Using the Instructional Tetrahedron to Classify College Algebra Instructors' Peer Observations

Keely Ramirez
UT San Antonio

Jessica Gehrtz
UT San Antonio

Priya V. Prasad
UT San Antonio

Professional learning communities (PLCs) can be a way to support college mathematics instructors in shifting their instruction to be more student-centered. This study focuses on what College Algebra instructors noticed when observing their colleagues' teaching in a video club setting within the PLC. We used the instructional tetrahedron to classify what instructors noticed according to the four vertices: Content, Students, Teacher, and Tools and Technology. Results highlight that instructors' discussions shifted away from Tools and Technology after returning to in-person classes and that instructors' discussions about Tools and Technology differed depending on the in person or online class context. We also found that instructors frequently noticed Teacher interactions, which points to their perceptions about the goals of the PLC - to provide feedback about teaching and to generate ideas about how to improve one's own instruction. Finally, what instructors notice about their colleagues' teaching might shed light on that instructors' goals and beliefs about teaching.

Keywords: Instructional triangle, Peer observations, Professional learning community

There has been increased attention on instructional practices that center students' activity and thinking during class time because of the positive student outcomes associated with these practices (Freeman et al., 2014; Laursen et al., 2014). However, instructional change at the college level is often difficult to catalyze (Apkarian et al., 2021). As such, college mathematics instructors may need additional support to shift their instructional practices to center students and their thinking. For this study, we leveraged a professional learning community (PLC) as a means of professional development. PLCs provide a long-term structure for on-going discussions and incremental improvements, which can increase instructors' interest in making changes to their teaching (Wildman et al., 2000). We also incorporated video clubs within the PLC as these have been shown to support teachers' learning and focus on student thinking and can result in shifts in instructional practices (Sherin & Han, 2004; van Es & Sherin, 2010).

Theoretical and Analytic Framework

The Instructional Triangle is a classic model for conceptualizing instruction since it consists of "interactions among teachers and students around content, in environments" (Cohen & Ball, 2001; p. 122). The Instructional Triangle represents these three components (teacher, students, and content) as vertices and includes edges that represent the interactions between each of the vertices. Recent research at the college level has used the Instructional Triangle to characterize instructor discussions during an online working group centered around inquiry-oriented instruction in Abstract Algebra (Kelley & Johnson, 2022). Kelley & Johnson (2022) found that the focus of instructors' comments shifted over the course of the working group to focus less on content and more on the relationship between content and students. In other recent research, Liu & Buchbinder (2024) proposed the Instructional Technology Tetrahedron, which is an extension of the Instructional Triangle to include a vertex for technology. Their conceptualization of the Instructional Technology Tetrahedron places the Technology node in the center of the Instructional Triangle and in the same plane as the other vertices, indicating that technology is more than an element of the learning environment (which is how prior extensions of the

Instructional Triangle have included Technology; Tall, 1986; Olive et al., 2010). Liu & Buchbinder (2024) used the Instructional Technology Tetrahedron to analyze pre-service teachers' noticing of their own online teaching, and how what they noticed changed as they gained experience.

In order to investigate the types of things the instructors in this study noticed, we leveraged the Socio-didactical Tetrahedron (Rezat & Sträßer, 2012), which is an extension of the Instructional Triangle to include a vertex for artifacts such as physical or digital manipulatives, digital technologies, and textbooks. Rezat & Sträßer's (2012) conceptualization of the Socio-didactical Tetrahedron connects a node for artifacts with the Instructional Triangle in a 3-dimensional space, such that the Instructional Triangle is the base of 3-D tetrahedron. Rezat & Sträßer (2012) argued that the mediation of artifacts is inseparably intermingled with the three vertices of the instructional triangle, and as such, perspectives of how artifacts interact with other vertices should be able to be represented by the surfaces of the Socio-didactical Tetrahedron.

Our work seeks to classify what college instructors notice when examining their colleagues' teaching in online and in-person classroom environments. Specifically, we aim to answer the following research question: What do instructors teaching the same class notice when observing a recorded lesson from one of their colleagues? This research is important because it highlights what components of instruction (content, student, teacher, and technology) instructors focus on when observing their colleagues, which could shed light on their personal goals, knowledge, and beliefs (Russ & Luna, 2013). Further, it could indicate a particular instructor's strengths or opportunities for growth with teaching.

Methods

This paper uses data gathered from a project which began in Fall 2021 and concluded in Spring 2024. From this project, we focus on two semesters, Spring 2022 and Fall 2022, in which instructors of College Algebra participated in a PLC to share and review recordings of each other's lessons in a video club setting. In the Spring semester four instructors participated in the PLC, while in the Fall semester two additional instructors joined PLC. In this study, we will focus only on observations of the four instructors for which we have two semesters of data for. Each instructor had three recorded lessons observed every semester, with the exception of Nicholas, who only had two lessons observed in Fall 2022.

Instructors were rotationally paired in such a way that they watched their partner's recorded lesson beforehand, then led a portion of the video club meeting by sharing snippets of the video-recording along with commentary of interesting aspects they noticed; after initial observations, all instructors were invited to discuss any aspects they found interesting of the lesson, too. Video-recordings of these meetings were transcribed verbatim and coded according to an adapted version of the Socio-didactical Tetrahedron, which we refer to as the Instructional Tetrahedron, composed of four vertices -Content (C), Teacher (T), Student (S), and Tools & Technology (E)- and the edges and faces between them. This resulted in fourteen codes. For this coding, we considered Tools and Technology to diversely cover computer-based software like Desmos, Zoom, and PowerPoint, but also non-digital classroom tools such as textbooks and whiteboards, since all items listed are used as support tools for learning.

Participating instructors were interviewed at the end of each semester by a facilitator of the PLC. The interviews included questions where the instructors were asked to reflect on their experiences with technology and peer observations. We use quotes of two instructors from these interviews to highlight possible reasoning for features found in results of our data.

Results

For this report, we focus on overlapping clusters of the four main vertices of the Instructional Tetrahedron -Content, Teacher, Students, and Tools & Technology- because this provides a coarse breakdown of what instructors focused on in their observations of each instructor. These are referred to as Cluster C, Cluster T, Cluster S, and Cluster E. Note that the clusters are composed of overlapping codes. For example, a Content-Teacher interaction will be reflected in both Cluster C and Cluster T. Table 1 includes the percentage of coded segments for each cluster from the instructors' discussion in the video club when observing the lessons taught by the instructor listed in the left column. Since the clusters are composed of overlapping codes the percentages of the rows do not sum to 100%.

Table 1. Frequency of Codes from each Instructor's Observations

Instructor		Cluster C	Cluster T	Cluster S	Cluster E
Alex	%	48.99	74.75	50.51	28.79
Nicholas		39.25	70.09	75.70	28.04
Ivy		44.71	66.47	44.12	32.35
Shay		42.00	71.33	43.33	37.33
Average	%	**43.74**	**70.66**	**53.41**	**31.63**

In addition to looking at what the instructors focused on when observing a given instructor, it is also important to consider the context in which the two semesters' data were collected. The semester of Spring 2022 began online, which then shifted to in-person instruction for most participants. By the Fall 2022 semester, only Nicholas was leading online classes. Table 2 highlights the percentage of segments from the observation discussions for all instructors related to each cluster from Spring 2022 to Fall 2022. In the following sections we discuss insights from Table 1 and Table 2.

Table 2. Average Frequency of Codes from Each Semester

Semester		Cluster C	Cluster T	Cluster S	Cluster E
Spring 2022	%	32.77	71.44	40.48	38.16
Fall 2022	%	62.50	69.11	62.26	21.51

Noticing of Tools and Technology-Focused Interactions (Cluster E)

Overall, the discussions focused on Tools and Technology interactions were consistently lower than other clusters, with an average of only 31.63% of the conversation revolving around this cluster (Table 1). Each instructor implemented tools like Desmos, Zoom, PowerPoint, whiteboards, etc., in a variety of ways during lessons, and many of these implementations are discussed within the video clubs. However, there is a decreased focus on Cluster E from Spring 2022 to Fall 2022. Specifically, Table 2, which breaks down the discussions revolving around each cluster by the semester these discussions occurred, shows instructor noticing of Tools and Technology decreases from 38.16% to 21.51%. We hypothesize this change of about 17% is related to the switch of online to in-person classes for the majority of instructors. Since we also

consider technology to be an environment, we speculate that when instructors are removed from this environment, their noticing of Cluster E interactions instead shift toward viewing technology as a tool. Instead of instructing through a medium of technology by necessity, after shifting to in-person classes instructors may or may not deliberately bring in technology to lessons as learning tools.

In order to shed light on the types of Tools and Technology interactions that were part of the discussions within the video club, we provide a comparison of instructor noticing during observations of Nicholas, an online instructor, and Shay, an in-person instructor. For comparison of these two instructors, we will refer to Table 1. Nicholas, who solely teaches online classes in both semesters and must constantly utilize technology for all of his lessons, only has 28.04% of instructors' noticing discussion points to Tools and Technology interactions. This could be because the technology serves as an environment that operates in the background, almost unnoticed. Interestingly, observations of Shay have the highest percentage of noticing focused on Tools and Technology, with 37.33%. Many of these observations come from Shay's use of Tools and Technology to segment lessons, such as personal whiteboards and review games created in PowerPoint. During the final video club of Fall 2022, when leading discussion of one of Shay's lessons, Alex describes the lesson as "high energy," and goes on to elaborate more during this same lesson:

> But then I kept it going because, showing the whiteboards I thought was such a good idea, bringing in those whiteboards, mixing it up. They're not on the computer. Like, you could feel that the energy in that class is changing just from something new happening.

As a complimentary point of view, in an interview in Spring 2022 with Nicholas, when asked about whether he would have implemented active learning and technology like Desmos without intervention of the project, he responded:

> We were already doing group activities in the classroom and having that active learning happening. And so…I guess the only thing that changed was the implementation method. And so now getting them to do it online, we are using the Desmos [Classroom].

When we consider the environments of Shay's and Nicholas' classrooms, they are both heavily influenced and reliant on Tools and Technology in different manners: one reliant on technology to function and the other bringing in tools as learning supports.

Finally, we notice that observations focused on content-interactions (Cluster C) increase by about 30%, and student-interactions (Cluster S) increase by about 22% from the Spring 2022 to Fall 2022 semester. We hypothesize that the instructors' discussion is shifting away from Tools and Technology (Cluster E) as they are becoming more comfortable with the technology used in the project, Desmos Classroom, which also allows them to be more focused on other aspects of instruction.

Noticing of Teacher-Focused Interactions (Cluster T)

The teacher-interactions (Cluster T) only has about a 2% shift from one semester to the next. This consistency of noticing teacher interactions may suggest that participating instructors view one of the main goals of video clubs as a time to give feedback to colleagues and reflect on their own pedagogy. An excerpt from Shay when interviewed in Spring 2024, gives clarification of her view of the valuableness of the video-club observations:

> Observations are really good for course coordination, but again, not setting it up for people to criticize other people. It's more of 'oh, I did that. And this went really well for me', 'Oh, you know, this is something that I could do in the future.' So I like observation reports because it was spun in such a positive way.

Shay's reflection of video clubs shows that she considers dialogue in these meetings as useful feedback to compare and develop with her own classroom experiences. Shay's response shows how she may be contributing to the collective noticing of teacher-interactions, due to her perception of the video clubs.

Noticing of Student-Focused Interactions (Cluster S)

During viewings of Nicholas' lessons, instructors observed more student-related interactions when compared to other instructors' teaching. While observations of Alex, Ivy, and Shay range from about 43% to 51% in noticed student-interactions (Cluster S), observations of student-interactions during Nicholas' lessons are 75.70% of discussions. We hypothesize the noticing of student interactions, during Nicholas' lessons, to Nicholas actively focusing on a student-centered classroom environment. In an interview in 2023, Nicholas reflected on his view of tools like Desmos during the previous year, mentioning that he considered Desmos to contribute to "more student interaction and independence." In a later interview from Spring 2024 with Nicholas, he is asked to reflect on his role as an instructor, which he responds to by calling himself a "facilitator." He then expands on this by explaining:

> I don't feel the need to take control of the class. And I feel like that gives [the students] back ownership for the class, that I think they take their work and their commitment to the class differently because of it. Because it's not my class.

We consider the autonomy Nicholas has afforded his students in their learning to be noticed by other instructors, as indicated by the percentage of compiled noticing of Cluster S. We also see this from comments during a Fall 2022 video club session, when reviewing a lesson from Nicholas, a comment from Alex coded as a teacher-student-technology interaction (TSE) is:

> [I] guess just for like the wider context, Nicholas spends most of the class like going through the Zoom and or the Desmos and always looking at student work while also shuffling through rooms. But if they're not having a problem in the room, he doesn't, you know, bother them or anything. He's just checking on all the rooms and also looking at all the Desmos stuff.

In an observation of himself from Fall 2022, Nicholas simply notes himself to be "a more effective instructor" in online classrooms like Zoom, which other instructors also tend to notice during video clubs.

Discussion

This work shows what aspects of the instructional tetrahedron instructors participating in a video club within a PLC noticed when observing their colleagues' teaching. It is important to highlight that what happened in class (what the instructors were doing and what the students were doing) during a video-recorded lesson impacted what might have been notable in an observation. For example, if the instructor was primarily lecturing while the students listened, then an observation would likely highlight either Teacher or Content interactions. This raises the question: Could a shift in the focus of discussion in a video club point to a shift in instructional practices? We hypothesized that the shift in discussion about Tools and Technology after the change from online to in person teaching resulted in less discussion about this cluster in the video clubs. It will be important for future work to investigate this connection between what is noticed and discussed during a video club and how that might reflect shifts in teaching practices.

Acknowledgements

Support for this work was provided by the National Science Foundation (#2116187). Any

opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

References

Apkarian, N., Henderson, C., Stains, M., Raker, J., Johnson, E., & Dancy, M. (2021). What really impacts the use of active learning in undergraduate STEM education? Results from a national survey of chemistry, mathematics, and physics instructors. *PLoS ONE, 16*(2), 1–15.

Cohen, D. K., & Ball, D. L. (2001). Making change: Instruction and its improvement. *Phi Delta Kappan, 83*(1), 73–77.

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences, 111(*23), 8410-8415.

Kelley, M. A., & Johnson, E. (2022). The inquirer, the sense maker, and the builder: Participant roles in an online working group designed to support inquiry-oriented instruction. *The Journal of Mathematical Behavior, 67,* 100984.

Laursen, S. L., Hassi, M. L., Kogan, M., & Weston, T. J. (2014). Benefits for women and men of inquiry-based learning in college mathematics: A multi-institution study. *Journal for Research in Mathematics Education, 45*(4), 406-418.

Liu, J., & Buchbinder, O. (2024). Instructional Technology Tetrahedron and Network Visualization: Conceptualizing Online Teaching Through a Lens of Reflective Noticing. *Digital Experiences in Mathematics Education*, 1-31.

Olive, J., Makar, K., Hoyos, V., Kor, L., Kosheleva, O., & Sträßer, R. (2010). Mathematical knowledge and practices resulting from access to digital technologies. In C. Hoyles & J. Lagrange (Eds.), *Mathematics Education and Technology: Rethinking the Terrain* (pp. 133–177). Springer.

Rezat, S., & Sträßer, R. (2012). From the didactical triangle to the socio-didactical tetrahedron: artifacts as fundamental constituents of the didactical situation. *ZDM, 44*, 641-651.

Russ, R. S., & Luna, M. J. (2013). Inferring teacher epistemological framing from local patterns in teacher noticing. *Journal of Research in science teaching*, *50*(3), 284-314.

Sherin, M. G., & Han, S. Y. (2004). Teacher learning in the context of a video club. *Teaching and Teacher education, 20*(2), 163-183.

Tall, D. (1986). Using the computer as an environment for building and testing mathematical concepts: A tribute to Richard Skemp. *Papers in honour of Richard Skemp,* 21-36.

van Es, E. A., & Sherin, M. G. (2010). The influence of video clubs on teachers' thinking and practice. *Journal of mathematics teacher Education, 13*, 155-176.

Wildman, T. M., Hable, M. P., Preston, M. M., & Magliaro, S. G. (2000). Faculty study groups: Solving "good problems" through study, reflection, and collaboration. *Innovative Higher Education, 24*, 247-263.