Learning Analytics Beyond Traditional Classrooms: Addressing the Tensions of Cognitive and Meta-Cognitive Goals in Exercise Sessions

Zhenyu Cai(✉), Richard Davis, Roland Tormey, and Pierre Dillenbourg

EPFL, Lausanne, Switzerland
{zhenyu.cai,richard.davis,roland.tormey,pierre.dillenbourg}@epfl.ch

Abstract. A range of learning analytics (LA) tools have been designed and integrated into university classes to facilitate teaching and learning. However, exercise sessions, the educational setting that complements lectures with practical activities, are commonly overlooked by LA researchers and designers. Little work has focused on involving the key stakeholders, teaching assistants (TAs), and incorporating human-centered design approaches in this context. To address this gap, we conducted a qualitative study to understand TAs' common approaches and challenges of teaching in exercise sessions, and to explore their visions for LA dashboards that could be adapted into their current practices. Our results indicated that TAs in exercise sessions held two sets of goals in supporting students' cognitive and meta-cognitive activities, and while LA tools were seen as offering numerous potential benefits, they were also seen as introducing tensions threatened to disrupt the delicate balance of both goals.

Keywords: Teacher Dashboards · Learning Analytics · Exercise Sessions · Higher Education

1 Introduction

The integration of learning analytics (LA) into higher education holds great potential for empowering educators with actionable information for improved teaching and increasing learning effectiveness. LA dashboards designed for teachers have yielded positive outcomes in various areas, such as academic advising [2], learning design [3], and lesson planning [5].

One context in higher education that has been largely overlooked by learning analytics researchers and designers are exercise sessions (also called lab sessions, tutorials, or recitations). These sessions are usually led by teaching assistants (TAs), and serve as a practical component that complements the theoretical parts (i.e., lectures delivered by instructors) of many STEM courses. Despite

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their importance in providing hands-on activities to students, few LA tools have been designed especially for exercise sessions, and there is a lack of research that has involved teaching assistants (TAs) in the process of co-designing or co-developing LA tools [7].

This is somewhat surprising since exercise sessions are places where students take ownership of their learning and receive just-in-time feedback when needed. In such cases, LA has been found to be successful in supporting self-regulated learning [4] and providing personalized feedback [1]. Additionally, exercise sessions are also where teachers informally track students' performance and assess the effectiveness of course materials and teaching strategies. In response to such needs, it is evidenced that LA is powerful in terms of monitoring students' learning progress and behavior [8], as well as providing data-driven insights to improve the instructional design [6].

This work aimed to learn more about how learning analytics tools might be designed to support the unique needs of TAs in exercise sessions. Given the scarcity of related studies and the exploratory nature of our research, we adopted a human-centered approach to understand this context, to surface needs, and to imagine the types of LA tools that would best support them. The research questions that we aimed to address in the study were: **RQ1** What are the underlying goals of TAs based on their described experiences of facilitating students' learning activities during exercise sessions? **RQ2** In what ways should an LA tool be designed to meet TAs' goals while fitting their current practices?

2 Method

2.1 Materials

An interview protocol and a web-based mockup were developed for our semi-structured, task-based interviews, as a way to map between TAs' goals and their vision of how an LA dashboard could be adapted into their current practices.

The mockup[1] was designed with three hierarchical levels: the Course level showing the class progress across all notebooks, the Notebook level which gave an overview of a single notebook's tasks, and the Cell level that showed more details about a task of interest (including stats, predictions, and a code panel).

The interview protocol consisted of 25 questions: 13 questions about exercise sessions and TAs themselves (e.g., "What are your goals as a TA in an exercise session?"), 9 questions that required TAs to interact with the mockup and describe their perceived information and potential use cases, and 3 questions to encourage critical reflection such as "Do you have concerns about actually using a dashboard like this in an exercise session?"

2.2 Procedures and Participants

This study received ethical approval from our university. It involved a 1-hour interview session, during which the interviewers observed and took notes. The

[1] https://figmashort.link/bwcama.

recruitment started with purposive sampling in an European university from a pool of 36 courses in which Jupyter Notebooks had been integrated. After screening the courses by checking course books and GitHub repositories, we excluded those that used Jupyter Notebooks only for lectures. 18 instructors were contacted which led to a list of 18 TAs to be emailed. Eight TAs (4 females, 4 males; 6 PhD students, 2 MSc students) from four STEM subjects participated in our interviews.

All participants were compensated for their time in the study. Audio and participants' interactions with the mockup were recorded. A thematic analysis of the interview transcripts was then conducted by two researchers, while the inter-coder reliability was ensured by resolving all disagreements in person.

3 Results

Our analysis of the transcripts resulted in 9 top-level codes, 30 subcodes, and 655 coded segments. In summary, top-level codes including "TA goals", "TA values", "TA beliefs", and "What TAs do" were used to develop themes related to "Cognitive goals" and "Meta-cognitive goals", corresponding to RQ1. Additionally, other codes such as "Sources of information", "TA time constraints", "Dashboard features that TAs want", etc., were grouped into themes representing TAs' needs of LA tools and tensions between their goals, addressing RQ2.

3.1 RQ1: TAs' Goals in Exercise Sessions

Cognitive Goals. According to what TAs explicitly said when asked what their goals were, their primary goals were that students learned from the materials, and that students were able to make steady progress through the problems. We term these "cognitive goals". To help meet these goals, TAs monitored students at both the individual and aggregate level, and they used two main indicators to measure their success helping students learn. First, TAs viewed "stuckness" as something to resolve, and viewed steady progress through the problems as an indicator of success. For example, TA4 said, *"I was just happy that I could get help people being unstuck... it felt good to see them being able to progress."* Second, TAs monitored students' emotional states and associated success with students who were interested, engaged, and happy. For example, TA2 described the ideal exercise session as one where *"people were focused, not sidetracked by various things that are not the exercise session."* Therefore, TAs worked hard to create a responsive classroom environment where students could receive help as soon as they needed it.

While primarily relying on explicit requests for help from students (e.g., hand raising), TAs also monitored students' progress passively by walking around and actively by checking in on students. This helped TAs get a sense of how the class was doing at the moment, as TA6 said, *"by walking around and discussing with the students I can see which one is doing great or which one has more struggle for this, and so on."*

Meta-cognitive Goals. In addition to cognitive goals, TAs also aimed to help students develop skills related to problem solving, such as monitoring their own progress and seeking help when needed. We term these "meta-cognitive goals". There were three indicators that TAs used to measure their success in meeting this goal. First, TAs wanted to make sure that students would ask for help when they were stuck. Second, TAs valued when students could ask good questions, as TA3 described, *"if students asked me a lot of questions, and questions were interesting... then I'm happy."* Third, TA2 expressed a clear preference for students who took responsibility for their own learning if they had put serious thought into the problem before asking for help, stating, *"you do value your own learning more than just calling someone over."*

TAs supported students in developing their meta-cognitive skills by striking a careful balance between under- and over-helping. On the one hand, TAs wanted to make sure students knew they were available and willing to help, which they signaled to the students by moving through the room. As stated by TA4, *"that's much more engaged and it looks like you are available and they can ask questions."* On the other hand, TAs would periodically ask students who appeared to be stuck if they needed help, as TA1 described: *"when you see that they're stuck, or they're not doing anything that's when you can prompt them. You can be like, can I help you with something?"* Together, we interpret these two behaviors as scaffolding students' process-monitoring and help-seeking behaviors.

3.2 RQ2: Addressing TAs' Needs with LA Tools

LA Features to Support TAs' Goals. As steady progress and high engagement are two indicators to evaluate success in achieving meeting goals, multiple TAs expressed a need to monitor the overall progress of the class through the exercises. TA3 said, *"how they are currently doing is something that I am not always sure about"*. One feature that TAs highlighted in the mockup were real-time indicators showing the percentage of students who had accessed a cell, which would allow them to see approximately where the whole class was at any given moment.

Meanwhile, TAs requested features that were not present in the dashboard mockup to deal with similar issues. For example, TA8 said *"I think it would be super nice if they can also ask questions without raising their hands... like a board with questions that they pop up."* TA2 even suggested an automated approach of identifying students who needed help: *"you could see who's on which problem and then using like DKT [Deep Knowledge Tracing] or something, figure out how many more attempts they're going to take for that question to see where they're like struggling or on a bad trajectory, and then go walk over to them and see what's going on."*

Sometimes TAs also faced a difficulty in creating an atmosphere where students could rely on TAs to provide help when needed: students who needed help had to wait for long periods of time when TAs were busy helping other people. TA1 said that this problem was often caused by many students struggling with the same task, and suggested using the dashboard to identify common problems

and then discuss them with the entire class: *"I could say like, okay, so it seems to be like... a challenging cell. So I'm gonna switch to the other tab. And then we're going to do it together."* Moreover, to handle situations where TAs were overwhelmed with questions, TA8 suggested a user scenario where an LA tool could be helpful by supporting TA coordination: *"it would be nice like either one person is responsible for this (checking the LA tool) and notifies the other two people, you know, I've seen this problem and we might have it broadcast."*

Dilemmas Introduced by LA Tools. Although many of the obstacles that prevented TAs from achieving their cognitive goals were caused by factors that LA dashboards could help mitigate, there were concerns about the impact that LA tools could have in degrading a welcoming and comfortable atmosphere. Specifically, most TAs expressed concern that a TA sitting at the front of the room on a device monitoring a dashboard would be perceived by students as disengaged or "creepy". TA1 noted this problem by comparing two scenes: *"one concern could be that I'm more focused on [the dashboard] than on the students, right? So you're removing a bit the human part, instead of asking, how are you doing?"* To make it more straightforward, TA2 stressed the importance of keeping contact with students: *"one shouldn't rely on this to avoid or reduce his contact with the class."*

Furthermore, there were serious concerns about how students would react to being digitally monitored, and if this would lead to a breakdown of trust. For example, TA8 tried to empathize with students who might feel uncomfortable, saying *"as a student, I would feel very differently to know that I am monitored... I wouldn't be free to express how I actually interact with the exercise."* In addition, a dashboard that identified who needs help and automatically informed the TA would have the potential to violate the autonomy of the students, and could potentially lead to a situation where students would not have to develop process-monitoring and help-seeking behaviors. Similarly, students could come to rely on a tool that prompted them to ask for help when stuck, rather than developing their ability to recognize that should stop working on a problem and ask for help.

Consequently, most TAs emphasized the importance of anonymity by default, with students only being identifiable if explicitly choosing to be so, as stated by TA4: *"I would rather keep it anonymous and ask them and still let them choose if they want for help."* However, the following quote from TA7 also demonstrates how introducing anonymity into the dashboard would bring two values into conflicts: *"in the case it's anonymous... I couldn't give a personalized teaching... But at the same time, if it's not anonymous and I get the name, then I can go to see the person."*

Together, these concerns indicate that integrating LA tools into exercise sessions must be done carefully, and that they pose serious threats of destabilizing and degrading the atmosphere of safety and trust, especially when aiming to meet both TAs' cognitive and meta-cognitive goals.

4 Conclusion

Our study highlighted that university TAs in exercise sessions have two distinct sets of goals: cognitive goals around helping students master the material and maximize their learning, and meta-cognitive goals around supporting students in developing meta-cognitive skills related to monitoring their problem-solving processes and seeking help when appropriate. We found that introducing LA tools into exercise sessions threatened to place these two sets of goals in conflict. TAs expressed serious concerns with how LA dashboards designed only to meet cognitive goals, such as progress tracking or automated support, might disrupt the realization of meta-cognitive goals. These findings highlight the need to design LA features that enable TAs to provide personalized support without degrading their engagement and presence, and thus facilitate the development of students' autonomy, and meta-cognitive skills.

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