

Towards a Framework for Smart Classrooms that Teach Instructors to Teach

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Abstract: Teaching Assistants (TAs) play a major role in higher education; however, they receive little if any training on how to teach. Quality training requires access to grounded feedback and relevant suggestions for improvement. We developed a framework for using features of a smart classroom. This work reframes the instructor as the learner. It provides training on discursive practices with feedback based on the instructor's in-class behaviors. We built and deployed a system based on this framework to five STEM TAs as part of a larger study. This paper: discusses the action-reflection-planning framework we used, provides evidence for how the framework addresses TA learning goals, and discusses how other researchers might make use of the framework.

Introduction

Teaching Assistants (TAs) teach up to 26% of college classes (Friedman, 2017). Interestingly, most receive no pedagogical training (Ellis et al., 2016), nor do they receive regular feedback on their performance (Austin, 2002). Smart classrooms now offer many sensors that can detect various behaviors that occur during class (Blanchard et al., 2016). While this technology to date has focused mostly on students, it could also sense instructors' behaviors, recasting the instructor as a learner. Smart classrooms provide a new opportunity for training such novice instructors to teach using their own data as a form of input, creating opportunities for instructional feedback that have been difficult to achieve at scale.

We developed a framework for training instructors to teach that incorporates reflection on practice and planning for upcoming classes that is distributed over time within cycles of teaching. In addition, we prototyped a system to train instructors on discursive practices, simulated a smart classroom with research assistants logging behaviors, provided feedback in the form of data visualizations, and prompted instructors to both reflect on their performance and plan for the next class. We conducted a field trial with a small number of TAs and observed movement towards better teaching practices and some shift in beliefs around student-centered learning.

Related work

Support for TAs is rare. Many schools provide no training. When available, many TAs choose not to participate for reasons including the need to dedicate many consecutive hours to the typical workshop format of such training (Ellis et al. 2016). However, professional development (PD) research on faculty and TAs shows that they need help to notice their own poor practices (Henderson et al., 2011) and for setting goals (Brinko, 1993). Regular, data-supported feedback on teaching would address some of these needs (Brinko, 1993).

Researchers have previously offered digital feedback to instructors, typically as dashboards showing what students do or know (Jivet et al., 2017). Research on instructor feedback systems shows that instructors must have pre-existing expertise to interpret them. Currently, most TAs have no prior teaching experience nor access to feedback. Our work investigates opportunities for addressing this lack of expertise through automated feedback on what TAs actually do in the classroom combined with online training.

System design

Our socio-technical training system (STTS) is meant to simulate a future smart classroom that can provide training and feedback, and it is meant to scaffold reflection and planning. Our system aims to help TAs develop the use of discursive teaching tactics (Rocca, 2010) to reduce non-interactive lectures and shallow questioning strategies; actions which harm student attention, focus, and learning (Chi & Wylie, 2014; Freeman et al., 2014). It introduces simple research-proven strategies for eliciting student participation and describes how increased participation improves student learning (Rocca, 2010). It trains TAs on the use of discursive techniques such as asking questions, asking content questions, pausing after asking questions, and calling on students by name.

We developed a framework (Figure 1) of the TA as a learner based on our pilot studies of how TAs prepare for teaching. It is also influenced by Clark and Hollingsworth's interconnected model of professional growth (2002). This functioned as an overarching guide for the design of the STTS. The STTS directs TAs through an iterative process of reflection, planning, and acting (i.e., teaching their class).

We simulated a smart classroom by having research assistants with a logging tool capture in-class behaviors, such as the length and order of TA and student speech turns, the number and types of questions TAs asked, and the pauses between speech turns. We prototyped the training aspect of our STTS using the commercial survey service, Qualtrics. We used this to deliver training materials on discursive practices, to present data visualizations of teaching behaviors, and to scaffold reflection on recent teaching and planning for an upcoming class.

Our design organizes activities into conceptual Units that are delivered over about ten days via three subsection, called modules (M). They are M.1: training and reflecting on performance to notice teaching behaviors, M.2: planning for use of new tactics, and M.3: reviewing and reflecting on the results of attempting those tactics. M.1 provides instruction on the value of student participation and asks TAs to recall details of their most recent class. It shows them data visualizations from that class, revealing their patterns of teaching. TAs respond to reflection prompts immediately after viewing these data. M.2 supports goal-setting and guides TAs through practical tactics (e.g., “Write questions up on the board rather than just saying them out loud”). TAs commit to trying new tactics in their next class. After the next class, M.3 reveals updated sets of visualizations comparing prior and current performance, and the outcomes of their selected strategies.

In the current field trial, we deployed two content Units, each containing these three modules. Unit A trains TAs to ask more questions and to ask questions about the course content, as opposed to simply asking if the students have “any question?”. Unit B trains TAs to wait at least 3 seconds after asking a question before speaking.

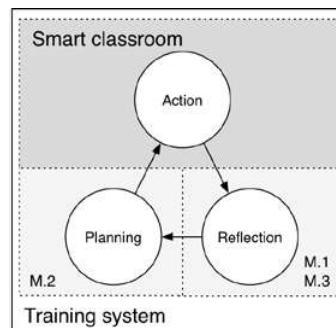


Figure 1. Diagram of framework for sensing and training to align with TA activities.

Method

We conducted a qualitative study of our STTS to examine how well it promotes the features of the framework. We wanted to understand how our design might impact TAs’ in-class actions, post-class reflections, and pre-class planning. We recruited 5 TAs in an American university (one undergraduate and four PhD students) who volunteered due to interest in improving their teaching. They were all male. They taught either a recitation section or a stand-alone course in math, engineering, or accounting. Average attendance per class was about 20 students. We observed a total of 80 class sessions totaling 89 hours of observation across the 5 TAs.

Before deploying our STTS, we observed a baseline of about 6 sessions per participant. Participants then interacted with the STTS seven times over the three-week trial. Each TA’s interaction with the tool was short (no more than 10 minutes per session). Sessions that included class data were available within 1 hour of teaching. TAs were prompted with email messages containing links to the Qualtrics forms. TAs were prompted to plan 2 days before their next class.

Following the trial, we conducted semi-structured interviews with each TA for 1 hour, followed by a deep review of the conversation by the research team. We followed a style of contextual inquiry interviews that produces line by line segments of subject sentiments, each of which we used to produce inductive sentiment themes across participants (Beyer & Holtzblatt, 1997).

Data analysis

To assess the framework, we reviewed three data sources: interview sentiments, interactions with the STTS, and in-class behaviors. For Action, we looked at the use of suggested discursive strategies, and whether or not TAs changed behaviors following the use of the STTS. From the class logs, we calculated discursive actions at the class level (e.g., number of questions asked per session) and used exploratory data analysis to uncover behavioral trends at an individual TA level, both across sessions and between baseline and instructional sub-units. For Reflection, we reviewed STTS interactions and interview sentiments to discern whether TAs engaged in reflection, including assessments of their ability to perform critical self-evaluation. For Planning, we reviewed the strategies TAs selected to try, and we judged whether they enacted those tactics in class.

Findings

In general, the TAs all used our STTS as designed. We observed them all engage in a structured cycle of action, reflection, and planning. None abandoned the system. They typically responded to each emailed prompt to use the system within one or two days at which point they completed the module. All participants described the system as “useful” for improving their teaching. P1, P3, and P4 all exhibited positive change over the semester. P2 and P5 exhibited ineffective teaching strategies from the start, and these persisted throughout the semester. Below, we characterize the TAs’ interactions with the STTS based on our Action, Reflection, and Planning framework.

Reflection (M.1 & M.3)

We designed two distinct types of reflection: *before practice* and *after practice*. *Before practice reflection* relates to module M.1, where participants received training and saw visualizations of their behavior from the previous class. *After practice reflection* relates to module M.3, where participants viewed visualizations of their performance after they had previously created a plan to try something new for their next class.

With respect to *before practice reflection*, all TAs expressed curiosity and surprise when viewing visualizations of in-class behaviors. They generally seemed to appreciate the objective nature of the data. We observed P1 and P4 rationalizing what they viewed as negative aspects of their data by explaining some challenge they faced in class. In answering the reflection prompts, P1 focused on a high number of unanswered questions. He shared that he had a “bad habit” of “chaining” several questions together, which seemed to not offer the students the time or opportunity to answer. P4 focused on his first visualization, which showed that he talked for 75% of class time and the students only talked for 5% of class time. He explained that this might be happening because he tried to “prioritize delivering all the materials on time...” He felt more pressure to cover all of the content as opposed to creating time for students to participate.

With respect to *after practice reflection*, all TAs acknowledged the validity of the data and tried to explain some aspect of it. In M.3 TAs were asked to review their attempts to enact new tactics. Some TAs expressed positive self-evaluations of themselves as instructors, pointing to increases in student participation/responses or describing their skill with a new tactic. For example, P4 shared that preparing questions before class helped him ask more content questions than he had previously been asking. In the interview, he shared that he continued this practice throughout the rest of the semester. P1 shared that he “paid more attention to what [he] was saying question-wise,” as he began to notice going “on autopilot.” P4 reflected on the fact that he was not able to increase the percentage of student talk. Interestingly, he gave himself credit for trying. “I set goals for myself after seeing the data, like when I saw the data where I waited too short. So, I set the goal to wait longer.”

TAs did not all feel they improved. When prompted to recall their goals, neither P2 or P5 could recall the techniques they had planned to try. When asked to reflect on his goal attainment in Unit A/M.3, P5 stated he could not remember the class in question. Our system prompts TAs to review their data soon after teaching. However, in these cases, P2 waited 3 days before logging in, and P5 waited 9. Later, in Unit B, P2 reflected that waiting longer after asking questions, “Did not seem to make any particular difference, as students could not answer the question anyway.” P5 reflected that he should probably wait longer in the future, despite waiting longer than the target of 3 seconds. He seemed to fail to notice a larger issue, that he asked very few questions.

Planning (M.2) and Action

We report Planning and Action together to support evaluations of TAs’ attempts to use their selected tactics in class. Overall, TAs were responsive to goal-setting. When planning their upcoming class, TAs saw a list of strategies they might try in order to increase the content questions they asked, e.g., preparing questions in advance of class, or putting questions up on slides. In baseline observations, most TAs relied on lecture and shallow questioning strategies. We observed each TA select at least one improvement strategy in Unit A/M.2. Following the strategy selection, they all increased the number of content questions they asked in the following class.

P1 selected the most strategies, setting goals to slow down during question asking, ask a wider variety of question types, and wait longer before giving hints or answering a question. P4 set a more conceptual goal, describing how the questions should support the need to cover material. P3 said he planned to ask, “a few more questions than last time.” After planning, P1 avoided rapidly repeating/rephrasing questions, and his students responded to a greater ratio of the questions he asked. P4 increased his use of content questions and reduced non-content questions. P3 increased his use of content questions, and this persisted for the rest of the semester.

Alternatively, P2 and P5 showed only isolated teaching improvement. P2 jumped from 1 content question at the beginning of Unit A to 19 following planning. P5 went from 6 to 15. Both then reverted to very low numbers of content questions after a single class. Goal-setting for these TAs seemed vague or disconnected from their practice. P5’s only goals in Unit A/M.2 were to “Ask better questions” and “Give students more time to think about questions,” (despite already averaging over 3 seconds of wait time). P5 never explained the dramatic rise and drop of content questions. Importantly, during the class where he asked 15 content questions, he averaged only 1 second of wait time after each question, and no students responded to any of the questions.

Discussion

The framework seemed to promote some reflection and planning for all TAs. Three engaged in substantive self-critique, and these instructors seemed to improve. Each TA made plans, and all of them attempted at least one new strategy. However, they did not all maintain the use of these strategies. Each TA who made concrete plans and performed more thoughtful reflection seemed to continue challenging themselves as the course progressed.

Although two of the TAs did not engage in meaningful reflection, concrete planning, or beneficial changes to their teaching, they did still engage with each stage of the STTS. Deeper analysis of their interactions with the system and possible changes in their beliefs may provide some insight into what went wrong and reveal specific needs to address to make the system more successful. Our analysis leads us to conclude that a fully deployed system would function better if it accounted for individual differences in instructors. We suspect that paying attention to beliefs in teacher-centered learning versus student-centered learning is a good place to start. A deployed system might also collect self-efficacy measures and adapt to instructors more individually.

For others attempting to operationalize this framework, we point out that it is critical to consider consistency in user engagement. Parts of the framework require specific timing constraints, such as planning before class begins and active reflection very soon after teaching. If learners fail to review their data when prompted, it will likely reduce the system's impact. Missing sessions of planning or reflection can create gaps in the training cycles where instructors lose track of their goals. Future systems should consider how the system can motivate instructors to quickly engage.

The design of this kind of teacher-as-learner system benefits from information on what drives the instructor. Instructors may embrace training due to a genuine motivation to change, or they might be compelled if this becomes a requirement of their job. They may avoid training because they are not interested in improving, do not feel it is worth the time, or because they do not believe that the strategies actually work. Future systems could use social motivations, such as connecting instructors to a community of practice. Or they could follow a more extrinsic approach, such as hinting that training could enhance the instructor's CV.

This field study of our STTS that combines smart classrooms that sense instructors' actions with personalized feedback and training shows promise, and it offers a new approach to instructional PD. Beyond producing actionable, scalable methods for TA training, we believe this data-rich approach to interacting with novice instructors may reveal interesting new insights into how people learn to teach.

References

- Austin, A. E. (2002). Preparing the Next Generation of Faculty: Graduate School as Socialization to the Academic Career. *The Journal of Higher Education*, 73(1), 94–122.
- Beyer, H., & Holtzblatt, K. (1997). Contextual design: Defining customer-centered systems. Elsevier.
- Blanchard, N., Donnelly, P. J., Olney, A. M., Samei, B., Ward, B., Sun, X., & D'Mello, S. K. (2016). Semi-Automatic Detection of Teacher Questions from Audio in Live Classrooms. In *Proceedings of the 9th International Conference on Educational Data Mining* (pp. 288–291).
- Brinko, K. T. (1993). The Practice of Giving Feedback to Improve Teaching: What Is Effective? *The Journal of Higher Education*, 64(5), 574.
- Chi, M. T. H., & Wylie, R. (2014). The ICAP Framework: Linking Cognitive Engagement to Active Learning Outcomes. *Educational Psychologist*, 49(4), 219–243.
- Clark, D., & Hollingsworth, H. (2002). Elaborating a model of teacher professional growth. *Teaching and Teaching Education*, 18, 947–967.
- Ellis, J., Deshler, J., & Speer, N. M. (2016). Supporting instructional change: A two-pronged approach related to graduate teaching assistant professional development. *Proceedings of the 19th Annual Conference on Research in Undergraduate Mathematics Education*, (February).
- 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 of the United States of America*, 111(23), 8410–5.
- Friedman, J. (2017, February). *10 Universities Where TAs Teach the Most Classes*. Retrieved from <http://www.usnews.com/>
- Henderson, C., Beach, A., & Finkelstein, N. (2011). Facilitating change in undergraduate STEM instructional practices: An analytic review of the literature. *Journal of Research in Science Teaching*, 48(8), 952–984.
- Jivet, I., Scheffel, M., Drachsler, H., & Specht, M. (2017). Awareness is not enough: Pitfalls of learning analytics dashboards in the educational practice. In *Lecture Notes in Computer Science* (Vol. 10474, pp. 82–96).
- Rocca, K. A. (2010). Student Participation in the College Classroom: An Extended Multidisciplinary Literature Review. *Communication Education*, 59(2), 185–213.

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