Exploration of TAMI-OP as a Professional Development Tool for Mathematics Instructors

Sarah Wise
U. of Colorado Boulder

Kyra Gallion
U. of Colorado Boulder

Sandra Laursen
U. of Colorado Boulder

The VIP-Math project aimed to understand whether and how teaching practices of mathematics instructors are influenced by discussions of their classroom data visualized using the TAMI-OP classroom observation tool. We found that TAMI-OP data visualizations supported discussions that led the participating mathematics instructors to set both short- and long-term teaching goals, and to experiment with teaching practices related to at least one of their goals. Given the limitations of the participant pool, further research is recommended with a greater diversity of instructors and coaches.

Keywords: classroom observation tool, professional development, college instruction

Introduction

Research in STEM higher education has investigated a number of tools for measuring teaching, in order to study teaching practices in real time. Alongside surveys, interviews, and classroom artifacts, classroom observation is a valued tool in the education researcher's toolbox because it provides direct evidence of what teachers and students are doing and can be used to measure change in effective teaching over time (AAAS, 2013; Weston et al., 2021). Observations can also be used for evaluating teachers for retention or advancement, for providing feedback to teachers about their work, and for evaluating professional development offerings and their impacts.

For any of these distinct purposes, the observation protocol and sampling must be carefully chosen to align with the goals of the measurement and the purposes for which the data will be used (Esson et al., 2022; Hora & Ferrare, 2013; Weston et al., 2021). Classroom observation tools tend to be either segmented or holistic. Segmented tools typically describe teacher and student classroom activities by taking data across short time intervals. Holistic tools tend to use Likert-scaled items to arrive at ratings. Holistic tools are more inferential, requiring more expertise to use reliably (Weston et al., 2021), though both types require attention to features that affect the tool's validity and interrater reliability (Weston et al., 2023).

Many tools have been developed and tailored for specific kinds of classrooms, including for example the RTOP (holistic, applied to K-12 and college contexts; Sawada et al., 2022), the TDOP (segmented, for college instructors; Hora et al., 2013), the COPUS (segmented, designed for college STEM classrooms; Smith et al., 2013), the GSIOP (segmented, designed for use with graduate student teaching assistants; Yee et al., 2019), and the CRIOP (holistic, for middle school instructors; Powell et al., 2013).

One observation tool developed for college mathematics classrooms is the TAMI-OP, a segmented, descriptive tool (Hayward et al., 2017, 2018; Weston et al., 2021, 2023). The classroom observer records what both the instructor and the students are doing across each two-minute interval of class time and can record notes. The tool includes codes for modalities of active learning often seen in mathematics classrooms—students working in groups or individually, answering or asking questions, giving presentations—as well as listening to lectures (Laursen et al., 2014). Instructor codes include asking and answering questions, reviewing student thinking, moving and guiding student work, lecturing, and working problems. Thus TAMI-OP can capture teaching activities that involve students actively or more passively, and

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the mix of these. Designed to track changes in teaching behaviors such as may result from professional development, the TAMI-OP is deliberately behavior-focused and non-evaluative.

The TAMI-OP tool automatically generates two visualizations that display 1) a timeline of what students and teachers were doing across the class period, and 2) the proportion of two-minute periods of class time in which certain codes appear (Hayward et al., 2018). The visualizations highlight how class time is used, enabling instructors to quickly see class features such as how much class time is devoted to activities other than lecture, the use and timing of questions and answers, and the balance between instructor questions and student answers.

With a few exceptions (Dillon et al., 2020; Reinholz et al., 2020; Yee et al., 2022), the use of observation data has not been well explored as a formative feedback mechanism for improving college instruction (in contrast to education research). Interest in this application is growing, however, and follows a long tradition of employing observation for feedback (and evaluation) in K-12 education (Martinez et al., 2016). Recent work exploring the use of observation tools in the college arena for feedback purposes have emphasized their application to spur instructor self-reflection (Dillon et al., 2020), and to assess the impact of feedback on graduate student teaching assistants' teaching practices (Yee et al., 2022). Observed instructors have reported that observation-grounded feedback opportunities are helpful (Dillon et al., 2020). Graduate students were found to improve instruction when the feedback was well contextualized (Yee et al., 2022). It has been suggested that interactions between expert teaching faculty and research-oriented faculty (including through observation-grounded feedback) could support the adoption of student-centered instructional practices (Rozhenkova et al., 2023).

Previously, the TAMI-OP had been used for research and evaluation purposes, but its descriptive emphasis and simplicity led us to explore how the TAMI-OP tool could be used in a professional development context focused on supporting observation-grounded feedback and instructor reflection. The theory of planned behavior (Ajzen, 1991; Archie et al., 2022) shapes our understanding of how teaching arises from planning. The theory led us to design a cyclical process of gathering data, reflecting, and conversing about teaching can help teachers to assess and change their practices in self-driven ways. Thus, we did not use the theory to make predictions or model quantitative data, but it informed the design of the professional development process.

The process specifically involved two coaches facilitating a series of goal-oriented discussions with instructors about TAMI-OP visualizations. We wanted to know if instructors would use the data to experiment with their teaching or change some teaching practices in ways aligned with their goals and, ideally, also aligned with evidence-based teaching. We nicknamed this project VIP-Math (Visualization Instructional Practices). The coaches engaged each VIP-Math participant as follows: they met with instructors to learn their initial set of teaching goals and orient them to the TAMI-OP instrument. Instructors then video-recorded a session of their mathematics class. The coaches scored the teaching video using TAMI-OP and met with the participant to discuss patterns in the data and visualizations. Participants were prompted to reflect on progress around their goals and set future intentions. This cycle was repeated two more times over the academic term, roughly 4 weeks apart.

Here "VIP-Math process" refers to this process of repeated gathering, sharing and discussing the TAMI-OP data and visualizations. We asked the following research questions:

- RQ1: Which elements of the TAMI-OP data and visualizations did VIP-Math participants tend to focus on?
- RQ2: How did the VIP-Math process influence participants' teaching practices?

Using the findings, we consider the affordances and limitations of the TAMI-OP as a tool for coaching, and the implications of the results for observation-based professional development.

Methods

Development of the VIP-Math process. Two of the authors were the coaches for this project, an early-career research assistant with classroom and professional development observation experience and a mid-career researcher with teaching and research experience in K12 and higher education. The coaches co-developed the VIP-Math process in consultation with the third author and conducted all participant-facing activities. Participants were sent a digital video camera and instructions for recording, and they uploaded each recording to a secure cloud storage folder.

Participants. Three mathematics instructors participated in this study, recruited from a list of participants in teaching professional development workshops. All three were white women with over 5 years of college-level instructional experience, and each stated a commitment to creating student-centered and active learning classrooms. Each also described herself as influential to colleagues, through formal or informal means. Two were full-time tenured faculty and one was a full-time, non-tenure-track lecturer. All worked at primarily undergraduate institutions, two at community colleges and one at a small liberal arts college.

Coding and analysis. The two coaches coded several sample videos to arrive at a common understanding of TAMI-OP code application. Both coaches coded all participant videos, coming to consensus on codes prior to discussing them with participants. Coaches tracked qualitative features of the classroom using the notes feature of the TAMI-OP. During each discussion, coaches prompted instructors to reflect on their video-recorded class, patterns in the TAMI-OP visualizations, their initial teaching goals and ways they are addressing them, and to revise their goals and intentions for future sessions or classes. Coaches responded to such reflections with a mix of follow-up questions, encouraging comments, and ideas for the instructor to consider in planning. Discussions were conducted and recorded on Zoom, and coaches also documented the flow of ideas in a research journal. Both the research journals and discussions were analyzed qualitatively for evidence related to the research questions, and the TAMI-OP data provided quantitative evidence about teaching.

Results

We present brief summaries of each participant’s engagement with VIP-Math, referencing each by their first initial (Table 1). These summaries focus on the goals the instructors set and related patterns in TAMI-OP data we observed across their three recorded sessions, which provide evidence of change in their teaching practices.

Table 1. Characteristics of courses, goals, and key change made by the three participants.

Participant	J	S	M
Course	Calculus 1	Precalculus	Finite Math
No. students	20	20	15
Class length	90 min.	60 min.	90 min.
Initial goals	Assess use of class time	Active learning; wait time	Student math talk; equity
Key change	Increased use of reasoning questions; Created plan to adjust materials	Introduced structured group work	Alternated questions between Zoom & room students

Participant S

Coaches noted that S's first videotaped class was highly interactive, with over 55% of time spent on activities other than lecture. She asked informational questions that students typically answered (Figure 1, Q&A). Students spent significant class time working on problems individually and used white boards to show individual work to S (Figure 1, IND).

The coaches suggested that S could expand the variety of her active learning techniques by incorporating structured group work and inviting students to present their work, and S set related goals. With the second recorded class, S incorporated structured group work for the first time. By the third class, she improved the written directions provided for group work, to increase their ability to work independently, and had one student present their group's work on the board.

S set long-term intentions to continue using structured group work and student presentations in both the Precalculus class that we observed and other classes, even though she anticipated some challenges:

> I am teaching precalc again in the fall so this is great, because I can implement it again. [I] want to start the student presentations earlier in the semester, and [I am] hoping that motivates them to be on time. My next goal: How do I add that level of structure in the group to ensure that everyone in the group participates and has a role?… I haven't tried [this] with the higher-level classes yet, but I definitely think I would try them. The actual physical classroom is logistically challenging because the class is really full and the room is really small. Could definitely do pairs though.

Participant M

In M's hybrid class for non-STEM majors, students could choose each day to attend online or in person. Her initial recording featured 90% of class time spent on activities other than lecture. In accordance with M's goal, coaches tracked the numbers of questions that M posed to students in the Zoom room and overall. The fraction of questions to Zoom students (typically about ⅓ of the class) rose from 20% to 35% across the three sessions. For M, making this change didn't feel entirely comfortable, but she had developed a system that seemed to work:

> Intentionally directing Qs to Zoom vs room without knowing whether they are actually there – that feels tricky. I'm doing it alternating now, and if there is no pick-up in Zoom, I pivot to room.

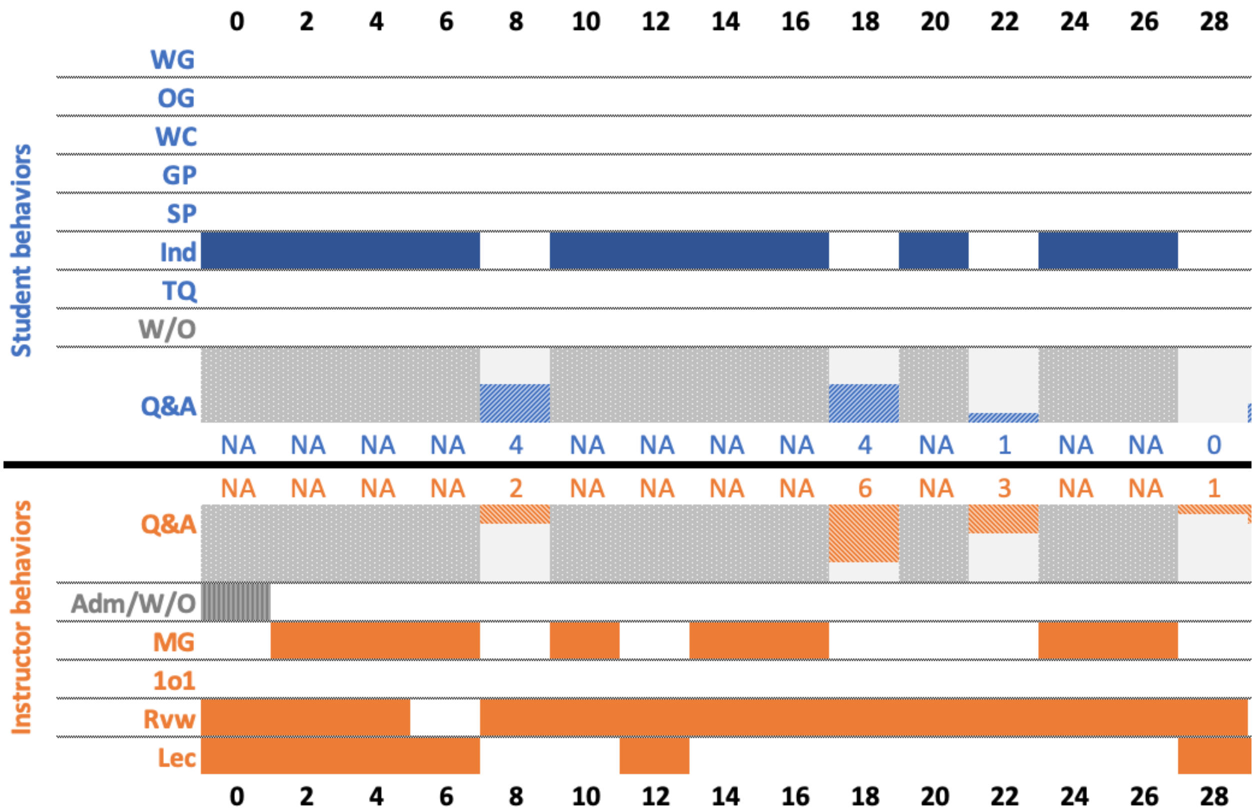

Figure 1. Excerpt of timeline visualization of S's first class, generated from TAMI-OP codes. Student codes (blue): WG, working in groups; OG; other group work; WC, whole class discussion; GP, group presentation; SP, student presentation; Ind, students working individually; TQ, taking a test or quiz; W/O, waiting/other. Instructor codes (orange): Adm/W/O, administrative/waiting/other; MG, moving and guiding; 1o1, teacher interacting with one student; Rvw, reviewing student thinking; Lec, lecturing. Horizontal axis represents elapsed time in class session, in minutes. Q&A numbers represent questions and answers from students (blue) and teacher (orange).

M devoted significant class time (25-90%) to student group work, in ways aligned with evidence-based teaching. Coaches noticed several ways in which class time was spent inefficiently, limiting opportunities for students to communicate mathematical understandings, but M did not engage with this observation.

During her final discussion, M continued to wrestle with the problem of engaging Zoom room students, in line with her initial goals. The coaches encouraged her to look at the norms she was setting around Zoom participation during her introduction to the course, and she came up with an idea to encourage Zoomers to use emojis to signal their presence and willingness to answer questions. She additionally generated an idea to create an introductory video of how Zoomers appear and sound in her hybrid-flexible classroom, to help Zoomers know how they appear to the in-person class.

Participant J

We observed three of J's Calculus I sessions. J's initial goals were to assess the balance of student group work time to other teaching activities, and to increase student voice in her classes. She wanted to devote 50% of class time to group work; in her initial class, she spent >60% of class time on activities other than lecture.

Across the three class sessions, TAMI-OP data revealed that J allocated 25-35% of class time specifically to group work. Discussion of J's second class centered around this balance:

> I have been thinking about restructuring the worksheets for this day. This is confirmation of that, that there is something missing in the balance of how it is set up.

J realized she needed to carefully choose example problems to illustrate new material, so there is "conceptual meat" yet without distracting details such as "dividing fractions." By our final discussion, J expressed a related long-term goal: "I need… to redevelop so I can get around them being bad at algebra." This was related to J's goal of increasing active learning: by restructuring class materials to maintain focus on new concepts, she could shift the balance of class time away from explanations and toward group work. Further, J described how TAMI-OP data led her to alter her expectations for use of class time:

> I have mentally adjusted by benchmark to realize that 50% group work may not be realistic… It will change how I approach others in my department. [I] don't want to set unrealistic expectations for other people.

Coaches also noticed that J asked 70-95 questions per class session, mostly informational. In discussions, J did not respond directly to the coaches' prompts around reasoning questions, but she did begin to ask more reasoning questions, increasing their share from 0% to 25% across the three class sessions.

RQ1: Which elements of the TAMI-OP data and visualizations did VIP-Math participants tend to focus on?

All three participants oriented quite quickly to the instrument. They had few questions about the meaning of different code categories and were able to interpret sample visualizations readily. Most frequently discussed were instructor codes LEC (lecture), REV (review), IQ and RQ (informational and reasoning questions), and MG (moving and guiding); and student codes SA (student answers), WG (working in groups), and SP (student presentations). Conversations focusing on TAMI-OP data tended to be brief. None of the participants tended to pore over the data, looking for patterns that were not obvious.

Participants tended to focus on TAMI-OP elements that aligned well with their initial goals. M tended to focus on the share of questions that she was asking to students in the Zoom room, while S and J tended to focus on the amount of class time devoted to student active learning. Participants also often commented on TAMI-OP data that they perceived as validating their current teaching practices.

RQ2: How did the VIP-Math process influence participants' teaching practices?

We found that the VIP-Math process influenced participants to change specific teaching practices in the short term. Each participant altered some teaching practices across their recorded classes, and mentioned altering some practices in classes that were not recorded. Some teaching practices changed as recommended by coaches, even when goals were not explicitly set around them. Changes were observed in how participants allocated class time to student group work and presentations, and how participants asked questions. At final discussions, all three participants also set long-term teaching goals, some of which could be traced to patterns in their TAMI-OP data. S set goals for increasing student presentations and structured group work, while M set goals about increasing the engagement of her online students, and J set goals for altering class materials so student group work can proceed more efficiently.

Discussion

Patterns across the three VIP-Math participants suggest some preliminary answers to our research questions. Participants readily engaged with the data visualizations generated about their class sessions and referenced them in reflecting on how their uses of class time related to their teaching goals (RQ1). Participants also made specific goal-related changes to their teaching, and they set long-term goals for future teaching changes (RQ2).

The VIP-Math project also allowed us to gather insights about the affordances and limitations of TAMI-OP as a professional development tool. As affordances, we found uploaded recordings of class sessions easy to score remotely, and we could accomplish an observation-feedback cycle with less than a week of lag between recording and discussion. Participants oriented quickly to the codes and visualizations, maintained a focus on their teaching goals, made related changes across the course of their sessions, and reacted positively to the VIP-Math process overall.

However, the VIP-Math process was time-intensive for coaches, and two coaches were needed to manage the logistics across three sessions. Coaches found some aspects of high-quality teaching challenging to address, particularly evaluative elements not captured by the protocol, and elements not well aligned to participants' teaching goals. For instance, coaches' concerns about M's efficiency in using class time were never discussed in depth, in part because these concerns did not align with M's goals.

This study is also limited by the small sample of participants with limited diversity. There were no instructors of color, novice or early-career instructors, instructors who expressed ambivalence around incorporating active learning into their teaching, or instructors who were teaching large classes. This limits our ability to generalize about the tool's benefits in professional development contexts.

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