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Rehearsing and Reflecting on Questioning Practices: Science Pre-service Teacher Engagement with an AI-based Classroom Simulator

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Abstract: Engaging learners in science involves equitable participation in rich scientific discourse. However, leading scientific discussions can be difficult for teachers to orchestrate and for pre-service teachers (PSTs) to rehearse and learn. Artificial intelligence-based simulations offer opportunities for teachers to rehearse science teaching practices and receive automated feedback on performance. However, very few tools have been used with science methods courses. This pilot study investigates the use of an AI-based classroom simulator that provides feedback to PSTs on the types of questions asked during a simulated conversation. Results demonstrate that the PSTs were able to use the tool to practice science talk moves and reflect upon their performance with automated feedback. Findings highlight the potential of the tool to be used in science methods courses to support pre-service teachers' rehearsal of leading productive science talk.

Introduction

Promoting equity in science classrooms involves positioning all students as capable contributors to scientific knowledge (e.g., Duschl & Osbourne, 2002). Equitable science instruction involves creating opportunities for all learners to engage in sense-making through discussion where their ideas are elicited, valued, and used as the foundation for building scientific understanding (Windschitl et al., 2020). This kind of productive classroom discourse encourages students to articulate their thinking and provide evidence-based explanations, engaging students as legitimate participants in the sense-making process (Driver et al., 2000).

As such, science teacher education research has investigated how to support pre-service teachers (PSTs) to lead and orchestrate scientific talk in their classrooms (e.g., Giles & Buck, 2020). However, PSTs typically get very few opportunities to rehearse engaging students in science talk. Moreover, these practice opportunities are traditionally done in whole-group settings where PSTs get few practice opportunities and very little individualized feedback on their performance.

Artificial intelligence-based classroom simulations offer the potential to engage PSTs in science talk with simulated students. These tools enable each PST to lead discussions and receive immediate, automated feedback on their performance. Although these tools are emerging for mathematics instruction (Bywater et al., 2025), very few studies have investigated the use of classroom simulations for science talk (e.g., Mikesa et al., 2025).

This exploratory case study investigates the use of the AI-based classroom teaching simulator (ACTS) within a secondary science methods class. The tool has been refined over multiple cycles of co-design with practitioners and enables PSTs to practice engaging with a simulated student around a specific concept with the use of a digital whiteboard. In this study, PSTs received immediate, automated feedback on the types of questions that they asked during the session and were able to inspect and reflect upon the transcript of their conversation. In particular, this study answered the following research questions: How do pre-service teachers use an AI-based classroom simulation tool? How do they reflect on feedback the tool provides immediately afterwards? The study connects to the ISLS theme by investigating ways that co-designed technologies can help provide more impactful learning experiences for teacher candidates.

Background

The Next Generation Science Standards (NGSS) call for science classrooms to be places where students engage in scientific practices, using cross-cutting concepts to learn specific disciplinary core ideas (NGSS Lead States, 2013). This kind of student-centered approach requires teachers to be facilitators of student inquiry and support students' sense-making. However, many teachers can struggle to engage students in these kinds of discussions (e.g., Windschitl et al., 2011), and move away from traditional lecture-based formats or common initiate-respond-evaluate discourse patterns (e.g., Scott et al., 2006). Thus, teacher preparation programs need to provide

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opportunities for PSTs to develop their ability to foster scientific discourse in their classrooms (e.g., McNeill & Pimentel, 2010).

Practice-based teacher education approaches (e.g., Grossman et al., 2009) seek to engage PSTs in approximations of practice that enable PSTs to rehearse specific, discrete skills. Instead of focusing solely on developing content knowledge or pedagogical knowledge (e.g., the 'what' of teaching), practice-based approaches emphasize the 'how' of teaching by engaging PSTs in rehearsal opportunities of specific pedagogical skills. For example, in addition to reading about various talk moves that are involved with leading science talk in classrooms, PSTs can engage in approximations of practice that enable them to rehearse using the talk moves in a simulated class discussion.

Research demonstrates how different kinds of simulations can engage PSTs in approximations of practice (Kazemi et al., 2016). For example, Sherin and van Es (2009) provided PSTs with pre-recorded video scenarios to analyze and respond to. Others engage PSTs in in-person, role-playing simulations (e.g., Lampert et al., 2013; Shaughnessy et al., 2025) where the PSTs take on the role of students in a class. These simulations have the benefit of PSTs practicing with adults and minimizing the risk of negatively affecting real students as they are learning specific pedagogical skills.

A growing body of research has investigated the use of mixed-reality simulations in science teacher education, where there is a human actor controlling a virtual avatar of a student (Lottero-Perdue et al., 2024). For example, Mikesa et al. (2023) investigated the use of a mixed-reality simulation, Mursion, to help PSTs learn how to facilitate argumentation-focused discussions. They found that the use of the simulation resulted in a significant increase in PSTs' ability to lead discussion compared to video analysis, lesson planning, and peer rehearsals. Similarly, Cao et al. (2025) used the same mixed-reality simulation tool to explore how to support in-service teachers' framing of discussions. Results demonstrated not only that the teachers changed their framing in the simulations but also that the teachers were able to apply what they learned in the simulation to their real-life classrooms.

Other computer-based simulations use AI-powered virtual students to engage PSTs in leading sensemaking discussions. For example, Zhang et al. (2025) describe a virtual environment, *EVETeach,* where there is a 3D virtual classroom with six AI-powered virtual students. Results demonstrated that PSTs using the environment were able to rehearse using ambitious science teaching talk moves compared to professionally trained science teachers.

Although these environments enable PSTs to rehearse science talk moves, they do not provide feedback to PSTs on the kinds of talk moves they use and rely on feedback from a course instructor or TA to analyze their performance. Moreover, the virtual environments in the previous studies approximate a virtual classroom, but do not provide the ability to interact with the virtual student in more ways than only verbal communication. In a real classroom, both students and teachers would be able to use diagrams or visualizations of science concepts to anchor discussions.

Thus, this study investigates the use of an AI-based simulation that provides automated feedback on the PST's performance. Specifically, the environment provides the PST with the kind and quantity of talk moves that they used immediately after the session. In addition, the computer-based environment has a whiteboard with a static diagram of the focal science phenomenon, and enables the PST or the virtual student to annotate or draw upon the diagram as part of the activity. Although ACTS has been used in mathematics contexts with demonstrated increases in PST's questioning skills (Bywater, Lilly, & Chiu, 2025), it has not yet been extended into science contexts. By exploring the use of this kind of environment with PSTs in science methods courses, we aim to investigate the potential affordances and challenges for AI-based classroom simulation tools in science teacher preparation.

Methods

This study uses an exploratory case study research approach to understand how PSTs may use science ACTS to rehearse science talk moves. We explore the affordances and challenges of ACTS with science methods courses.

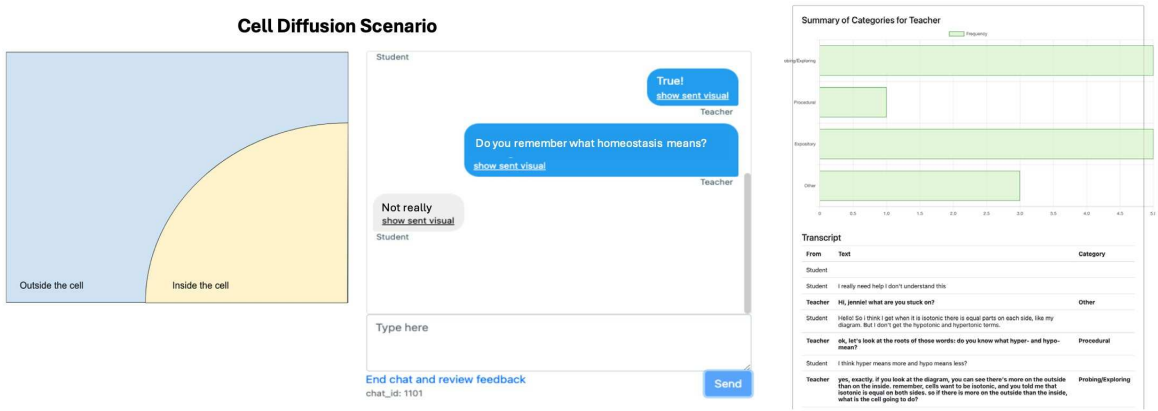
Participants

Two PSTs, Maddie and Darcy (pseudonyms), were selected as case studies. The PSTs were enrolled in a secondary science methods course from a large research university in the Mid-Atlantic region of the United States. Maddie and Darcy were a convenience sample of those who consented to be part of the study. Both aimed to be life science teachers upon graduation and were concurrently enrolled in a practicum where they were placed in local middle school science classrooms. Neither had prior formal classroom teaching experience.

Simulation

ACTS offers the ability for PSTs to rehearse engaging with one student around a domain-specific task. In the ACTS environment, PSTs can enter into a scenario with a visualization of a science concept and start an online, simultaneous chat conversation as a teacher with another PST who logs into a separate computer and acts as a student. Both the PST acting as the teacher and the PST acting as the student have the ability to draw upon the visualization with standard whiteboard functionality. The ACTS environment automatically stores the transcript of the chat. Once the session is over, the PST is provided with automated feedback about the types of questions asked during the session, along with a session transcript (Figure 1).

Figure 1
Screenshot of the ACTS Environment.



The ACTS environment has a visualization of the science phenomenon on the left, and chat area in the center. The right shows the automated feedback screen provided at the end of the session with the number and type of question at the top of the screen and the chat transcript below with the codes assigned for each turn.

The ACTS system uses a question classification system based on the Instructional Quality Assessment rubric (IQA; Boston & Candela, 2018) that roughly corresponds to the science talk moves framework (Windschitl et al., 2020; Table 1). Given that PSTs were just learning about the different types of talk moves and questioning strategies, we posited that providing simple feedback of probing, procedural, expository, and other categories from mathematics contexts could be actionable and digestible for PSTs in science contexts.

Procedure

Participants were asked to engage with ACTS during their typical in-person secondary science methods course. As part of the coursework, they had previously discussed and read about various science talk moves (TeachingWorks, n.d.) to increase sensemaking opportunities in science classes. The simulation activity was introduced in a whole-class setting, with the instructor reviewing the goals of the activity and providing an overview of the broad categories of question types and how they relate to talk moves. The instructor and the TA modeled the use of the technology simulation, demonstrating how the PSTs could log in, start the conversation, draw on the whiteboard, and end the session. The instructor displayed the kind of feedback received after finishing the session.

The PSTs were then grouped in pairs, given written instructions for the activity, and instructed for one person to play the teacher role while the other person played the student role for one session and then to switch roles for the next session. PSTs were given four different scenarios to choose from given their content area: circular motion, the greenhouse effect, enzymes, and diffusion (Figure 2). These different scenarios were co-designed with the science methods instructor as either common concepts that students typically have difficulties with or an upcoming concept that the PSTs would see in classrooms in their placements. PSTs then engaged in the simulation activities for 15 minutes. After finishing, they were instructed to do an individual reflection upon their experience, and then the instructor led a whole-class discussion about the activity.

Table 1
IQA and Science Talk Crosswalk with Examples.

IQA	Science Talk	Example

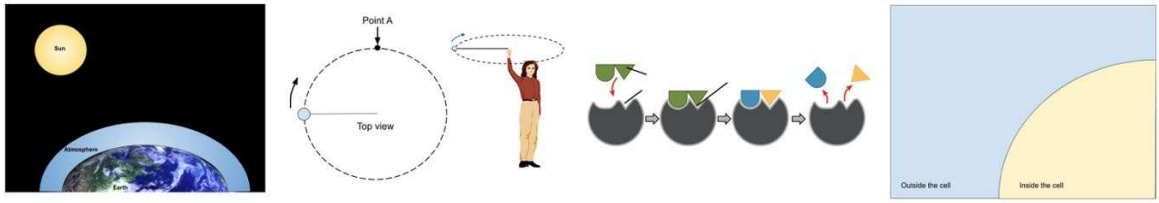
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Probing/ Explanation	Probing, Pressing, Higher Cognitive Demand	• Why do you think that happened? • Can you tell me more? • What evidence do you have?
Procedural	Lower Cognitive Demand	• What is the name of this organelle? • What is the temperature?
Expository	Provides explanation of concept to students, rhetorical questions	• So diffusion is when something from a higher concentration goes to a lower concentration, right?
Other	N/A	• Great job!

Data sources and analysis

Transcripts from the simulation activity, question types feedback, and individual reflections from the two participants were analyzed thematically to investigate the affordances and challenges of using these kinds of simulations in science methods courses.

Figure 2.
Science Scenarios used in the Study.



Different starting visualizations on the whiteboard for the different simulation activities: (a) greenhouse effect; (b) circular motion; (c) enzymes; and (d) diffusion.

Findings

Based upon the analyses of the two PSTs engaging in the simulations, we assert that the PSTs were able to use ACTS to rehearse asking students probing questions. We provide brief descriptions of the two cases as evidence of the success of ACTS in a science context. Written descriptions of the sessions are provided with the ACTS classifications of the questions in brackets following the text.

Case 1: Maddie

Maddie chose the enzyme scenario. Overall, Maddie asked ten questions categorized as probing/exploring, three questions categorized as procedural, and one question classified as other. She started by setting the context of the student being absent and helping them make-up missed work. Maddie then asked the student, “Can you start by telling me what you see happening in this diagram? [probing]” When the student mentioned colored shapes, Maddie followed by asking a probing/exploring question, “Think back to our unit on chemical reactions. What do you think the colored shapes might represent? [probing]” When the student mentioned a compound, Maddie pressed for a definition of a compound by saying, “I like that you said a compound. Can you tell me what a compound is? [procedural]” Once the student responded with a definition of a compound, Maddie then referred back to the diagram and asked the question, “So in the diagram, what is happening to the compound? [probing]” When the student made an incomplete response, Maddie recognized part of the response that was correct and then drew on the whiteboard and highlighted the diagram, telling the student, “I think that's a great inference. I highlighted something on the diagram in response to what you said. Can you tell me what you think is different about the part I highlighted from how it was before? [probing]” When the student noticed that the shapes were no longer connected, Maddie gave a procedural question, “I see. So, if I'm understanding correctly, we had a compound interacting with an enzyme, and the parts that made the compound up are now separated because the enzyme broke the bonds. Is that right? [procedural]” The student said that they thought so but asked why the parts wouldn’t just recombine. Maddie responded by asking, “That's a great question. Can you think of any examples

of chemical reactions that are 'reversible' like that? [probing]" The student replied no. Maddie offered saltwater as an example, then related the Na and Cl in the water to the enzyme in the visualization through a question of, "Think back to what you said about salt, water, and ionic bonds. What might an enzyme do that works the same way? [probing]" The student then said the enzyme would break the attraction between components in the substrates. Maddie then responded by asking, "That is a good description of what is happening in this diagram. Before we wrap up, can you think of any other reactions that might involve an enzyme? [probing]" to which the student said, "Digesting food." Maddie asked about how an enzyme might help in that process before ending the conversation.

In their reflection upon the activity in general, Maddie stated, "I acted slightly differently because I was being scored on question asking and types of questions, but I don't think it's bad to be conscious of what types of questions you are asking as a science teacher." When asked about the extent to which the activity would help them consider different ways that students might think about the content, Maddie responded, "I thought it was very helpful. It made me be critical about what types of situations I deploy certain questions in." Reflecting upon the feedback of question types, Maddie stated: "It was easier for me to use probing/exploratory questions when students weren't 'getting it.' When the student understood the content I fell into a pattern of asking for the next right answer so students could demonstrate mastery sooner." These reflections show how practicing questioning may have led Maddie to think more about her own questioning strategies and a felt need to support all students to engage in probing/exploratory discussions regardless of the student's level of understanding.

Case 2: Darcy

Darcy chose the greenhouse effect activity, which started with a prompt of how the greenhouse effect works. Overall, Darcy had eight questions classified as probing/exploring and one question classified as expository. To start the conversation, she asked the student, "What are your initial thoughts on this question? [probing]" The student stated that they were unsure how there was a greenhouse around the Earth. Darcy responded:

> That is a great connection you are making! Sometimes when we use the term greenhouse, we are referring to the glass structures that keep plants warm. However, in this scenario we are using the term a little bit differently, but it also connects to keeping us warm in a way. Are you familiar with the term greenhouse gases?

The student responded to Darcy's question that they had heard of greenhouse gases, and thought they were bad. Darcy continued this pattern by asking, "What do you mean 'bad for you?' Can you elaborate on that? [probing]" to which the student replied that they had heard that greenhouse gases like "carbon dioxide" caused global warming. Darcy responded, "Awesome job! They are a contributing factor to global warming. I think you might be thinking of carbon dioxide. What are some sources of carbon dioxide emissions? [probing]" to which the student mentioned cars, factories, and other things that pollute the air. Darcy then asked, "Great. Do you know of any other greenhouse gases? [probing]" The student replied they did not, so Darcy provides an example of methane, and asks the student how these gases might affect Earth's temperature. The student replied that they thought they trapped heat, and Darcy responded, "Yes, they do! Just like your connection to plant greenhouses before, they are insulating. Where do you think this heat comes from? Can you draw your thoughts on the image for me? [probing]" The student subsequently drew infrared radiation coming from the Sun. Darcy then stated, "Fantastic, solar radiation from the sun is the source of the heat you are discussing. Finally, can you add to your drawing how the greenhouse gases trap heat as you mentioned before? [probing]" The student added to their drawing that the radiation gets trapped in the atmosphere and stated that it was like a blanket around the Earth trapping heat. Darcy replied with the only expository statement by ending the session:

> Great - I love that metaphor! Some of the solar radiation is absorbed by Earth's surface and some is reflected. The radiation that is reflected can either escape the atmosphere or be reflected back and trapped by the greenhouse gases. More greenhouse gases resembles [sic] a bigger, fluffier blanket trapping more of that heat, warming the Earth.

In the reflection upon the activity, Darcy wrote, "It is a great, low-stakes way to practice interacting with students with misconceptions. I appreciate the inclusion of a visual element, especially since we are interacting via chat." When replying to the prompt about the extent to which the activity helped her consider different ways students think about the content, she wrote, "One major limitation is that another person with a degree in biology is responding. It was hard to think of realistic ways students might be confused … I wonder if we could train AI with the most frequent misconceptions." In response to the usefulness of the feedback, Darcy reflected:

> I like that it gives a graph at the top for a quick visual of the breakdown of our instructional moves. I wonder if including even more codes for different instructional moves would be helpful, or if the simplicity of just three categories is more ideal.

These reflections show Darcy's views of the importance of the "student" who is responding and how their responses affected her questioning, as well as her desire to potentially have more feedback about her instructional moves. In addition, Darcy also noted that she would have liked an easier way to erase drawings on the whiteboard, and that she wished she could use the simulation with an AI student instead of another human so that she could practice anytime instead of only in a classroom setting.

Discussion

To our knowledge, this is the first simulation of its kind for science education that provides immediate, automated feedback on PST performance with specific science scenarios. Results reveal that PSTs were able to use the simulation to engage in realistic dialogue around specific science concepts, with positive reactions to the activity.

Both Maddie and Darcy commented on the affordance of having immediate feedback on the question types used in their sessions. Maddie commented on how knowing that there was going to be feedback on the question types influenced how she actually engaged with the activity and made her more aware of the kinds of questions that she was asking. Darcy questioned the simplicity of the categories, and the potential utility of having more categories of talk moves instead of only the four. In this pilot, exploratory study, the research team decided to provide only four categories of questions back to the PSTs. Given that they had recently learned about various science talk moves and it was one of a very few computer-based rehearsal experiences, the research team, in conjunction with the methods instructors, agreed that having simple feedback to start would be the best for novice teachers. However, future research can investigate if having more nuanced feedback provided to the PSTs in the form of more categories or more contextualized simulations may help PSTs rehearse a wider variety of talk moves.

Another affordance that emerged from the results was the use of a diagram and whiteboard during the simulation. PSTs were able to use the whiteboard and drawing tools in the ACTS system. However, the interface was not as easy to use as a physical piece of paper and the PSTs took time to create arrows or other annotations on the diagram. Challenges included being able to erase the annotations and sometimes missing an annotation from their partner. In the system, to see the other person's contributions, one has to click on the "show sent visual" link in the dialogue for each message. Future research can explore revisions to the whiteboard tool to make it more automatic and intuitive to use.

Results also demonstrate the utility of the ACTS tool in science methods courses. Other computer-based simulation tools do not provide automated feedback on performance. The ACTS environment not only supports PSTs to rehearse talk moves, but also enhances the instructor's ability to provide individualized feedback to their students. The transcript appearing immediately after the session ends also enables PSTs to reflect directly on specific moves of their performance. Future research can explore the extent to which explicit reflection upon specific moves within the discussion can prompt deeper PST learning or different questioning performances.

Limitations and implications

Limitations include the small sample size of this study. Future work can explore ACTS in other science methods courses to see if the same kinds of affordances and challenges emerge with a larger sample of PSTs. Another limitation of this study was that the classifier used in ACTS was trained on mathematical questions (e.g., Bywater et al., 2025). Although the accuracy of the classifier was moderate with science questions as compared to mathematical questions (Boyle et al., 2026), the categorizations were only meant to provide a rough, general idea of the kinds of questions that were used during the session. Future studies can explore ways to increase the accuracy of a classifier for science questions, as well as how patterns of questioning types may occur in science contexts differently than in mathematics contexts.

AI-based simulation tools have the potential to provide rich and authentic teacher learning opportunities and can be used to bridge research and practitioner needs. As educative materials and tools are critical for teachers to learn about practice (Windschitl et al., 2020), AI-based simulation tools can be added to the repertoire for teacher educators to support teacher learning. Further, researchers can work with science methods instructors to create or integrate simulation tools into other activities to help PSTs continue to practice their use of questions. This could include supporting PSTs to plan to include specific types of questions in lesson plans that they create and then to practice asking these, as well as other questions added in-the-moment, during in-class rehearsal activities. Simulation tools can then be co-designed with practitioners to be based on authentic scenarios from real classrooms and potentially help both in-service and pre-service teachers rehearse and reflect upon specific

pedagogical moves. In this way, the paper connects to the ISLS theme of partnering with purpose to create meaningful and relevant learning experiences.

Conclusion

This exploratory study demonstrates that AI-based tools can provide automated feedback on PSTs' use of different types of science questions. Providing these kinds of rehearsal experiences can support PSTs' understanding and use of questions that probe student thinking and press for explanation to encourage rich scientific discourse in classrooms. This paper presents a novel use of AI to support science teacher learning and teacher preparation.

References

Boston, M. D., & Candela, A. G. (2018). The Instructional Quality Assessment as a tool for reflecting on instructional practice. *International Journal of Mathematics Education, 50*(3), 427-444.

Boyle, D., Lilly, S., Bywater, J., & Chiu, J. L. (2026, April). Exploring the use of LLMs to automatically classify teacher questions in science classrooms. Poster presented at the Annual Educational Research Association, Los Angeles, CA.

Bywater, J., Lilly, S., & Chiu, J. (2025, March). Pre-service teacher acceptance of a chat-based dialogue simulator for rehearsing mathematical questioning. In *Society for Information Technology & Teacher Education International Conference* (pp. 2333-2340). Association for the Advancement of Computing in Education (AACE).

Bywater, J. P., Lilly, S., & Chiu, J. L. (2025, July). Labeling Disagreements: Illuminating the Classification of Mathematics Teacher Questions. In *International Conference on Artificial Intelligence in Education* (pp. 49-59). Cham: Springer Nature Switzerland.

Bywater, J. P., Lilly, S., Datta, D., Ansari, S., Mohammad, A., Watson, G., Brown, D., & Chiu, J. L. (2025). The role of automated post-rehearsal feedback on pre-service mathematics teacher questioning. *The Journal of Applied Instructional Design*, *14*(2).

Cao, L., Hennessy, S., & Wegerif, R. (2025, online). Thinking Fast, Slow, and Ahead: Enhancing In-service Teacher Contingent Responsiveness in Science Discussion with Mixed-reality Simulation. *Computers & Education, 237*, https://doi.org/10.1016/j.compedu.2025.105389.

Driver, R., Newton, P., & Osborne, J. (2000). Establishing the norms of scientific argumentation in classrooms. *Science Education, 84*(3), 287-312.

Duschl, R. A., & Osborne, J. (2002). Supporting and promoting argumentation discourse in science education. *Studies in Science Education*, *38*(1), 39-72.

Gilles, B., & Buck, G. (2020). Preservice teachers' use of discourse to shape the construction of scientific arguments. *Journal of Science Teacher Education*, *31*(3), 291-310.

Grossman, P., Compton, C., Igra, D., Ronfeldt, M., Shahan, E., & Williamson, P. W. (2009). Teaching practice: A cross-professional perspective. *Teachers College Record, 111*(9), 2055-2100.

Kazemi, E., Ghousseini, H., Cunard, A., & Turrou, A. C. (2016). Getting inside rehearsals: Insights from teacher educators to support work on complex practice. *Journal of Teacher Education, 67*(1), 18-31.

Lampert, M., Franke, M. L., Kazemi, E., Ghousseini, H., Turrou, A. C., Beasley, H., ... & Crowe, K. (2013). Keeping it complex: Using rehearsals to support novice teacher learning of ambitious teaching. *Journal of Teacher Education, 64*(3), 226-243.

Lottero-Perdue, P. S., Masters, H. L., Mikeska, J. N., Thompson, M., Park Rogers, M., & Cross Francis, D. (2024). Elementary preservice teachers' responsiveness while eliciting students' initial arguments and encouraging critique in online simulated argumentation discussions. *Science Education, 108*(2), 546-580.

McNeill, K. L., & Pimentel, D. S. (2010). Scientific discourse in three urban classrooms: The role of the teacher in engaging high school students in argumentation. *Science Education, 94*(2), 203-229.

Mikeska, J. N., Howell, H., & Kinsey, D. (2023). Do simulated teaching experiences impact elementary preservice teachers' ability to facilitate argumentation-focused discussions in mathematics and science? *Journal of Teacher Education, 74*(5), 422-436.

Mikeska, J. N., Francis, D. C., Lottero-Perdue, P. S., Rogers, M. P., Shekell, C., Bharaj, P. K., Howell, H., Maltese, A., Thompson, M., & Reich, J. (2025). Promoting preservice teachers' facilitation of argumentation in mathematics and science through digital simulations. *Teaching and Teacher Education, 154,* 104858.

NGSS Lead States. (2013). Next generation science standards: For states, by states. National Academies Press.

Scott, P. H., Mortimer, E. F., & Aguiar, O. G. (2006). The tension between authoritative and dialogic discourse: A fundamental characteristic of meaning making interactions in high school science lessons. *Science Education, 90*(4), 605-631.

Shaughnessy, M., Boerst, T. A., Garcia, N., & Claiborne, B. (2025). Orienting to student sense-making: Using simulations to support the development of equitable mathematics teaching. In C. Lee, L. Bondurant, B. Sapkota, and H. Howell (Eds.) *Promoting Equity in Approximations of Practice for Mathematics Teachers* (pp. 253-276). IGI Global.

Sherin, M. G., & Van Es, E. A. (2009). Effects of video club participation on teachers' professional vision. *Journal of Teacher Education, 60*(1), 20-37.

TeachingWorks. (n.d.). Www.teachingworks.org. https://www.teachingworks.org/

Windschitl, M., Thompson, J., & Braaten, M. (2020). *Ambitious science teaching.* Harvard Education Press.

Windschitl, M., Thompson, J., & Braaten, M. (2011). Ambitious pedagogy by novice teachers: Who benefits from tool-supported collaborative inquiry into practice and why? *Teachers College Record, 113*(7), 1311-1360.

Zhang, N., Ke, F., Dai, C. P., Barrett, A., Bhowmik, S., Southerland, S. A., West, L. A., & Yuan, X. (2025). Enhancing responsive teaching through in-the-moment interpretations of student resources: A study in AI-supported simulation. Computers & Education, 235, 105449.

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