Designing an AI-powered chatbot to support the development of questioning skill

Session Description

In this session participants will collectively consider the decisions that need to be made to design a chatbot that can emulate a child's mathematical thinking with the goal of providing opportunities for prospective teachers to develop their questioning skills. These decisions include what questions prospective teachers might ask in a specific scenario, how the chatbot will interpret the intent of such questions, and how the chatbot could or should respond in order to promote learning. Participants can then try out a prototype chatbot that is currently being piloted in methods courses.

Background and Literature

As the need for reforming teaching practice in mathematics education has grown, calls for practice-based teacher education that centers on teachers' enactment of decomposed practicable skills have increased (e.g., Ball & Forzani, 2009), mainly through "approximations of practice" (Grossman et al., 2009). Approximations are "opportunities to rehearse and enact discrete components of complex practice in the setting of reduced complexity" (p. 283), and they can help pre-service teachers (PSTs) pay attention to and develop a specific aspect of teaching practice in a manageable manner (Santagata & Yeh, 2014). In this presentation, we focus on eliciting and extending students' mathematical thinking through questioning, which has been recognized as a crucial component of effective practice (Jacobs & Empson, 2016; National Council of Teachers of Mathematics, 2014).

Simulations can function as a critical step in developing skills, as interacting with virtual students provides low-risk environments where PSTs can practice their teaching skills before working with real students. Some studies have employed simulations in in-person settings in which adults play the role of children (e.g., Shaughnessy & Boerst, 2018), and others utilized digital simulations such as video-based simulations (e.g., Codreanu et al., 2020) and web-based teaching simulations (e.g., Lee, 2021; Webel & Conner, 2017). These efforts provide PSTs with rehearsal opportunities to engage in mathematical discourses without the challenges and risks associated with PSTs interacting with real children.

However, designing and implementing teaching simulations – in-person or computer-based – comes with challenges and limitations. In the work by Shaughnessy and Boerst (2018), adults must be trained to perform in a way that mimics a real student's mathematical thinking and accounts, and resources must be continually allocated to training and enactment. *LessonSketch* activities, such as those designed by Webel and Conner (2017), typically only provide a few closed-ended decision points in which users are asked to select among multiple response choices. In real teaching situations, however, teachers are not prompted with possible options that they could choose, and their teaching moves are open-ended with many pedagogical contingencies (Rowland et al., 2005).

In this presentation, we share our work to develop an AI-powered chatbot to better approximate teaching situations, including giving personalized feedback and providing opportunities to reflect on and learn from simulated interactions. This work builds on other projects involving chatbots in mathematics education, such as Nguyen and colleagues (2019), who developed an interactive intelligent chatbot for mathematical learning at a high school, and Feng et al. (2021), who designed an intelligent tutoring chatbot to support secondary students' mathematical learning by providing personalized feedback, explanations, tips, and additional problems to solve. A recent approach by Datta et al. (2021) used chatbots to engage PSTs in directly teaching the chatbot a mathematical idea. This showed potential in enabling learners to play an active role in making fine-grained instructional moves.

In our project, we use chatbots to simulate students with varied strategies and levels of understanding around a fraction topic. Our approach is connected to the practices of using evidence of student thinking and posing purposeful questions (National Council of Teachers of Mathematics, 2014) and is an important step forward because it acknowledges the reality that children already have mathematical understandings that need to be understood before teachers can support further development (Jacobs et al., 2010). In the designed modules, PSTs will interact with the chatbots that will fulfill the roles of both student and a mentor agent, allowing the PSTs to both practice their teaching moves and reflect on their effects.

Design of the Session

The goals of the session are threefold; first, we will spend about 30 minutes engaging participants in the process of thinking through the components of a high-quality simulation, including defining the learning goal of the simulation and how the elements of the simulation work to promote that learning goal. In our case, we ask, "What does it mean for prospective teachers to improve in the skill of eliciting and responding to student thinking? What elements would be necessary in a set of simulated experiences for prospective teachers to move forward along a trajectory associated with that skill?" Once those questions are decided, we need to consider how a chatbot can be designed to incorporate those elements in a specific teaching scenario. This includes anticipating how prospective teachers might question a student in that scenario, how the chatbot will interpret those questions, how the chatbot could or should respond, and how PSTs might make sense of those responses. We see these activities as essential aspects of the design process, and this session will serve to support participants to understand what an AI-powered chatbot can and cannot do in terms of providing a simulated learning experience. The second goal of the session will be to ask participants to engage with our prototype chatbot with the previous conversation in mind. We will ask participants questions such as: To what extent does the chatbot respond to anticipated questions in ways consistent with the hypothesized learning experiences generated by participants? How well does it emulate student thinking? What learning opportunities are embedded in the simulated experiences, and what would evidence of learning look like? What additional experiences would enable PSTs to get the most benefit from their use of the chatbot?

Finally, we will discuss how AI can be used in teacher education through simulated experiences like the one we have designed and shared. This will include a conversation about what aspects of teaching can and cannot be emulated in a simulation and how simulations fit into other essential components of teacher education. This is an important conversation for teacher educators; we do not wish to reduce teaching to the execution of technical skills (Philip et al., 2019), yet we want to acknowledge that teaching does include the use of skills that can be improved through intentional practice. The question of how skill development can and should be incorporated into teacher preparation is one we need to consider as a community, and we hope that this session can help advance that conversation, particularly in the case of using AI to support practice-based pedagogy.

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