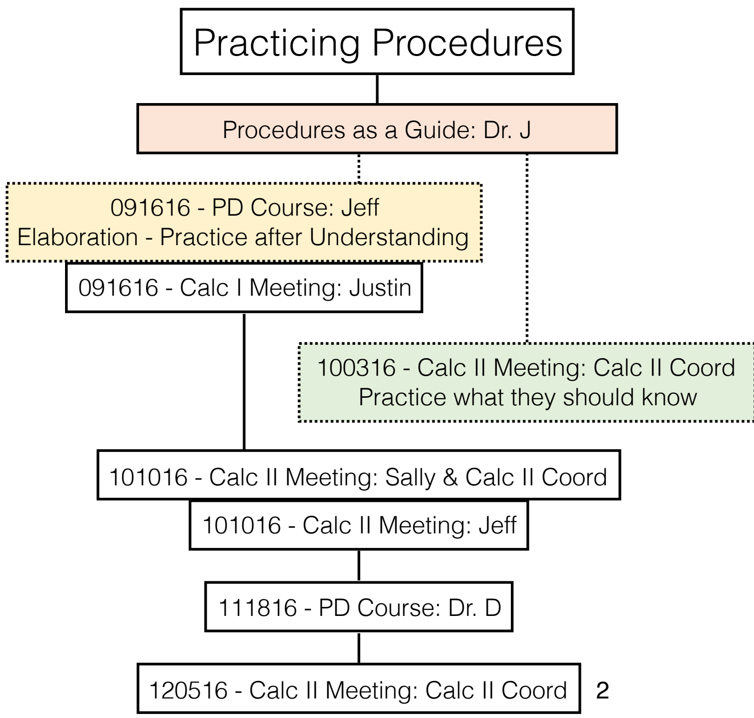
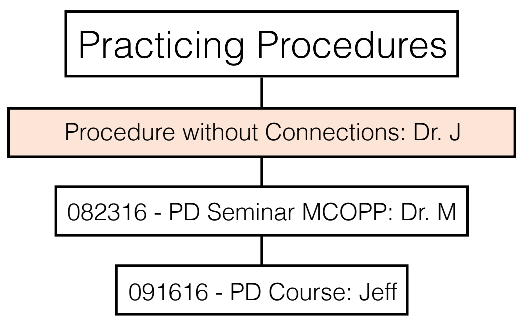
111516 - Tina Observation: Adam
111716 - Sheri Observation: Nancy
111716 - Tina debrief: Justin
120216 - PD Course: Joe

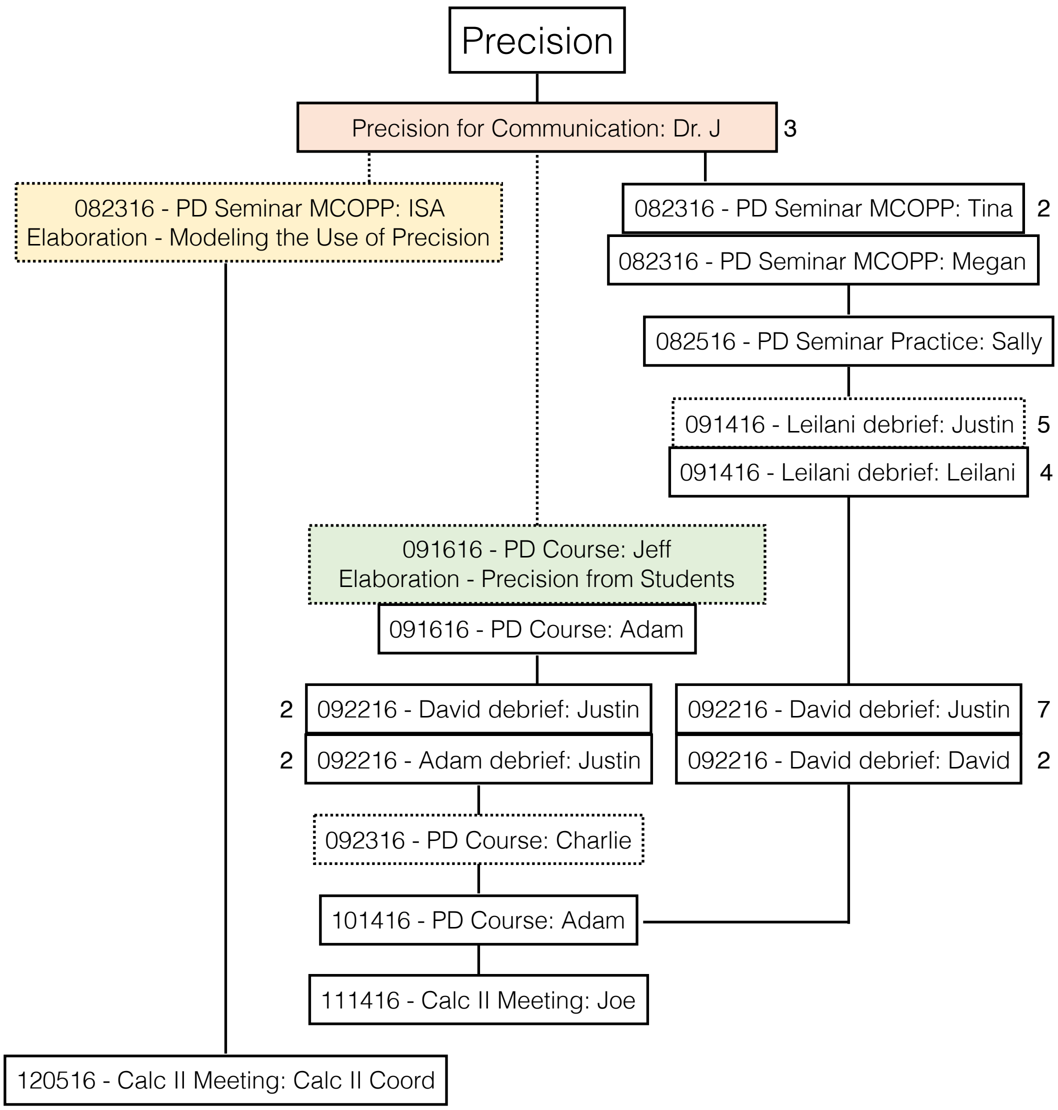

Cognitive Demand
Additional Problems: Dr. J
082416 - PD Seminar Decomp: Dr. D
092616 - Calc II Meeting: Jack
Elaboration - Add challenging Problems
2
101416 - PD Course: Dr. D
101716 - Calc II Meeting: Calc II Coord
102116 - Calc I Meeting: Justin
Additional Help and Work


Cognitive Demand
High Ceiling: Dr. M
082316 - PD Seminar Intro: Dr. S
082316 - PD Seminar Intro: ISA
082316 - PD Seminar Intro: Dr. J
2
082416 - PD Seminar Decomp: Joe
082416 - PD Seminar Decomp: Charlie
082516 - PD Seminar Practice: Dr. C
Elaboration - GTA Change Problem
4
082916 - Calc II Meeting: Jeff
Interesting Task at the End
091416 - Leilani debrief: Justin
100316 - Calc II Meeting: Sally
101716 - Calc II Meeting: Calc II Coordinator
102116 - Calc I Meeting: Justin
111416 - Calc II Meeting: Joe
111416 - Calc II Meeting: Jeff
120216 - PD Course: Tina


Cognitive Demand
Simplifying: Dr. D & Dr. B
082916 - Calc II Meeting: Calc II Coord
Make the Task Easier
092616 - Calc II Meeting: Jeff
3
092616 - Calc II Meeting: Megan & Jeff
092616 - Calc II Meeting: Calc II Coord
092616 - Calc II Meeting: Joe
092616 - Calc II Meeting: Megan
092616 - Calc II Meeting: Sally
100316 - Calc II Meeting: Calc II Coord
100316 - Calc II Meeting: Calc II Coord
Elaboration - Student Knowledge
2
101716 - Calc II Meeting: Jack
101716 - Calc II Meeting: Calc II Coord
2
102416 - Calc II Meeting: Calc II Coord
102416 - Calc II Meeting: Megan
111416 - Calc II Meeting: John & Jeff
111416 - Calc II Meeting: Calc II Coord
111416 - Calc II Meeting: Joe
120216 - PD Course: Tina


Practicing Procedures
Procedures as a Guide: Dr. J
091616 - PD Course: Jeff
Elaboration - Practice after Understanding
091616 - Calc I Meeting: Justin
100316 - Calc II Meeting: Calc II Coord
Practice what they should know
101016 - Calc II Meeting: Sally & Calc II Coord
101016 - Calc II Meeting: Jeff
111816 - PD Course: Dr. D
120516 - Calc II Meeting: Calc II Coord
2


Practicing Procedures
Procedure without Connections: Dr. J
082316 - PD Seminar MCOPP: Dr. M
091616 - PD Course: Jeff


Precision
Precision for Communication: Dr. J
3
082316 - PD Seminar MCOPP: ISA
Elaboration - Modeling the Use of Precision
082316 - PD Seminar MCOPP: Tina
2
082316 - PD Seminar MCOPP: Megan
082516 - PD Seminar Practice: Sally
091416 - Leilani debrief: Justin
5
091416 - Leilani debrief: Leilani
4
091616 - PD Course: Jeff
Elaboration - Precision from Students
091616 - PD Course: Adam
2
092216 - David debrief: Justin
2
092216 - Adam debrief: Justin
092216 - David debrief: Justin
7
092216 - David debrief: David
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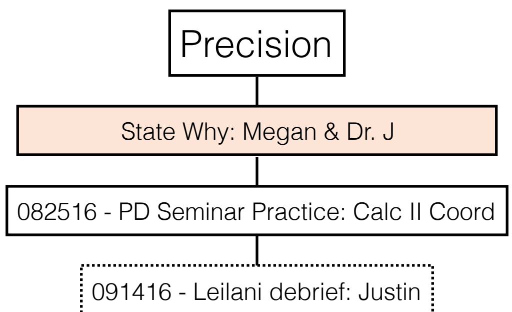
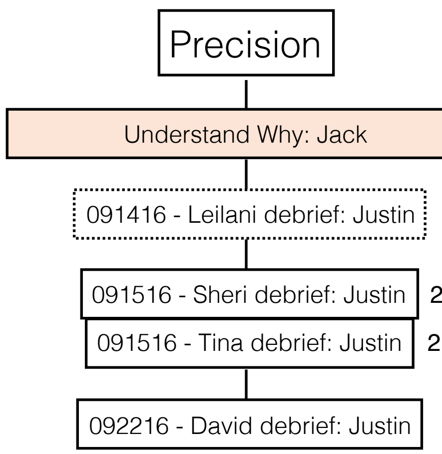
092316 - PD Course: Charlie
101416 - PD Course: Adam
111416 - Calc II Meeting: Joe
120516 - Calc II Meeting: Calc II Coord


Precision
State Why: Megan & Dr. J
082516 - PD Seminar Practice: Calc II Coord
091416 - Leilani debrief: Justin


Precision
Understand Why: Jack
091416 - Leilani debrief: Justin
091516 - Sheri debrief: Justin
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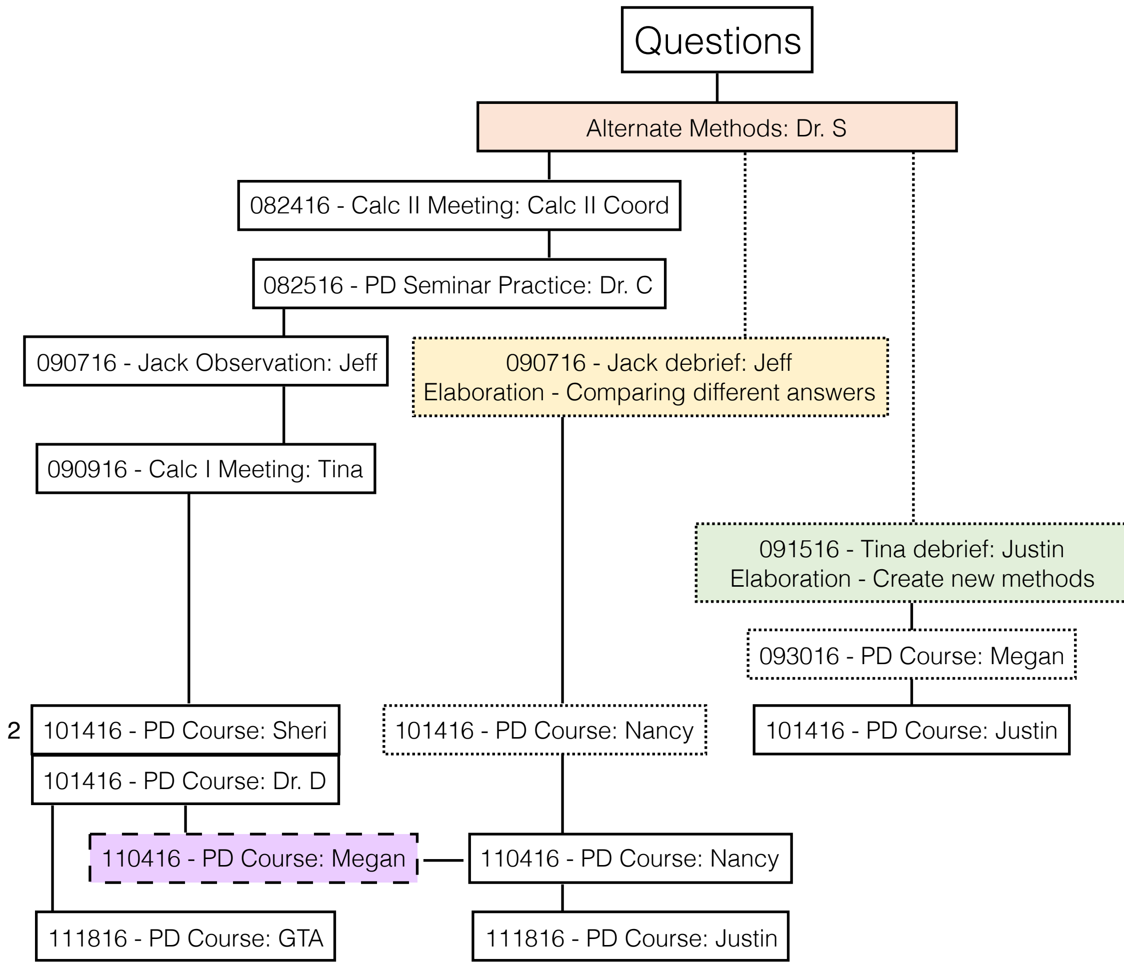
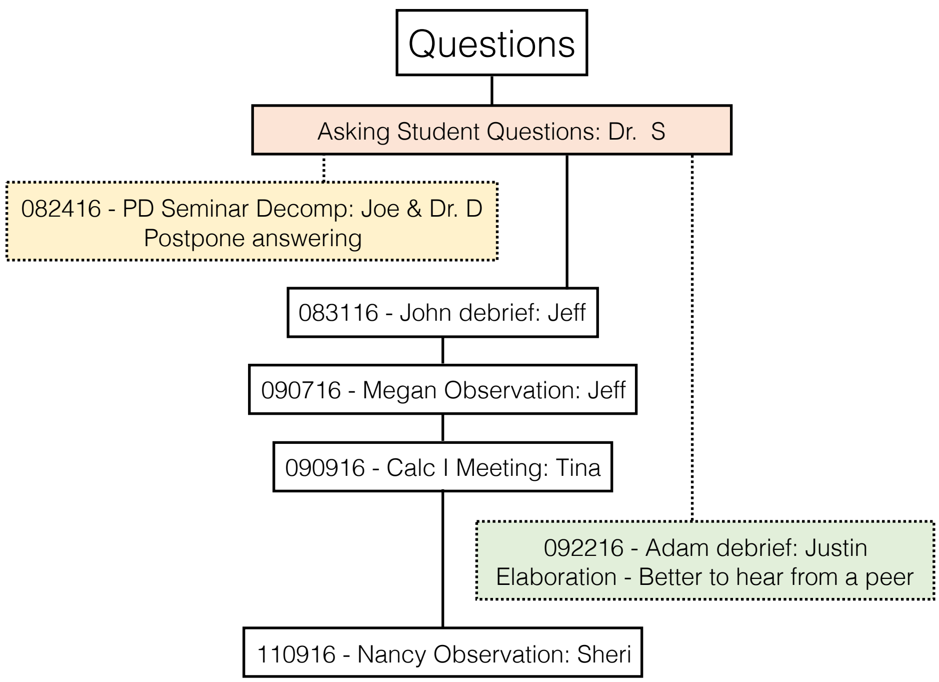
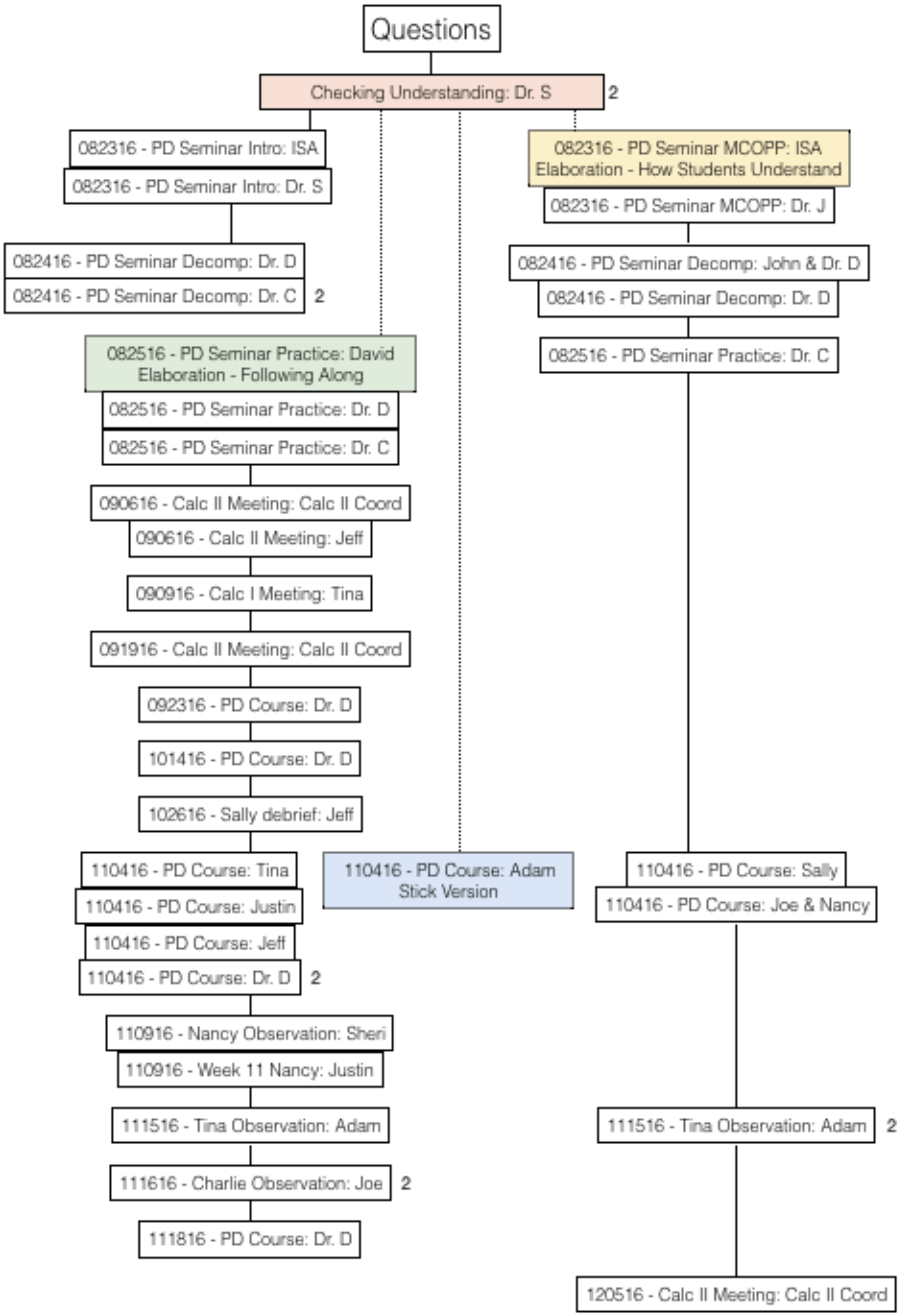
091516 - Tina debrief: Justin
2
092216 - David debrief: Justin


Questions
Alternate Methods: Dr. S
082416 - Calc II Meeting: Calc II Coord
082516 - PD Seminar Practice: Dr. C
090716 - Jack Observation: Jeff
090716 - Jack debrief: Jeff
Elaboration - Comparing different answers
090916 - Calc I Meeting: Tina
091516 - Tina debrief: Justin
Elaboration - Create new methods
093016 - PD Course: Megan
2
101416 - PD Course: Sheri
101416 - PD Course: Nancy
101416 - PD Course: Justin
101416 - PD Course: Dr. D
110416 - PD Course: Megan
110416 - PD Course: Nancy
111816 - PD Course: GTA
111816 - PD Course: Justin


Questions
Asking Student Questions: Dr. S
082416 - PD Seminar Decomp: Joe & Dr. D
Postpone answering
083116 - John debrief: Jeff
090716 - Megan Observation: Jeff
090916 - Calc I Meeting: Tina
092216 - Adam debrief: Justin
Elaboration - Better to hear from a peer
110916 - Nancy Observation: Sheri


Questions
Checking Understanding: Dr. S
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082316 - PD Seminar Intro: ISA
082316 - PD Seminar Intro: Dr. S
082416 - PD Seminar Decomp: Dr. D
082416 - PD Seminar Decomp: Dr. C
2
082516 - PD Seminar Practice: David
Elaboration - Following Along
082516 - PD Seminar Practice: Dr. D
082516 - PD Seminar Practice: Dr. C
090616 - Calc II Meeting: Calc II Coord
090616 - Calc II Meeting: Jeff
090916 - Calc I Meeting: Tina
091916 - Calc II Meeting: Calc II Coord
092316 - PD Course: Dr. D
101416 - PD Course: Dr. D
102616 - Sally debrief: Jeff
110416 - PD Course: Tina
110416 - PD Course: Justin
110416 - PD Course: Jeff
110416 - PD Course: Dr. D
2
110916 - Nancy Observation: Sheri
110916 - Week 11 Nancy: Justin
111516 - Tina Observation: Adam
111616 - Charlie Observation: Joe
2
111816 - PD Course: Dr. D
110416 - PD Course: Adam
Stick Version
082316 - PD Seminar MCOPP: ISA
Elaboration - How Students Understand
082316 - PD Seminar MCOPP: Dr. J
082416 - PD Seminar Decomp: John & Dr. D
082416 - PD Seminar Decomp: Dr. D
082516 - PD Seminar Practice: Dr. C
110416 - PD Course: Sally
110416 - PD Course: Joe & Nancy
111516 - Tina Observation: Adam
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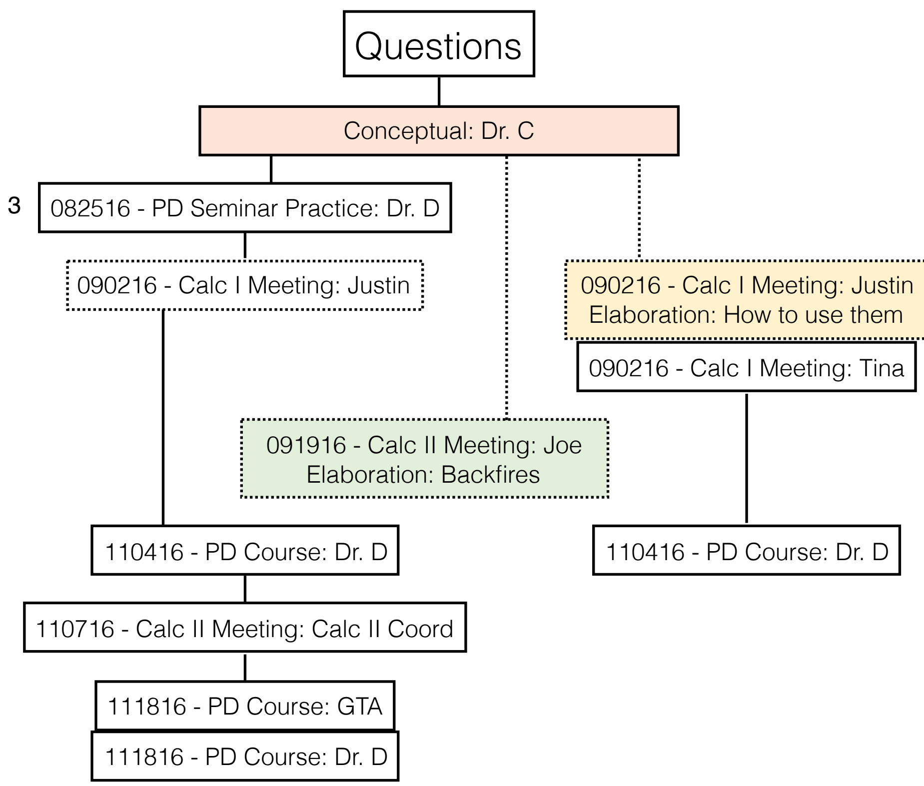
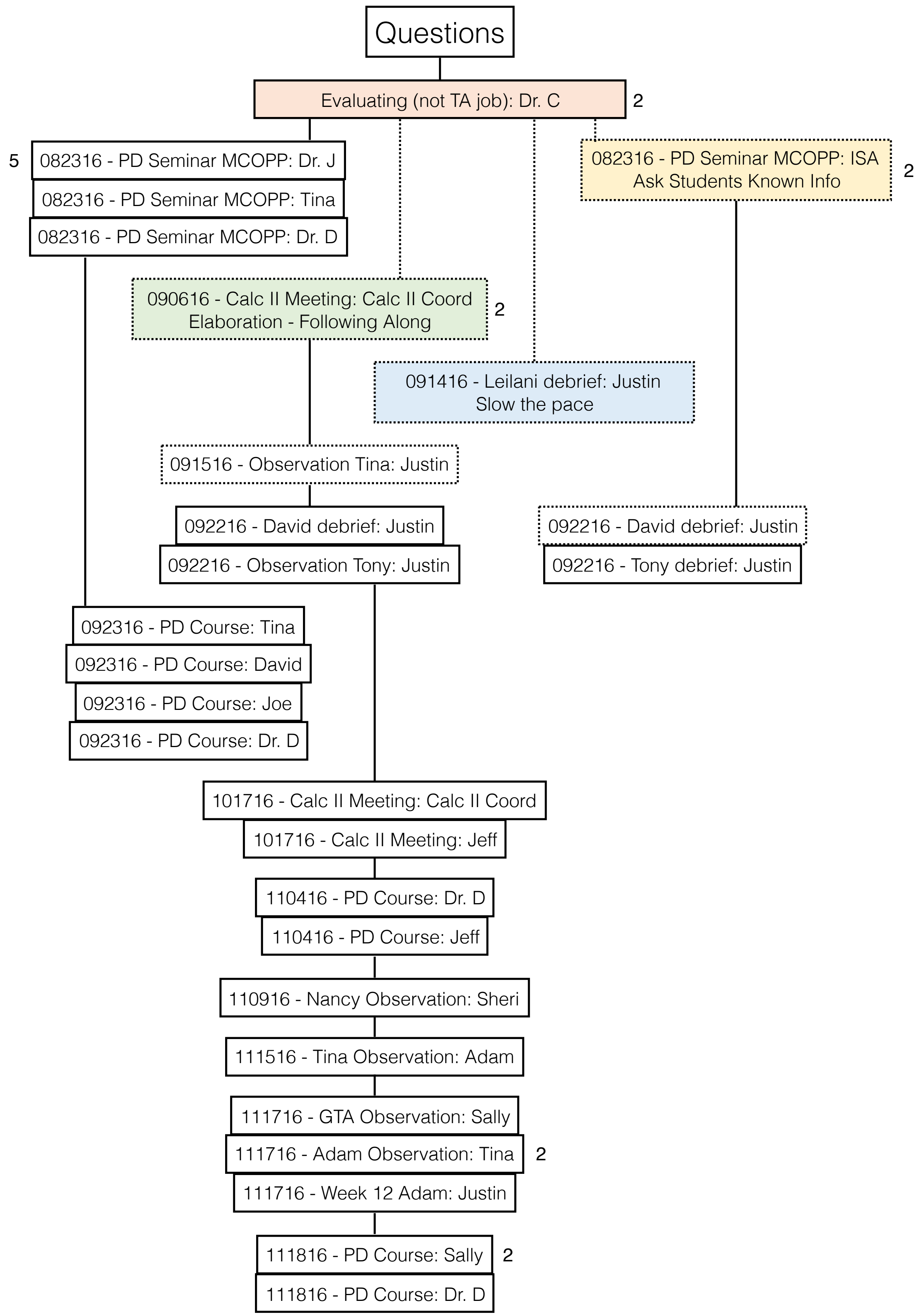
120516 - Calc II Meeting: Calc II Coord


Questions
Conceptual: Dr. C
3
082516 - PD Seminar Practice: Dr. D
090216 - Calc I Meeting: Justin
090216 - Calc I Meeting: Justin
Elaboration: How to use them
090216 - Calc I Meeting: Tina
091916 - Calc II Meeting: Joe
Elaboration: Backfires
110416 - PD Course: Dr. D
110416 - PD Course: Dr. D
110716 - Calc II Meeting: Calc II Coord
111816 - PD Course: GTA
111816 - PD Course: Dr. D


Questions
Evaluating (not TA job): Dr. C
2
5
082316 - PD Seminar MCOPP: Dr. J
082316 - PD Seminar MCOPP: Tina
082316 - PD Seminar MCOPP: Dr. D
082316 - PD Seminar MCOPP: ISA
Ask Students Known Info
2
090616 - Calc II Meeting: Calc II Coord
Elaboration - Following Along
2
091416 - Leilani debrief: Justin
Slow the pace
091516 - Observation Tina: Justin
092216 - David debrief: Justin
092216 - Observation Tony: Justin
092216 - David debrief: Justin
092216 - Tony debrief: Justin
092316 - PD Course: Tina
092316 - PD Course: David
092316 - PD Course: Joe
092316 - PD Course: Dr. D
101716 - Calc II Meeting: Calc II Coord
101716 - Calc II Meeting: Jeff
110416 - PD Course: Dr. D
110416 - PD Course: Jeff
110916 - Nancy Observation: Sheri
111516 - Tina Observation: Adam
111716 - GTA Observation: Sally
111716 - Adam Observation: Tina
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111716 - Week 12 Adam: Justin
111816 - PD Course: Sally
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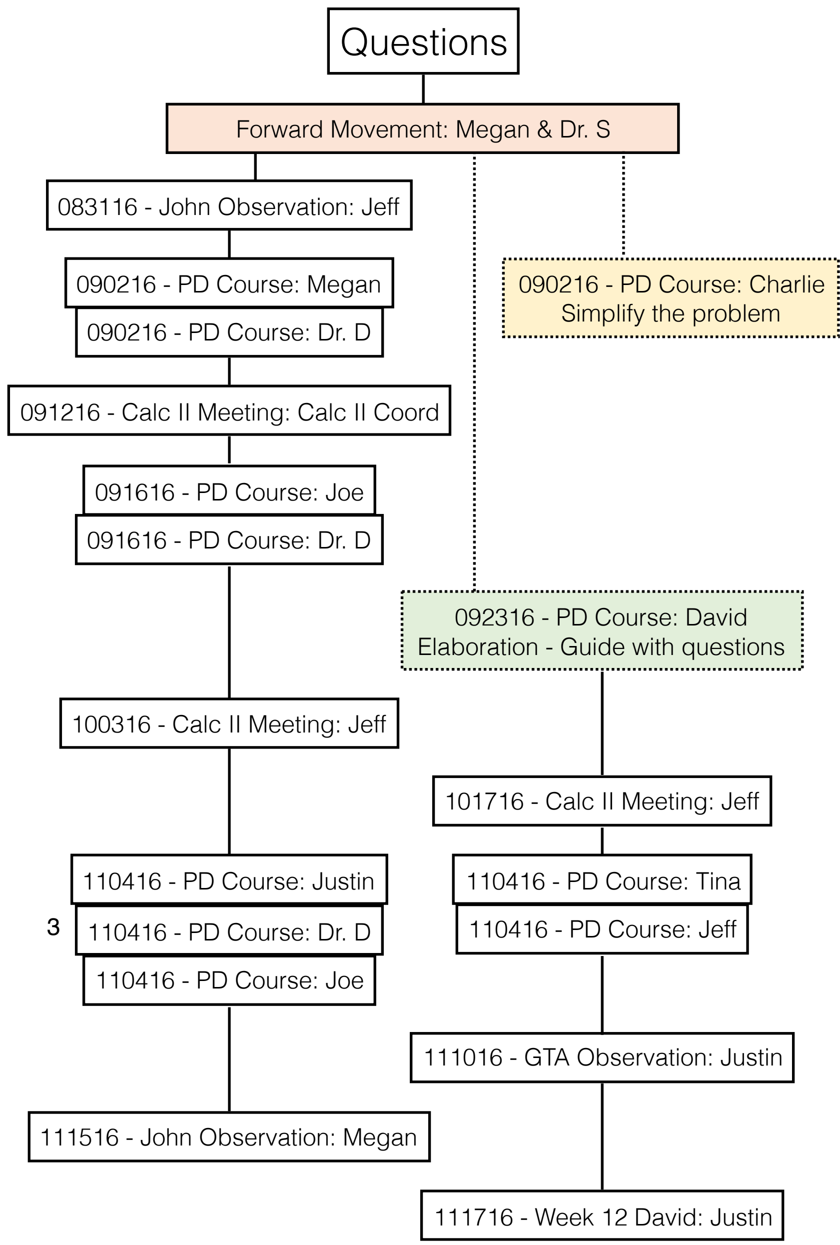
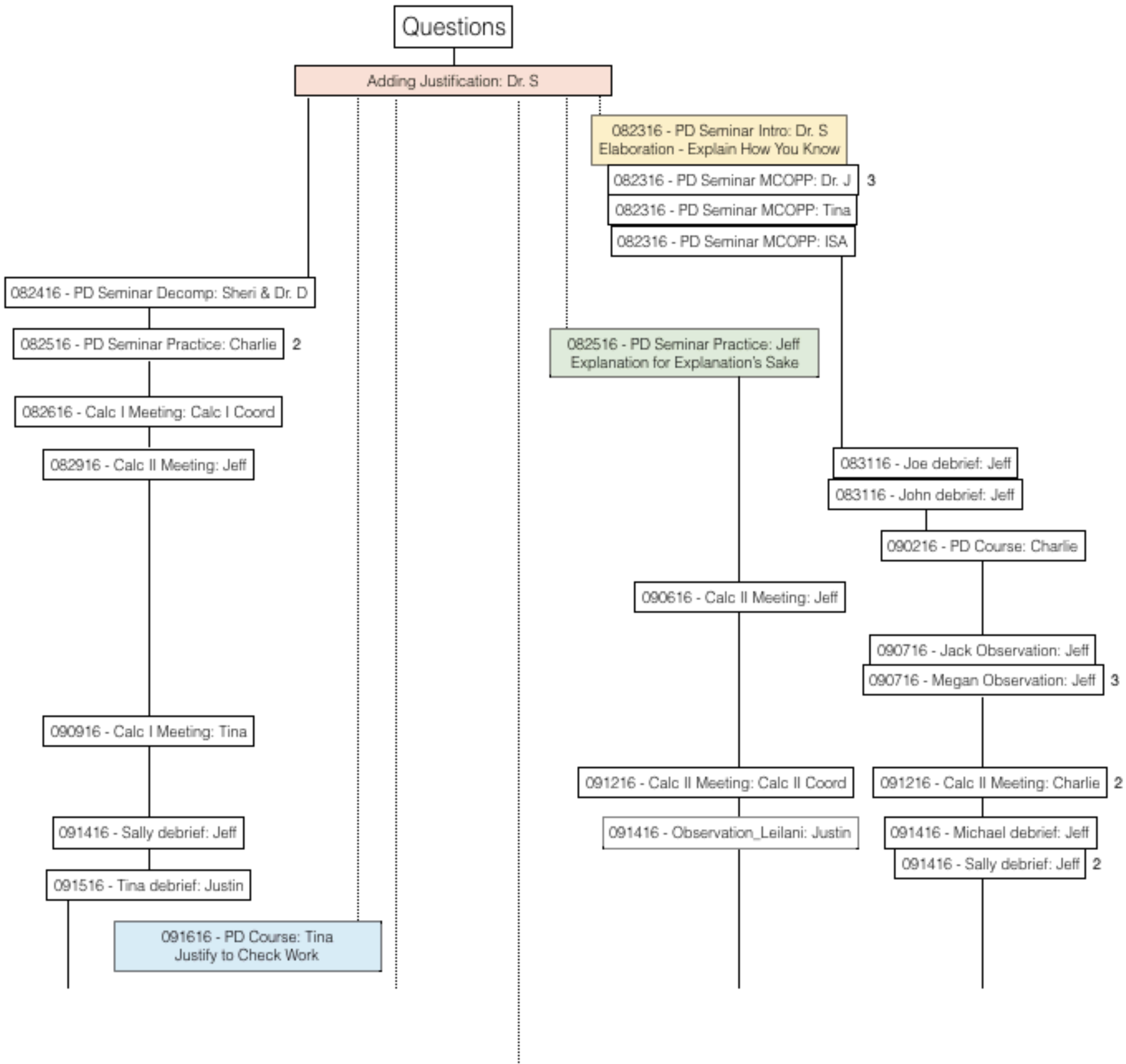
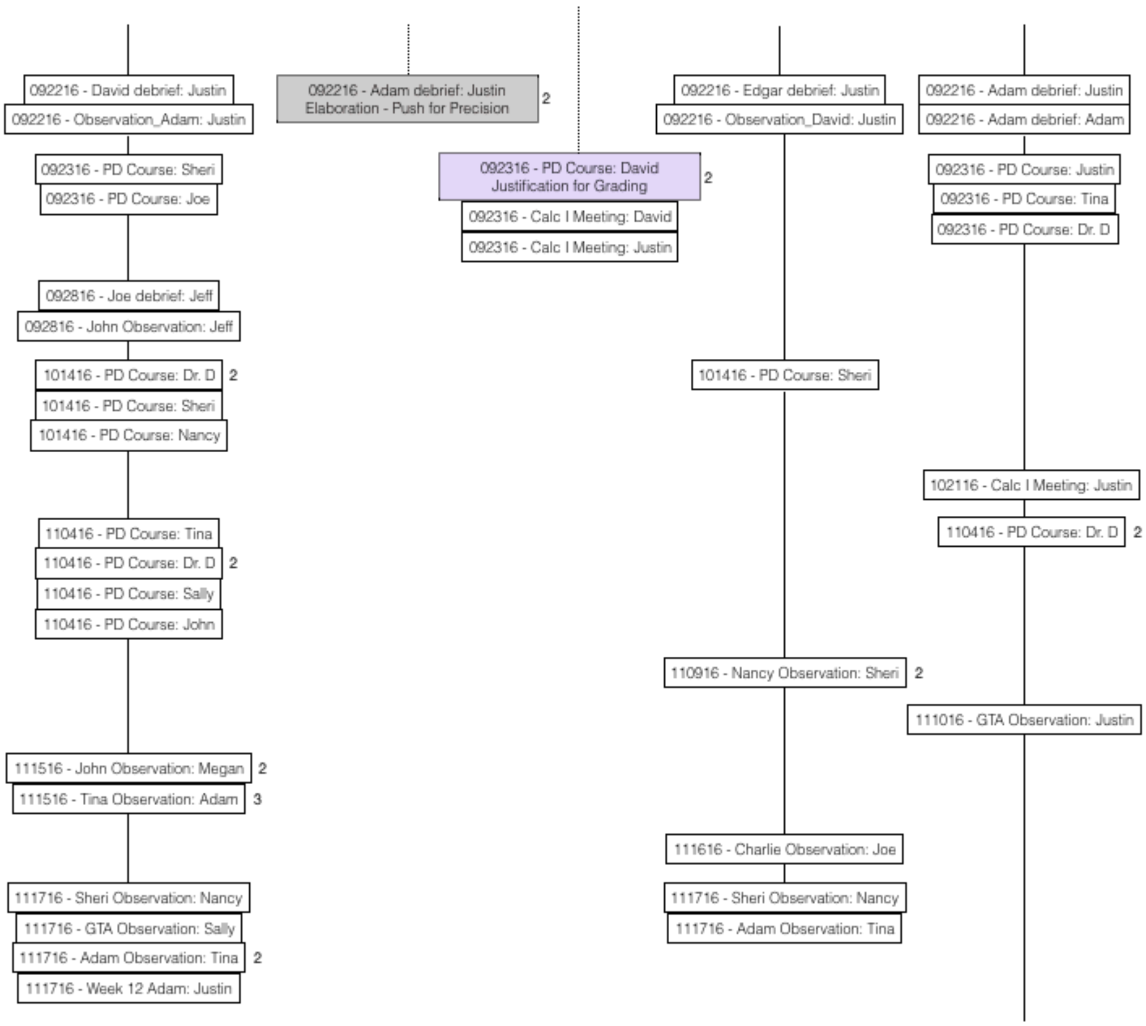
111816 - PD Course: Dr. D


Questions
Forward Movement: Megan & Dr. S
083116 - John Observation: Jeff
090216 - PD Course: Megan
090216 - PD Course: Dr. D
090216 - PD Course: Charlie
Simplify the problem
091216 - Calc II Meeting: Calc II Coord
091616 - PD Course: Joe
091616 - PD Course: Dr. D
092316 - PD Course: David
Elaboration - Guide with questions
100316 - Calc II Meeting: Jeff
101716 - Calc II Meeting: Jeff
110416 - PD Course: Justin
3
110416 - PD Course: Dr. D
110416 - PD Course: Joe
110416 - PD Course: Tina
110416 - PD Course: Jeff
111016 - GTA Observation: Justin
111516 - John Observation: Megan
111716 - Week 12 David: Justin


Questions
Adding Justification: Dr. S
082316 - PD Seminar Intro: Dr. S
Elaboration - Explain How You Know
082316 - PD Seminar MCOPP: Dr. J
3
082316 - PD Seminar MCOPP: Tina
082316 - PD Seminar MCOPP: ISA
082416 - PD Seminar Decomp: Sheri & Dr. D
082516 - PD Seminar Practice: Charlie
2
082516 - PD Seminar Practice: Jeff
Explanation for Explanation's Sake
082616 - Calc I Meeting: Calc I Coord
082916 - Calc II Meeting: Jeff
083116 - Joe debrief: Jeff
083116 - John debrief: Jeff
090216 - PD Course: Charlie
090616 - Calc II Meeting: Jeff
090716 - Jack Observation: Jeff
090716 - Megan Observation: Jeff
3
090916 - Calc I Meeting: Tina
091216 - Calc II Meeting: Calc II Coord
091216 - Calc II Meeting: Charlie
2
091416 - Sally debrief: Jeff
091416 - Observation_Leilani: Justin
091416 - Michael debrief: Jeff
091416 - Sally debrief: Jeff
2
091516 - Tina debrief: Justin
091616 - PD Course: Tina
Justify to Check Work


092216 - David debrief: Justin
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101416 - PD Course: Dr. D
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101416 - PD Course: Sheri
101416 - PD Course: Nancy
110416 - PD Course: Tina
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2
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110416 - PD Course: John
111516 - John Observation: Megan
2
111516 - Tina Observation: Adam
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111716 - Sheri Observation: Nancy
111716 - GTA Observation: Sally
111716 - Adam Observation: Tina
2
111716 - Week 12 Adam: Justin
092216 - Adam debrief: Justin
Elaboration - Push for Precision
2
092316 - PD Course: David
Justification for Grading
2
092316 - Calc I Meeting: David
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092216 - Edgar debrief: Justin
092216 - Observation_David: Justin
101416 - PD Course: Sheri
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111716 - Adam Observation: Tina
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092316 - PD Course: Tina
092316 - PD Course: Dr. D
102116 - Calc I Meeting: Justin
110416 - PD Course: Dr. D
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111016 - GTA Observation: Justin

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111816 - PD Course: GTA

111816 - PD Course: Dr. D 2

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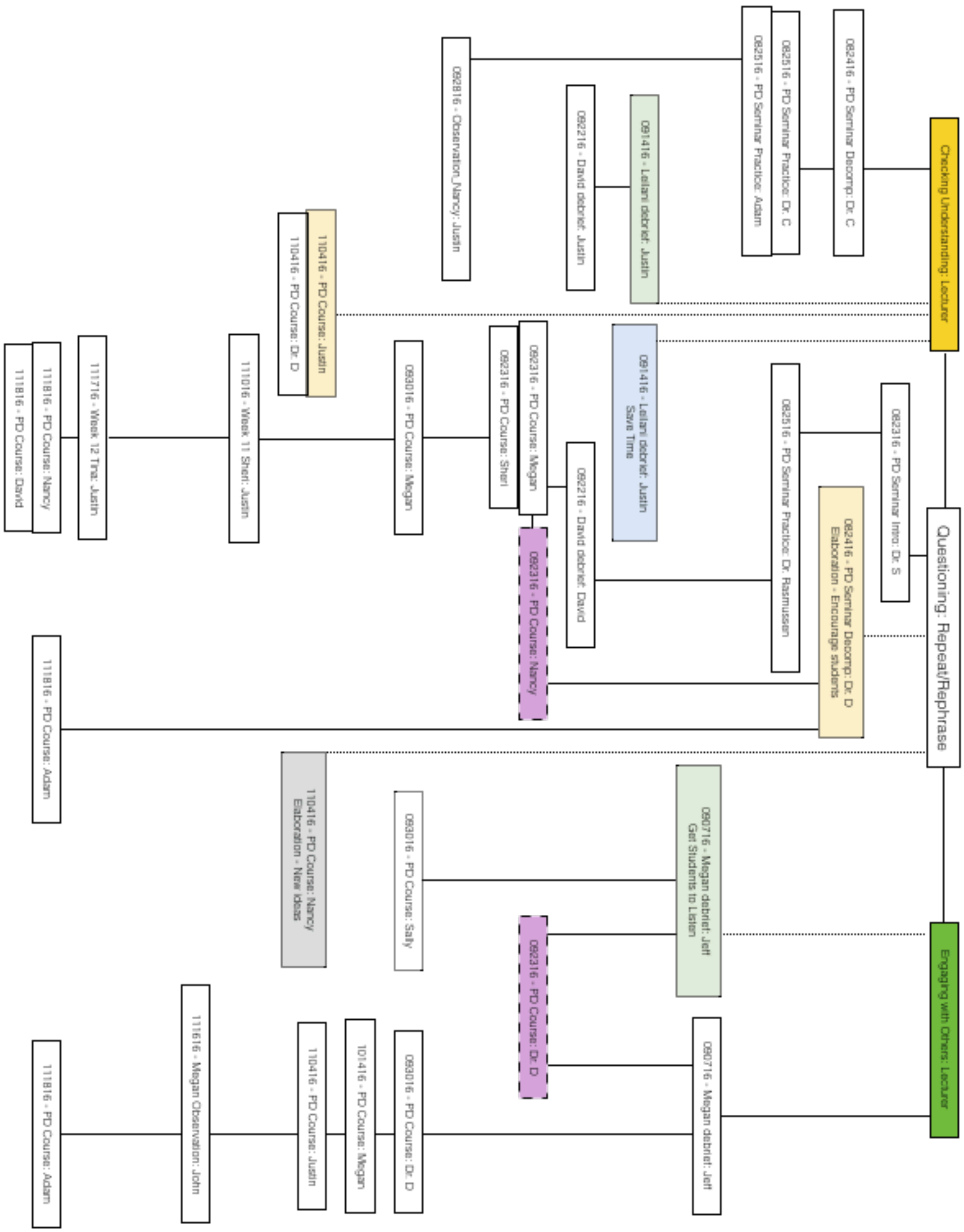
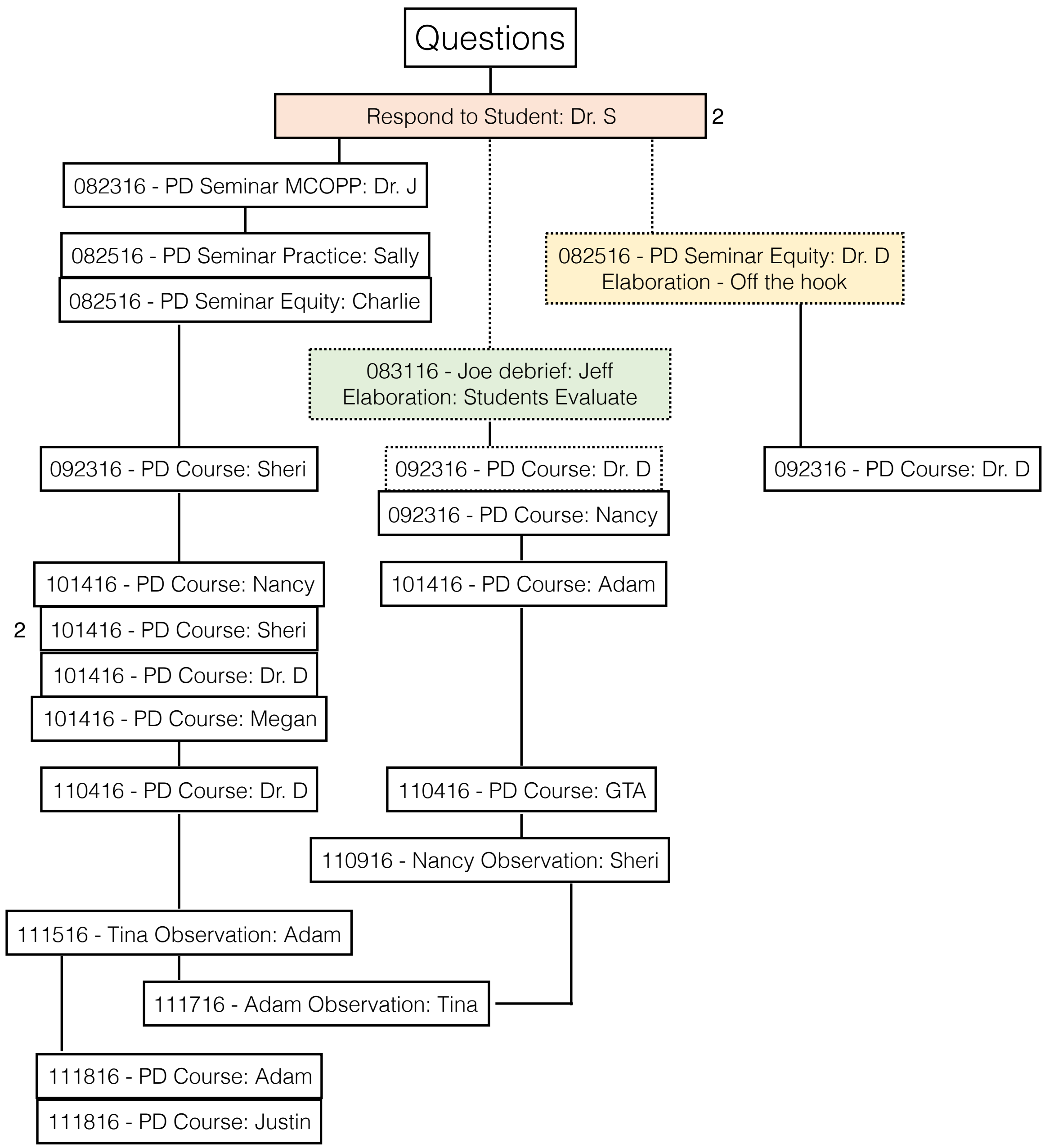
111816 - PD Course: Justin



Checking Understanding: Lecturer
082416 - PD Seminar Decomp: Dr. C
082516 - PD Seminar Practice: Dr. C
082516 - PD Seminar Practice: Adam
092816 - Observation_Nancy: Justin
091416 - Leilani debrief: Justin
092216 - David debrief: Justin
110416 - PD Course: Justin
110416 - PD Course: Dr. D
Questioning: Repeat/Rephrase
082316 - PD Seminar Intro: Dr. S
082516 - PD Seminar Practice: Dr. Rasmussen
082416 - PD Seminar Decomp: Dr. D
Elaboration - Encourage students
091416 - Leilani debrief: Justin
Save Time
092216 - David debrief: David
092316 - PD Course: Megan
092316 - PD Course: Sheri
092316 - PD Course: Nancy
093016 - PD Course: Megan
111016 - Week 11 Sheri: Justin
111716 - Week 12 Tina: Justin
111816 - PD Course: Nancy
111816 - PD Course: David
111816 - PD Course: Adam
110416 - PD Course: Nancy
Elaboration - New ideas
Engaging with Others: Lecturer
090716 - Megan debrief: Jeff
Get Students to Listen
093016 - PD Course: Sally
092316 - PD Course: Dr. D
090716 - Megan debrief: Jeff
093016 - PD Course: Dr. D
101416 - PD Course: Megan
110416 - PD Course: Justin
111616 - Megan Observation: John
111816 - PD Course: Adam


Questions
Respond to Student: Dr. S
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082516 - PD Seminar Equity: Charlie
082516 - PD Seminar Equity: Dr. D
Elaboration - Off the hook
083116 - Joe debrief: Jeff
Elaboration: Students Evaluate
092316 - PD Course: Sheri
092316 - PD Course: Dr. D
092316 - PD Course: Nancy
092316 - PD Course: Dr. D
101416 - PD Course: Nancy
2
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101416 - PD Course: Dr. D
101416 - PD Course: Megan
101416 - PD Course: Adam
110416 - PD Course: Dr. D
110416 - PD Course: GTA
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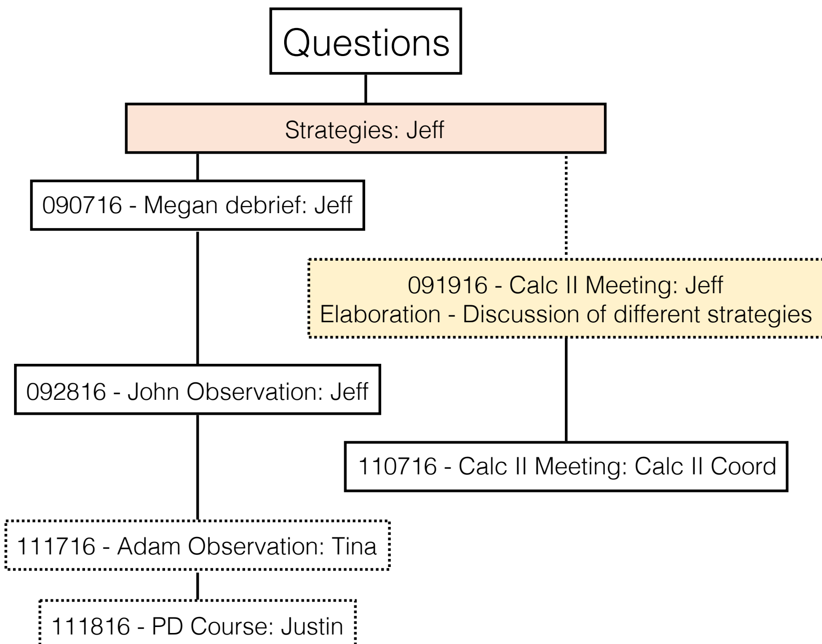
111816 - PD Course: Justin


Questions
Strategies: Jeff
090716 - Megan debrief: Jeff
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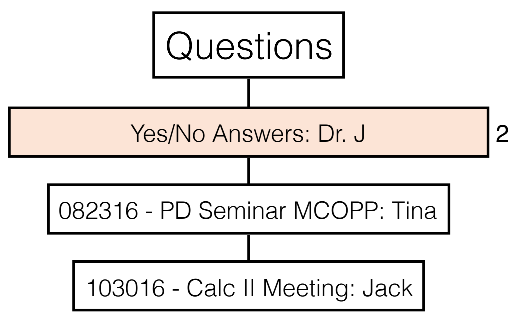
Elaboration - Discussion of different strategies
092816 - John Observation: Jeff
110716 - Calc II Meeting: Calc II Coord
111716 - Adam Observation: Tina
111816 - PD Course: Justin


Questions
Yes/No Answers: Dr. J
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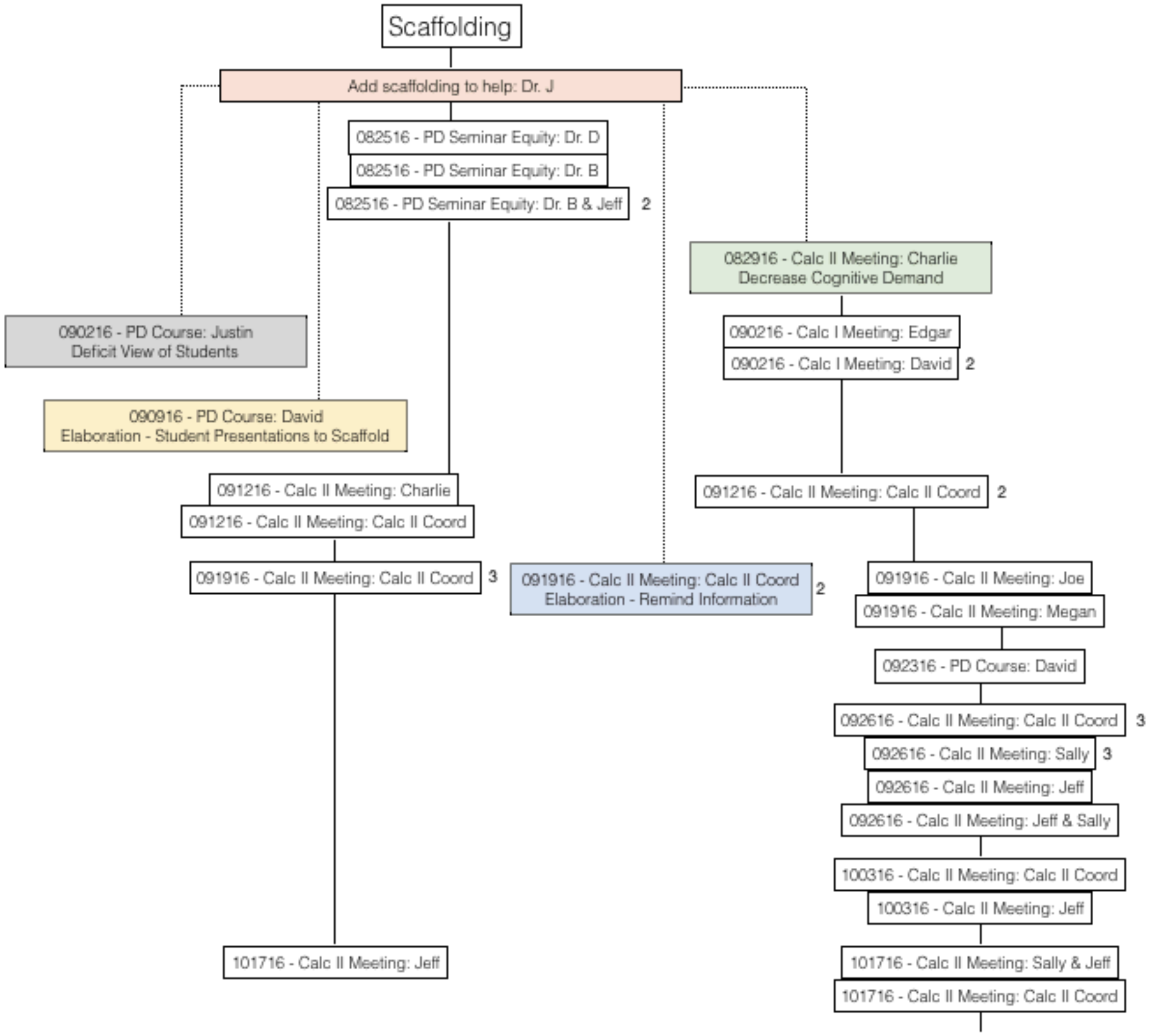
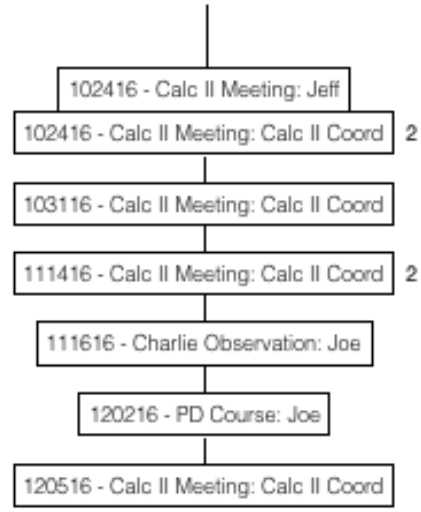
103016 - Calc II Meeting: Jack


Scaffolding
Add scaffolding to help: Dr. J
082516 - PD Seminar Equity: Dr. D
082516 - PD Seminar Equity: Dr. B
082516 - PD Seminar Equity: Dr. B & Jeff 2
082916 - Calc II Meeting: Charlie
Decrease Cognitive Demand
090216 - Calc I Meeting: Edgar
090216 - Calc I Meeting: David 2
090216 - PD Course: Justin
Deficit View of Students
090916 - PD Course: David
Elaboration - Student Presentations to Scaffold
091216 - Calc II Meeting: Charlie
091216 - Calc II Meeting: Calc II Coord
091216 - Calc II Meeting: Calc II Coord 2
091916 - Calc II Meeting: Calc II Coord 3
091916 - Calc II Meeting: Calc II Coord
Elaboration - Remind Information 2
091916 - Calc II Meeting: Joe
091916 - Calc II Meeting: Megan
092316 - PD Course: David
092616 - Calc II Meeting: Calc II Coord 3
092616 - Calc II Meeting: Sally 3
092616 - Calc II Meeting: Jeff
092616 - Calc II Meeting: Jeff & Sally
100316 - Calc II Meeting: Calc II Coord
100316 - Calc II Meeting: Jeff
101716 - Calc II Meeting: Jeff
101716 - Calc II Meeting: Sally & Jeff
101716 - Calc II Meeting: Calc II Coord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102416 - Calc II Meeting: Calc II Coord
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103116 - Calc II Meeting: Calc II Coord
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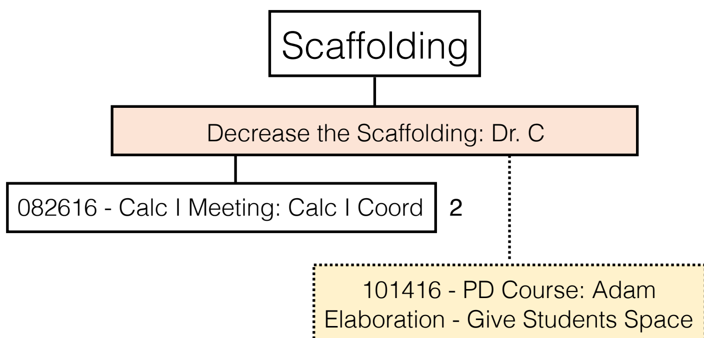
111616 - Charlie Observation: Joe
120216 - PD Course: Joe
120516 - Calc II Meeting: Calc II Coord


Scaffolding
Decrease the Scaffolding: Dr. C
082616 - Calc I Meeting: Calc I Coord
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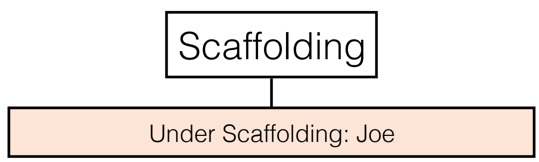
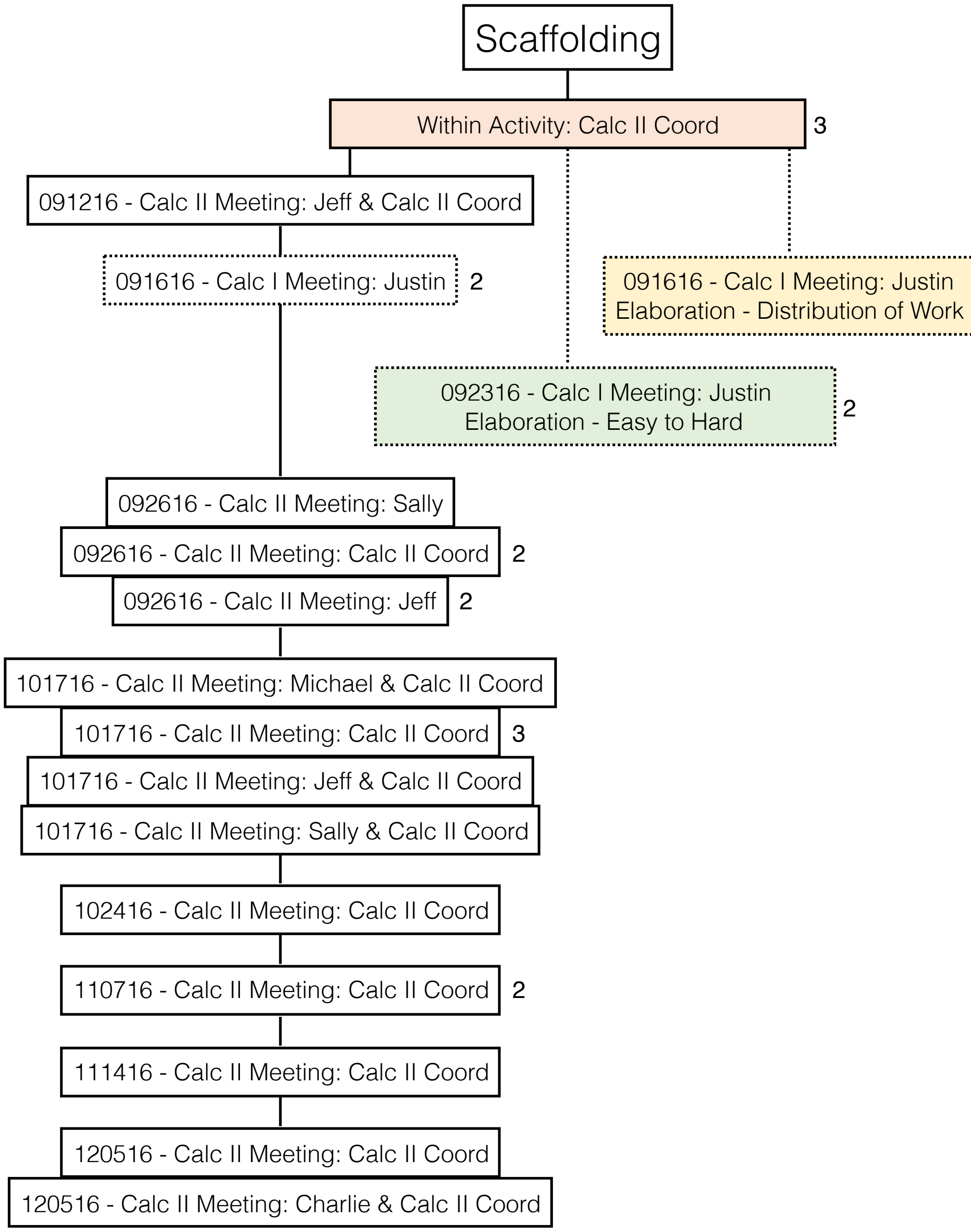
101416 - PD Course: Adam
Elaboration - Give Students Space


Scaffolding
Under Scaffolding: Joe


Scaffolding
Within Activity: Calc II Coord
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091216 - Calc II Meeting: Jeff & Calc II Coord
091616 - Calc I Meeting: Justin
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091616 - Calc I Meeting: Justin
Elaboration - Distribution of Work
092316 - Calc I Meeting: Justin
Elaboration - Easy to Hard
2
092616 - Calc II Meeting: Sally
092616 - Calc II Meeting: Calc II Coord
2
092616 - Calc II Meeting: Jeff
2
101716 - Calc II Meeting: Michael & Calc II Coord
101716 - Calc II Meeting: Calc II Coord
3
101716 - Calc II Meeting: Jeff & Calc II Coord
101716 - Calc II Meeting: Sally & Calc II Coord
102416 - Calc II Meeting: Calc II Coord
110716 - Calc II Meeting: Calc II Coord
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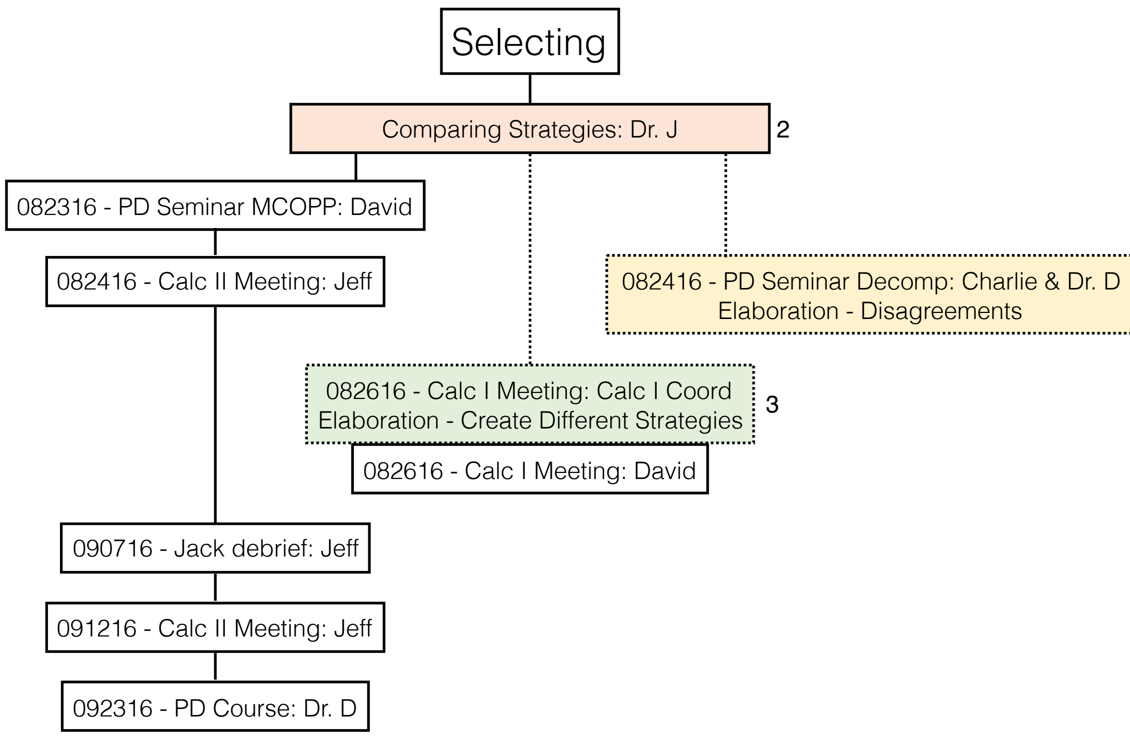
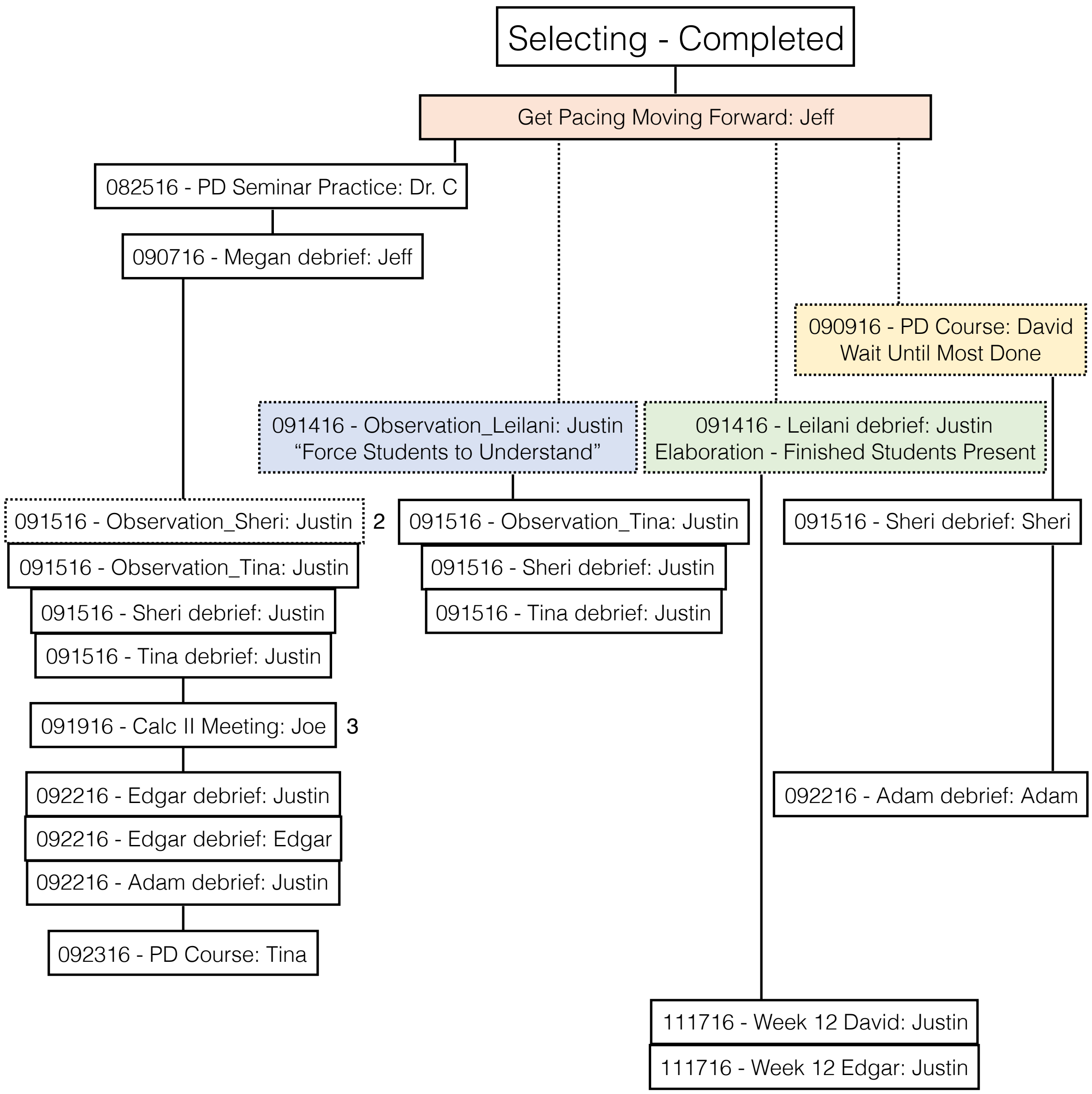
120516 - Calc II Meeting: Charlie & Calc II Coord


Selecting
Comparing Strategies: Dr. J
2
082316 - PD Seminar MCOPP: David
082416 - Calc II Meeting: Jeff
082416 - PD Seminar Decomp: Charlie & Dr. D
Elaboration - Disagreements
082616 - Calc I Meeting: Calc I Coord
Elaboration - Create Different Strategies
3
082616 - Calc I Meeting: David
090716 - Jack debrief: Jeff
091216 - Calc II Meeting: Jeff
092316 - PD Course: Dr. D


Selecting - Completed
Get Pacing Moving Forward: Jeff
082516 - PD Seminar Practice: Dr. C
090716 - Megan debrief: Jeff
090916 - PD Course: David
Wait Until Most Done
091416 - Observation_Leilani: Justin
“Force Students to Understand”
091416 - Leilani debrief: Justin
Elaboration - Finished Students Present
091516 - Observation_Sheri: Justin
2
091516 - Observation_Tina: Justin
091516 - Sheri debrief: Justin
091516 - Tina debrief: Justin
091916 - Calc II Meeting: Joe
3
092216 - Edgar debrief: Justin
092216 - Edgar debrief: Edgar
092216 - Adam debrief: Justin
092316 - PD Course: Tina
091516 - Observation_Tina: Justin
091516 - Sheri debrief: Justin
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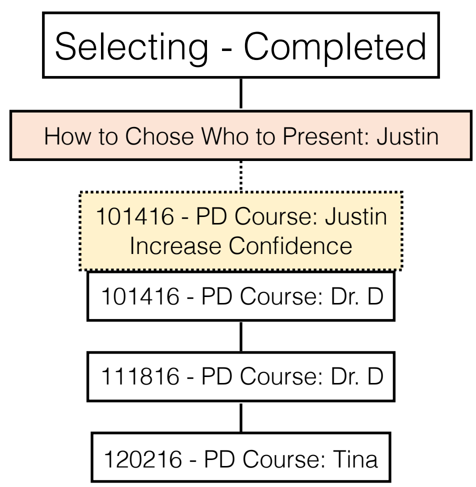
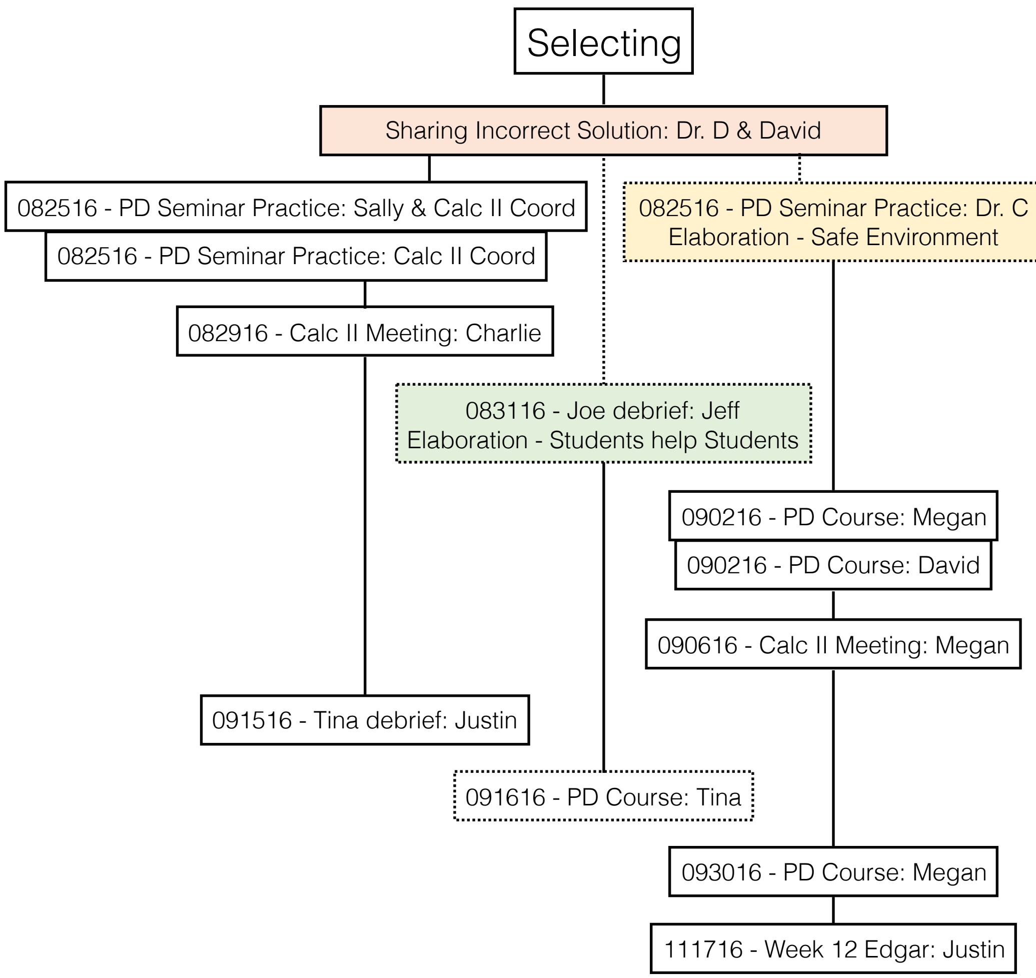
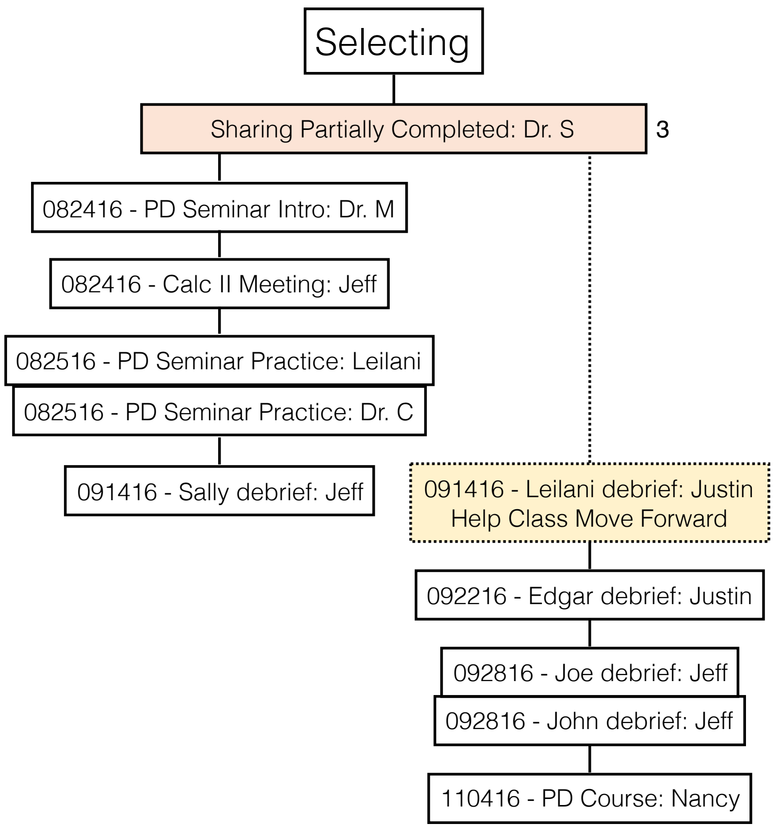
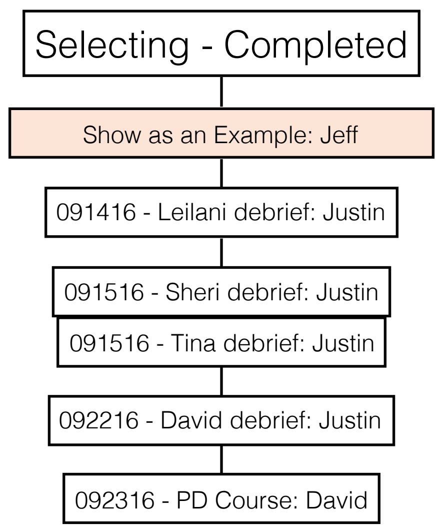
091516 - Sheri debrief: Sheri
092216 - Adam debrief: Adam
111716 - Week 12 David: Justin
111716 - Week 12 Edgar: Justin


Selecting - Completed
How to Chose Who to Present: Justin
101416 - PD Course: Justin
Increase Confidence
101416 - PD Course: Dr. D
111816 - PD Course: Dr. D
120216 - PD Course: Tina


Selecting
Sharing Incorrect Solution: Dr. D & David
082516 - PD Seminar Practice: Sally & Calc II Coord
082516 - PD Seminar Practice: Calc II Coord
082916 - Calc II Meeting: Charlie
082516 - PD Seminar Practice: Dr. C
Elaboration - Safe Environment
083116 - Joe debrief: Jeff
Elaboration - Students help Students
090216 - PD Course: Megan
090216 - PD Course: David
090616 - Calc II Meeting: Megan
091516 - Tina debrief: Justin
091616 - PD Course: Tina
093016 - PD Course: Megan
111716 - Week 12 Edgar: Justin


Selecting
Sharing Partially Completed: Dr. S
3
082416 - PD Seminar Intro: Dr. M
082416 - Calc II Meeting: Jeff
082516 - PD Seminar Practice: Leilani
082516 - PD Seminar Practice: Dr. C
091416 - Sally debrief: Jeff
091416 - Leilani debrief: Justin
Help Class Move Forward
092216 - Edgar debrief: Justin
092816 - Joe debrief: Jeff
092816 - John debrief: Jeff
110416 - PD Course: Nancy


Selecting - Completed
Show as an Example: Jeff
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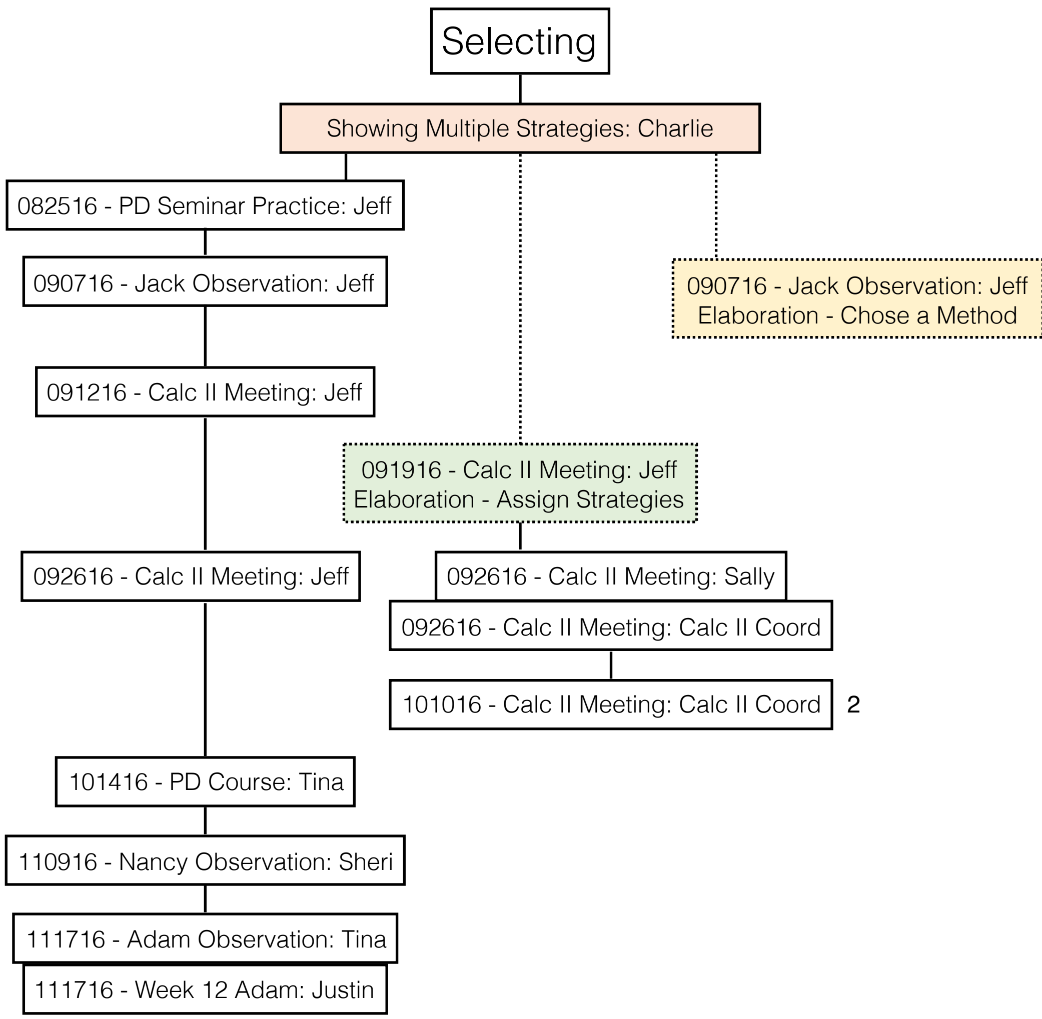
091516 - Sheri debrief: Justin
091516 - Tina debrief: Justin
092216 - David debrief: Justin
092316 - PD Course: David


Selecting
Showing Multiple Strategies: Charlie
082516 - PD Seminar Practice: Jeff
090716 - Jack Observation: Jeff
090716 - Jack Observation: Jeff
Elaboration - Chose a Method
091216 - Calc II Meeting: Jeff
091916 - Calc II Meeting: Jeff
Elaboration - Assign Strategies
092616 - Calc II Meeting: Jeff
092616 - Calc II Meeting: Sally
092616 - Calc II Meeting: Calc II Coord
101016 - Calc II Meeting: Calc II Coord
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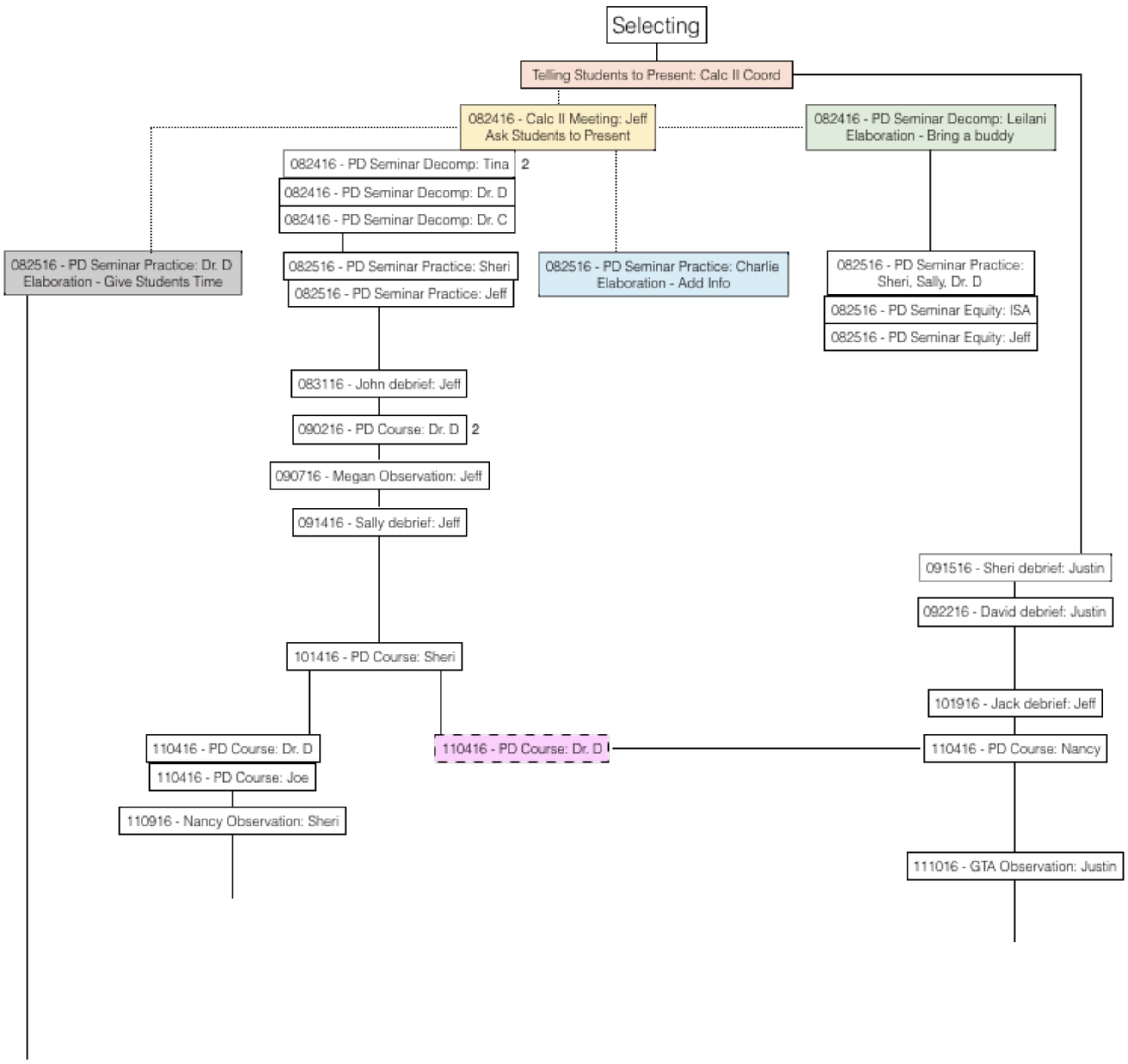
111716 - Adam Observation: Tina
111716 - Week 12 Adam: Justin


Selecting
Telling Students to Present: Calc II Coord
082416 - Calc II Meeting: Jeff
Ask Students to Present
082416 - PD Seminar Decomp: Leilani
Elaboration - Bring a buddy
082416 - PD Seminar Decomp: Tina
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082416 - PD Seminar Decomp: Dr. D
082416 - PD Seminar Decomp: Dr. C
082516 - PD Seminar Practice: Dr. D
Elaboration - Give Students Time
082516 - PD Seminar Practice: Sheri
082516 - PD Seminar Practice: Jeff
082516 - PD Seminar Practice: Charlie
Elaboration - Add Info
082516 - PD Seminar Practice:
Sheri, Sally, Dr. D
082516 - PD Seminar Equity: ISA
082516 - PD Seminar Equity: Jeff
083116 - John debrief: Jeff
090216 - PD Course: Dr. D
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090716 - Megan Observation: Jeff
091416 - Sally debrief: Jeff
091516 - Sheri debrief: Justin
092216 - David debrief: Justin
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101916 - Jack debrief: Jeff
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110416 - PD Course: Joe
110416 - PD Course: Dr. D
110416 - PD Course: Nancy
110916 - Nancy Observation: Sheri
111016 - GTA Observation: Justin


111516 - John Observation: Megan
111616 - Megan Observation: John
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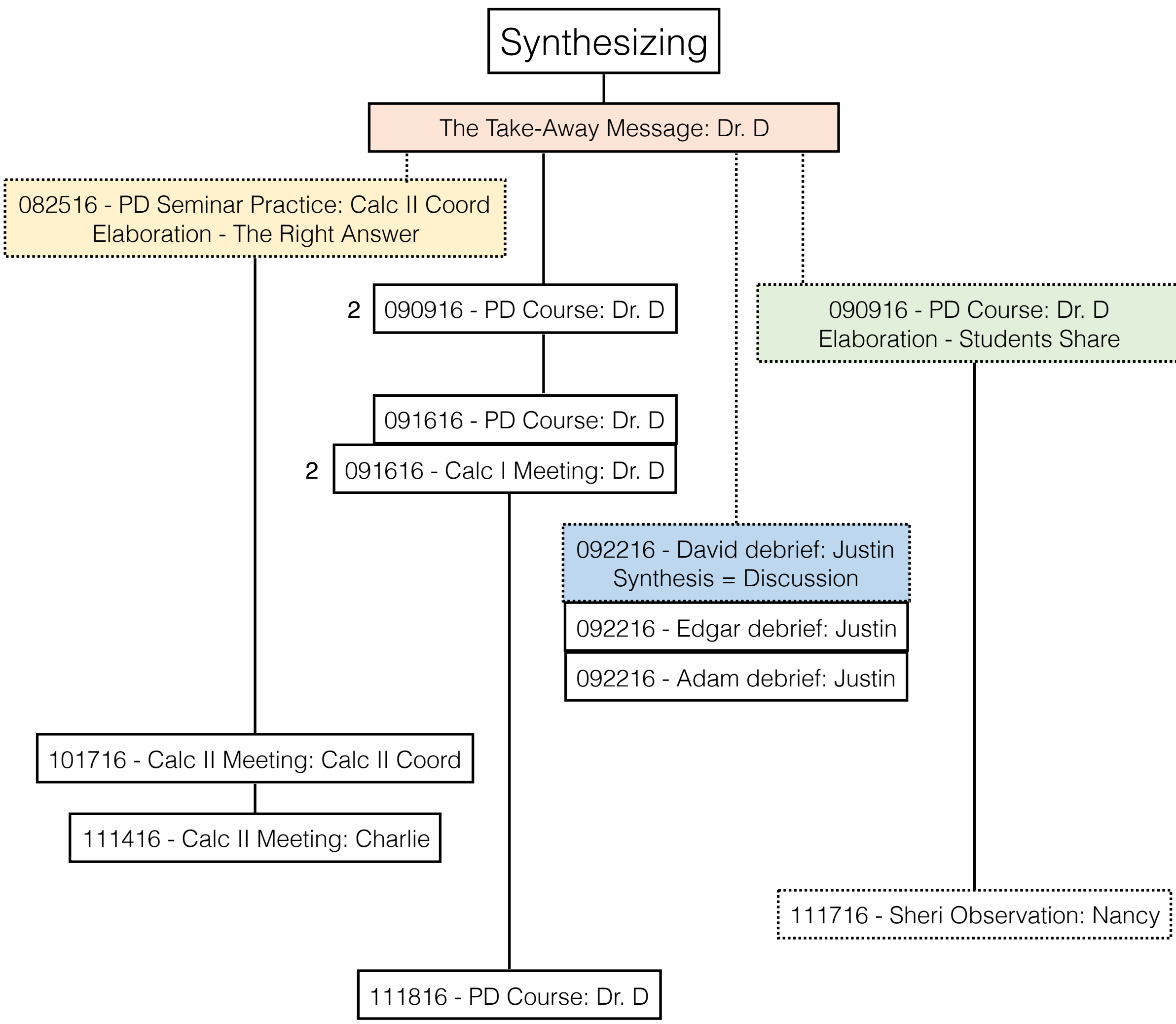
111816 - PD Course: Megan
120216 - PD Course: Tina
111716 - Tina debrief: Justin
111716 - Week 12 Edgar: Justin


Synthesizing
The Take-Away Message: Dr. D
082516 - PD Seminar Practice: Calc II Coord
Elaboration - The Right Answer
2
090916 - PD Course: Dr. D
090916 - PD Course: Dr. D
Elaboration - Students Share
091616 - PD Course: Dr. D
2
091616 - Calc I Meeting: Dr. D
092216 - David debrief: Justin
Synthesis = Discussion
092216 - Edgar debrief: Justin
092216 - Adam debrief: Justin
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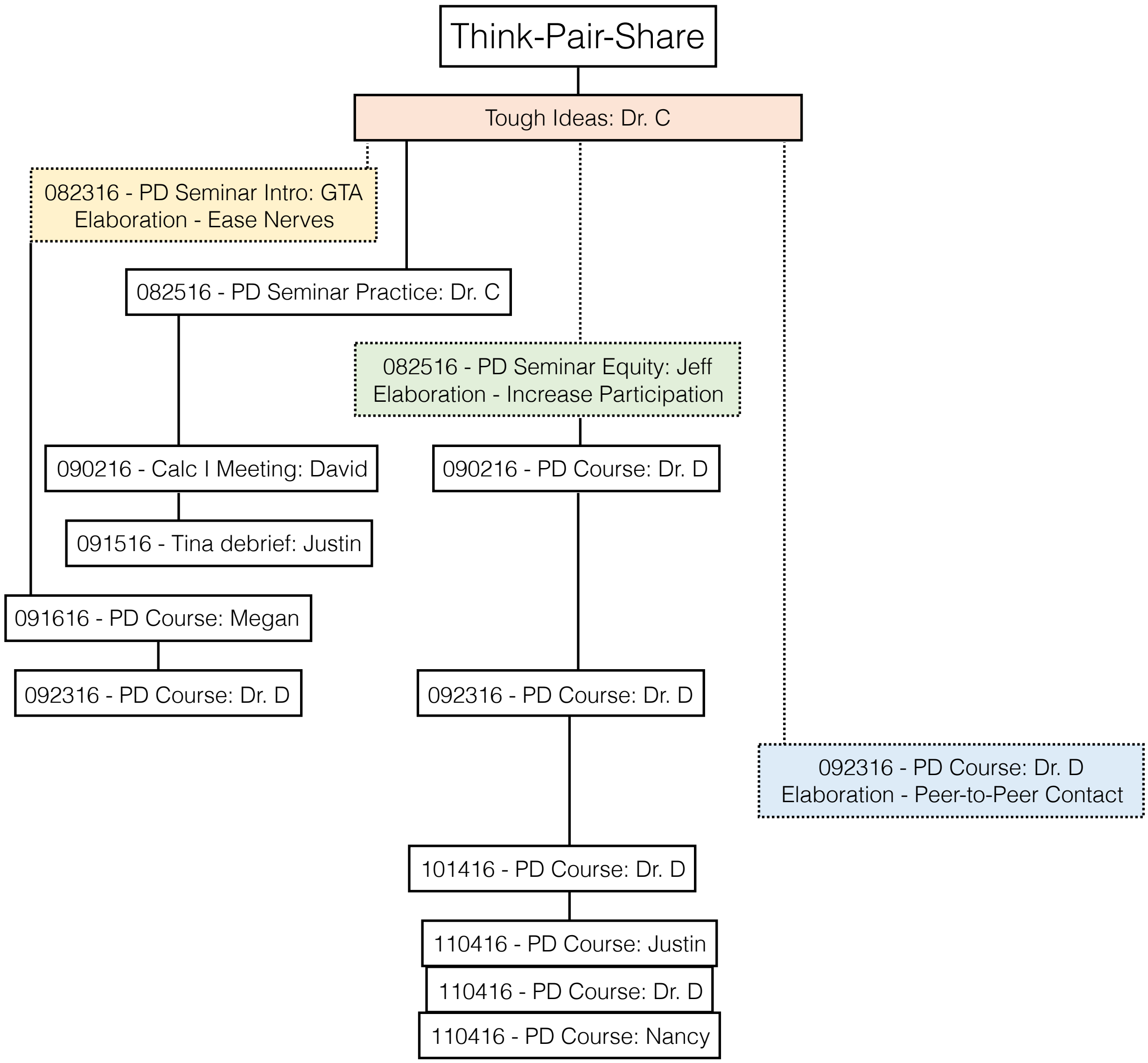
Think-Pair-Share
Tough Ideas: Dr. C
082316 - PD Seminar Intro: GTA
Elaboration - Ease Nerves
082516 - PD Seminar Practice: Dr. C
082516 - PD Seminar Equity: Jeff
Elaboration - Increase Participation
090216 - Calc I Meeting: David
090216 - PD Course: Dr. D
091516 - Tina debrief: Justin
091616 - PD Course: Megan
092316 - PD Course: Dr. D
092316 - PD Course: Dr. D
092316 - PD Course: Dr. D
Elaboration - Peer-to-Peer Contact
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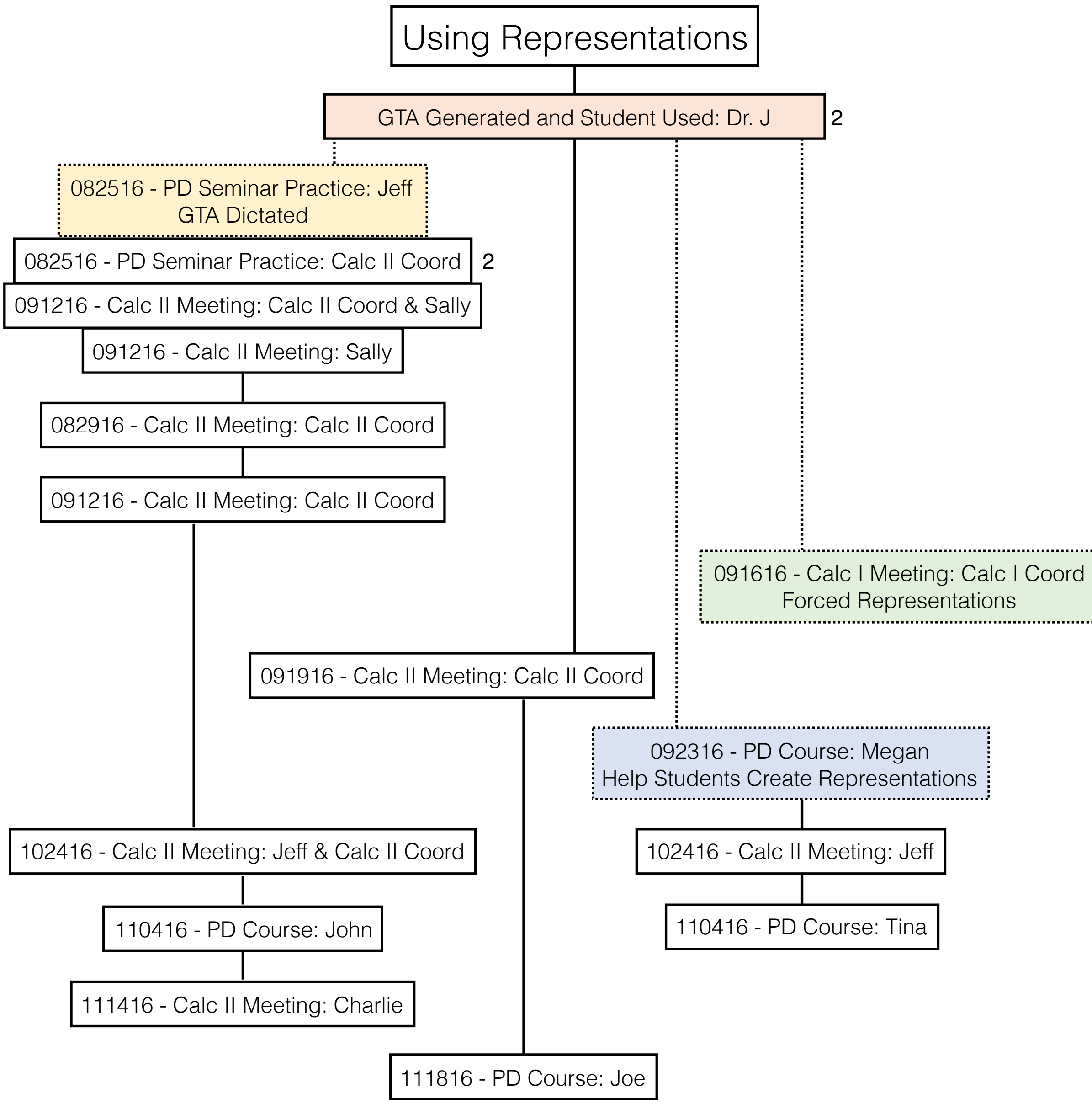
110416 - PD Course: Justin
110416 - PD Course: Dr. D
110416 - PD Course: Nancy


Using Representations
GTA Generated and Student Used: Dr. J
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082516 - PD Seminar Practice: Jeff
GTA Dictated
082516 - PD Seminar Practice: Calc II Coord
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091216 - Calc II Meeting: Sally
082916 - Calc II Meeting: Calc II Coord
091216 - Calc II Meeting: Calc II Coord
091616 - Calc I Meeting: Calc I Coord
Forced Representations
091916 - Calc II Meeting: Calc II Coord
092316 - PD Course: Megan
Help Students Create Representations
102416 - Calc II Meeting: Jeff & Calc II Coord
102416 - Calc II Meeting: Jeff
110416 - PD Course: John
110416 - PD Course: Tina
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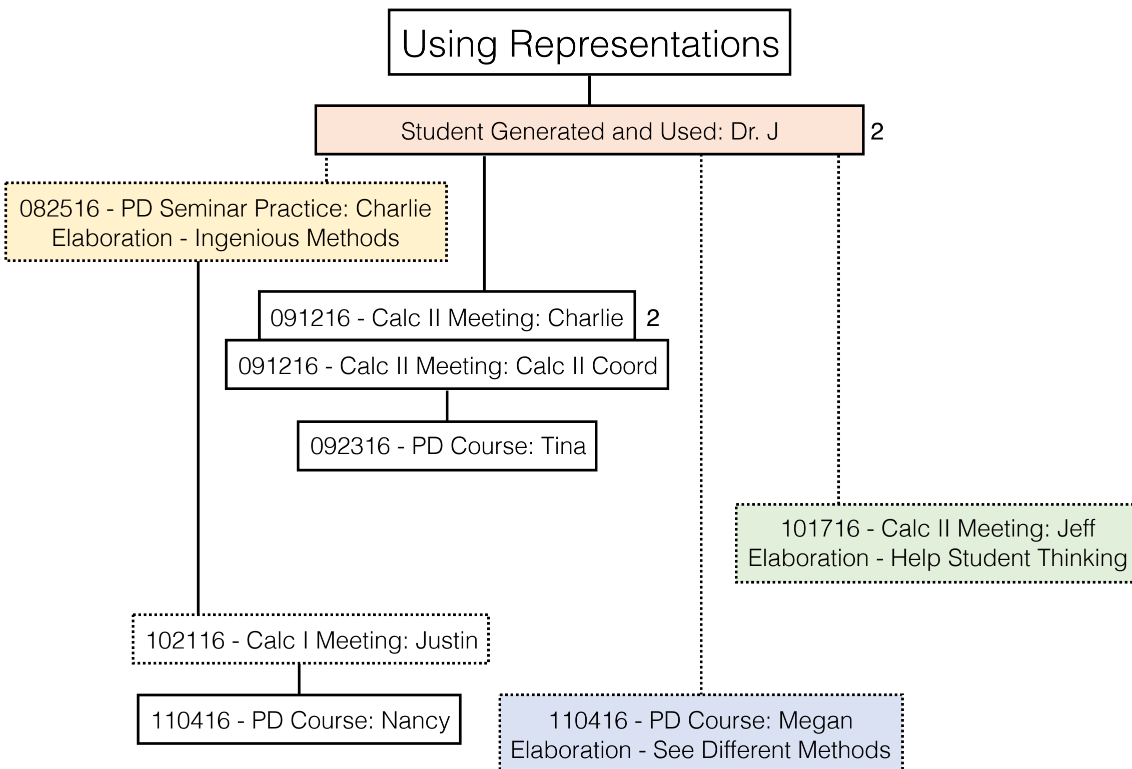
111816 - PD Course: Joe



Using Representations
Student Generated and Used: Dr. J
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Elaboration - Ingenious Methods
091216 - Calc II Meeting: Charlie
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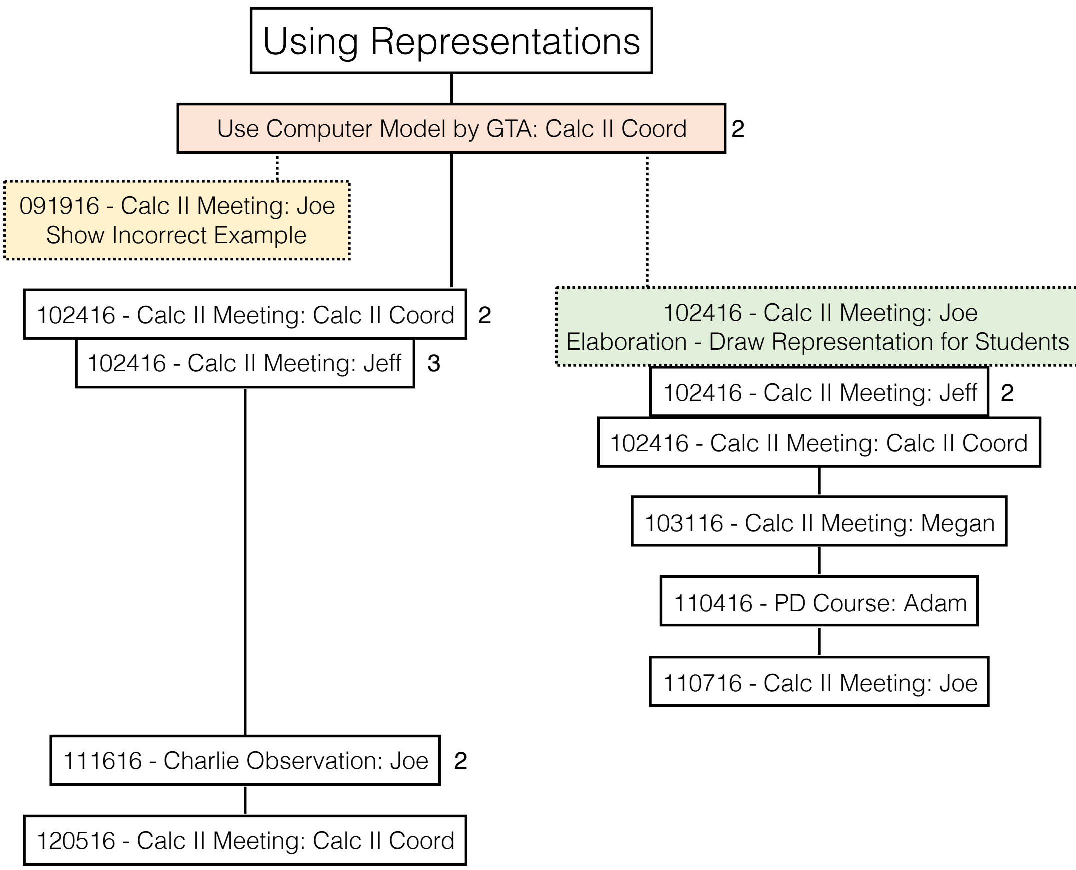
091216 - Calc II Meeting: Calc II Coord
092316 - PD Course: Tina
101716 - Calc II Meeting: Jeff
Elaboration - Help Student Thinking
102116 - Calc I Meeting: Justin
110416 - PD Course: Nancy
110416 - PD Course: Megan
Elaboration - See Different Methods


Using Representations
Use Computer Model by GTA: Calc II Coord
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091916 - Calc II Meeting: Joe
Show Incorrect Example
102416 - Calc II Meeting: Calc II Coord
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102416 - Calc II Meeting: Jeff
3
102416 - Calc II Meeting: Joe
Elaboration - Draw Representation for Students
102416 - Calc II Meeting: Jeff
2
102416 - Calc II Meeting: Calc II Coord
103116 - Calc II Meeting: Megan
110416 - PD Course: Adam
110716 - Calc II Meeting: Joe
111616 - Charlie Observation: Joe
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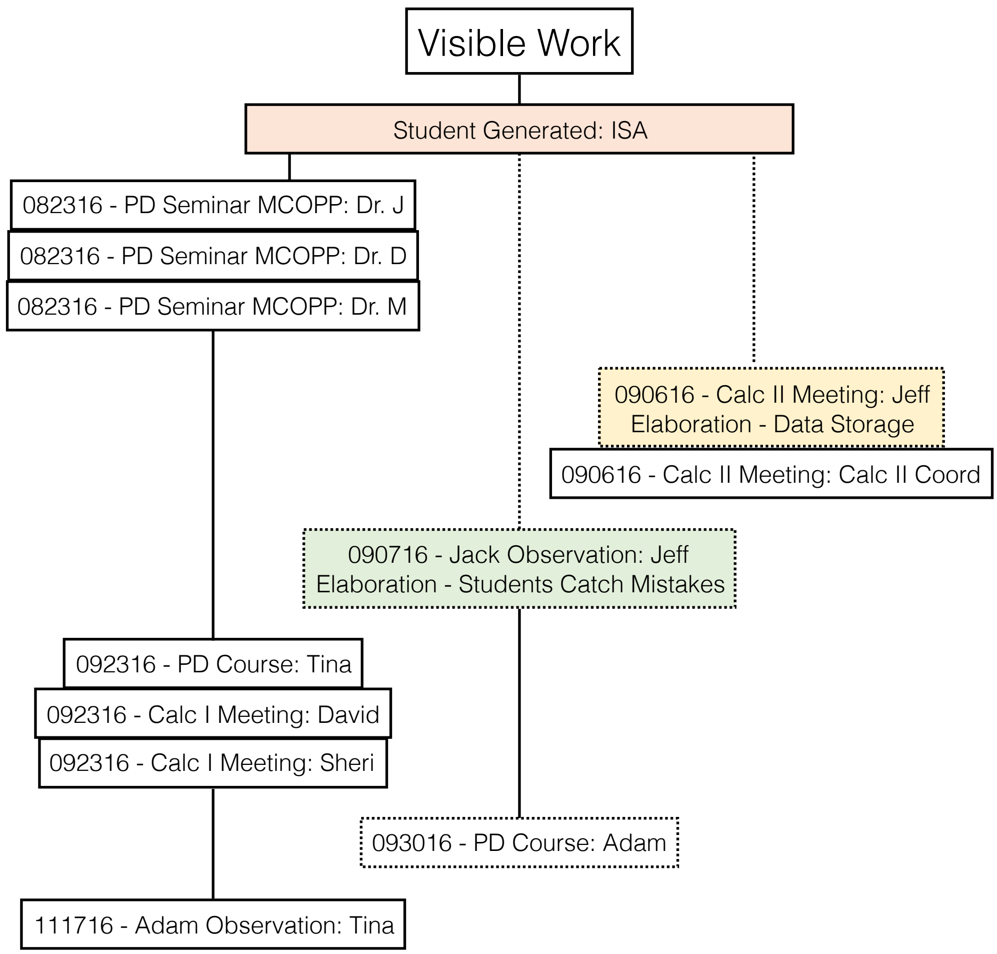
120516 - Calc II Meeting: Calc II Coord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Student Generated: ISA
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082316 - PD Seminar MCOPP: Dr. M
090616 - Calc II Meeting: Jeff
Elaboration - Data Storage
090616 - Calc II Meeting: Calc II Coord
090716 - Jack Observation: Jeff
Elaboration - Students Catch Mistakes
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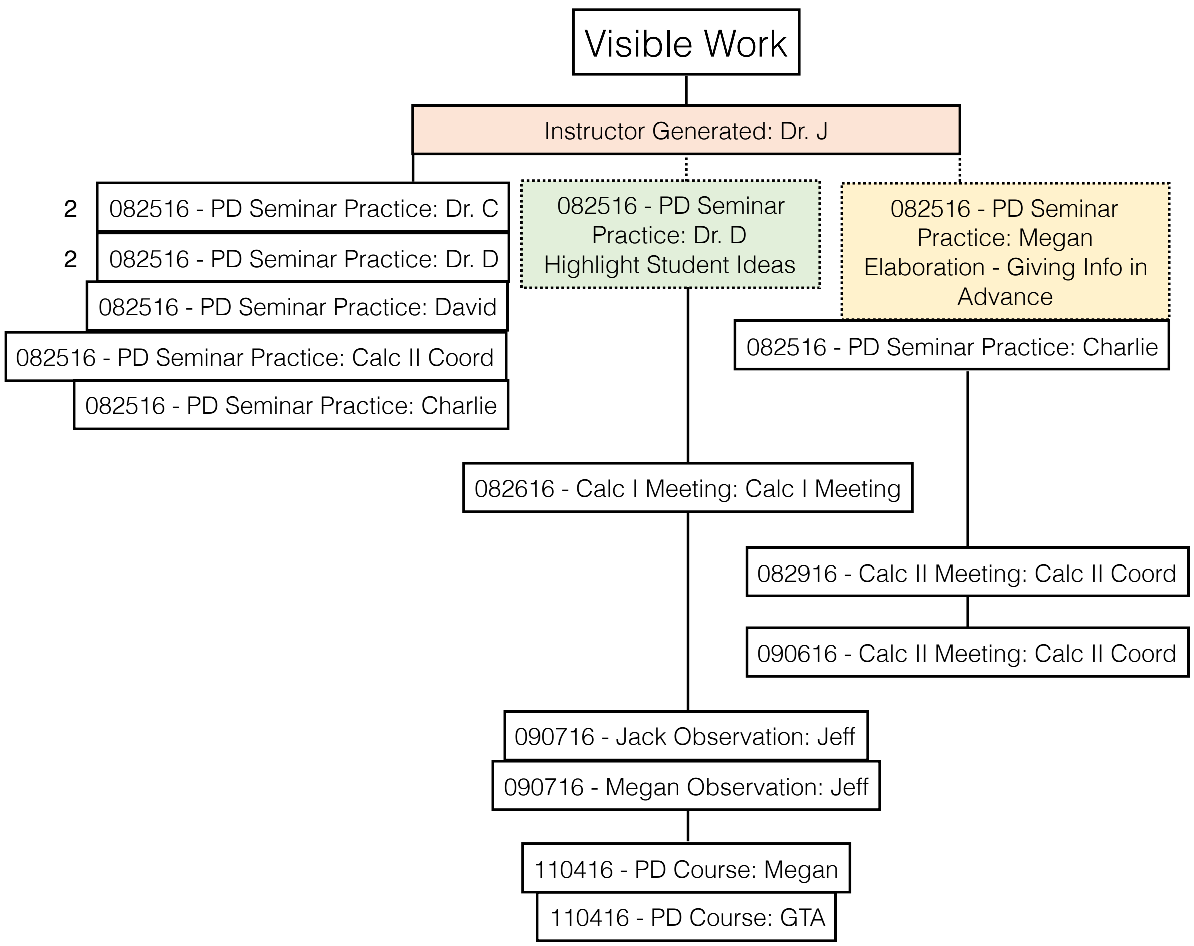
092316 - Calc I Meeting: David
092316 - Calc I Meeting: Sheri
093016 - PD Course: Adam
111716 - Adam Observation: Tina


Visible Work
Instructor Generated: Dr. J
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082516 - PD Seminar Practice: David
082516 - PD Seminar Practice: Calc II Coord
082516 - PD Seminar Practice: Charlie
082516 - PD Seminar Practice: Dr. D Highlight Student Ideas
082516 - PD Seminar Practice: Megan Elaboration - Giving Info in Advance
082516 - PD Seminar Practice: Charlie
082616 - Calc I Meeting: Calc I Meeting
082916 - Calc II Meeting: Calc II Coord
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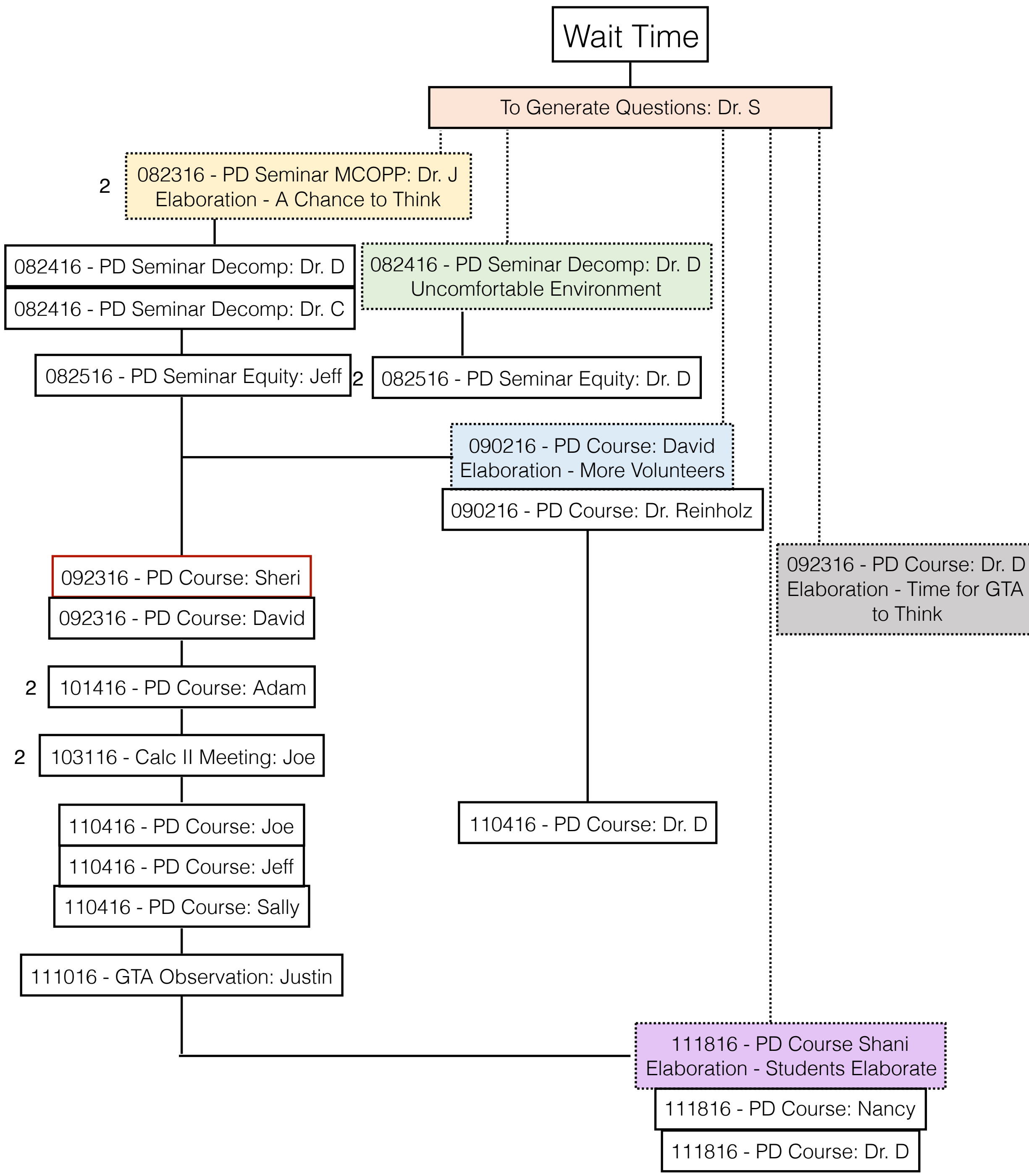
110416 - PD Course: GTA


Wait Time
To Generate Questions: Dr. S
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Elaboration - A Chance to Think
082416 - PD Seminar Decomp: Dr. D
082416 - PD Seminar Decomp: Dr. C
082416 - PD Seminar Decomp: Dr. D
Uncomfortable Environment
082516 - PD Seminar Equity: Jeff
2
082516 - PD Seminar Equity: Dr. D
090216 - PD Course: David
Elaboration - More Volunteers
090216 - PD Course: Dr. Reinholz
092316 - PD Course: Dr. D
Elaboration - Time for GTA to Think
092316 - PD Course: Sheri
092316 - PD Course: David
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101416 - PD Course: Adam
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103116 - Calc II Meeting: Joe
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110416 - PD Course: Jeff
110416 - PD Course: Sally
110416 - PD Course: Dr. D
111016 - GTA Observation: Justin
111816 - PD Course Shani
Elaboration - Students Elaborate
111816 - PD Course: Nancy
111816 - PD Course: Dr. D

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