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Preservice Teacher Learning in Virtual Reality Simulation with Artificial Intelligence-Powered Virtual Students: Emotions and Teacher Talk Patterns

Chih-Pu Dai, University of Hawai'i at Mānoa, cdai@hawaii.edu

Fengfeng Ke, Nuodi Zhang, Sherry A. Southerland, Alex Barrett, Saptarshi Bhowmik, Luke West, Xin Yuan
fke@fsu.edu, nzhang4@fsu.edu, ssoutherland@fsu.edu, abarrett3@fsu.edu, sbhowmik@fsu.edu,
lawest@fsu.edu, xyuan@cs.fsu.edu.
Florida State University

Abstract: The purpose of this study was to explore preservice teachers' emotions and dialogic teacher talks in a virtual reality (VR) simulation-based learning (SBL) environment with artificial intelligence (AI)-powered virtual students. We collected computer-logged natural language data with 22 preservice teachers in this exploratory case study. We employed a heuristic evaluation approach with data-mining techniques (i.e., association rule mining). The preliminary results suggested that the AI-powered virtual students designed in the VR SBL environment can 1) foster preservice teachers' positive emotions while also challenging them to achieve their teaching goals; 2) support preservice teachers in enacting and sustaining productive and meaningful ambitious teaching practices. The results highlighted that AI-powered virtual students, designed in the SBL environment, emulate natural interactions to enhance preservice teachers' enactive teaching practices, moving beyond merely presenting information thus increasing disciplinary-focused teaching enactments. The learning sciences community may refer to the findings to design SBL in teacher education.

Introduction and literature review

In modern teacher education, an essential objective is to endow preservice teachers with the knowledge and skills necessary to foster students' critical thinking and reasoning through meaningful classroom interactions (Darling-Hammond, 2006; Lampert et al., 2013). Preservice teachers can learn how to enact such meaningful classroom interactions via intentional exercise of ambitious teaching practices (Windschitl et al., 2018). Leveraging ambitious teaching practices as tools to support preservice teachers' abilities to promote their students' deep thinking and science reasoning has appeared to be prolific. In other words, ambitious teaching practices enactment allows preservice teachers to practice how to initiate and sustain constructive and productive learning experiences for their students, thus preparing their students with the necessary skills to thrive as independent thinkers in our ever-evolving world (e.g., Stroupe & Gotwals, 2018). However, the effective implementation of ambitious teaching practices demands a substantial accumulation of knowledge, practice, and experience; yet enhancing the opportunities of field experience for preservice teachers appears to be a tough challenge. To address this challenge, designing simulation-based learning (SBL) in virtual reality (VR) environments by deploying artificial intelligence (AI)-powered virtual students emerged as a feasible and promising solution. Exploring preservice teachers' interactions and experiences in VR SBL with AI-powered virtual students became important to sustain the use and maximize the potential of such learning technologies. To better support preservice teacher learning by using SBL in VR with AI-powered virtual students (Dai et al., 2024), we grounded our exploration in this paper in the teacher education literature focusing on two critical aspects——teachers' emotions (e.g., Hargreaves, 1998) and dialogic teacher talks (e.g., Mikeska et al., 2022). Specifically, we aim to address the following exploratory research questions (RQs):

> *What are the patterns of preservice teachers' enactment resulting from the interactions with AI-powered virtual students in SBL, in terms of teachers' emotions (RQ1) and dialogic teacher talk (RQ2)?*

The role of *teacher emotions* in professional practices

Teacher emotions are one of the driving forces for shaping transformative teaching approaches and the enactment of pedagogical strategies (Hargreaves, 1998). Teacher emotions continue to be regarded as a crucial factor for teacher agency (Tao et al., 2024). Specifically, teachers' positive emotions are considered enablers for teachers' transformative pedagogy and inquiry-based teaching practices that recognize students' unique resources and

contributions in building knowledge and making sense of the phenomenon, transcending conventional cognitive instruction. Teachers' positive emotions, such as excitement and caring for students' learning states and resources, can drive teachers' sustained endeavors in teaching; whereas negative emotions should be regulated and reduced for teachers to maintain professionalism (Sutton et al., 2009; Zembylas, 2002). Under these categories, we classified positive emotions as joy, excitement, and satisfaction; negative emotions as anger, frustration, and anxiety and uncertainty based on the literature (e.g., Hargreaves, 1998) (See Table 1).

The impacts of *dialogic teacher talk* on student thinking

The theoretical background of *dialogic teacher talks*, a pedagogical endeavor to maintain a classroom discourse that encourages students to think independently and critically (Reznitskaya & Gregory, 2013), can be supported by sociocultural theory (e.g., Vygotsky, 1978). Previous studies investigated the adoptions and benefits of dialogic teacher talks in different contexts. For instance, Mikeska et al. (2022) revealed that VR can result in robust effects on beginning teachers' argumentation-focused discussions in elementary education. Another study (Juuti et al., 2020) revealed that dialogic teacher talks are more effective for students' science learning interests, compared to non-dialogic, or authoritative teacher talks because it engages students by emphasizing the importance of students' ideas and concerns, which makes the learning experience more personally meaningful to the students. Nonetheless, these studies are limited to provide implications in the context that featured AI-powered virtual students, SBL in VR, and dialogic teacher talks. In this paper, we explored preservice teachers' eleven teaching enactments and talk moves in two science teaching stages (i.e., initiation and consensus building) (see Table 2) in VR for SBL with AI-powered virtual students.

Method

Positioning in an exploratory case study worldview (Yin, 2018), we used a heuristic evaluation approach (Nielsen & Molich, 1990) to explore the patterns of emotions and dialogic teacher talks demonstrated by the preservice teachers to inform the design and development of a VR environment with AI-powered virtual students for teacher education. The SBL environment used in this study was designed in *OpenSimulator*, integrated with a type of generative AI technologies (i.e., large language model, LLM) to power the virtual students. The virtual students provided real-time responses to and interacted with the preservice teachers. To design AI-powered virtual students with domain-specific interactions and discourses, we localized the LLM using openly-available ambitious science teaching audio and video data (Windschitl et al., 2018). We customized the LLM, with classroom data and layered trait states for the variation and personalization of virtual students; we then integrated the virtual students designed into the VR environment to create the teaching practice scenarios for SBL. The scenarios were designed to mainly focus on engagement and consensus building that occur within the engagement and exploration stages of a learning cycle (Bybee, 2009; Windschitl et al., 2018). The participants completed a two-hour session interacting with the AI-powered virtual students in the VR environment.

Data sources and analyses

Twenty-two preservice teachers agreed to participate in this exploratory case study. Three of them were male and 19 of them were female. Preservice teachers were recruited from various courses in a college of education and a school of teacher education in the southeastern U.S. We audio- and video-recorded their teaching sessions. Their text-based interactions were automatically logged by the computer in VR. We analyzed 1,269 natural language teaching instances.

We developed theory-informed and data-driven coding schema (see Table 1 for teacher emotions; and Table 2 for dialogic teacher talks) to label the natural language teaching instances. Three trained coders first reviewed and discussed the coding schema. After being well-informed about the coding schema and becoming familiar with the human-AI interactions natural language data, they proceeded to code twenty percent of the data. They debriefed the coding results instance-by-instance and reached full agreement. They then independently coded the remaining data.

With the coded data, we derived the design heuristic of AI-preservice teacher interactions with association rule mining as a data-mining technique to report preliminary findings. An association rule is an implication of the form "if X then Y," where X and Y are itemsets. The association rule mining procedures were conducted using Apriori Algorithm in Python (apriori-python 1.0.4). We used descriptive statistics to present preservice teachers' emotions (see Table 1) and dialogic teacher talks (see Table 2). We also reported the results of association rule mining with confidence, support, and lift values to demonstrate the association patterns across the preservice teachers. Based on the literature (Hornik, 2005) as well as the context of the dynamicity of teacher practices and performance, we set two threshold values for confident rules: the support value was set at 0.01 and the lift value was set at 1.2. In addition, a moderate confidence value in association rule mining is above 0.5.

Results

RQ1: Teacher emotions

From the human coding and labeling, we found that preservice teachers were mostly in the "neutral" emotion (n = 404), followed by "joy" (n = 371), "satisfaction" (n = 311), and "anxiety and uncertainty" (n = 141) (see Table 1 for the complete scheme and results). The preservice teachers were in the positive states (i.e., joy, excitement, and satisfaction) ($n_{\text{positive states}} = 791$) more than in the negative states (i.e., anger, frustration, and anxiety and uncertainty) ($n_{\text{negative states}} = 184$). Most of the negative emotions stemmed from uncertainties about achieving teaching goals and the complexity of teaching practices. This indicates that the challenges posed by the AI-powered virtual students were prompting preservice teachers to address students' learning needs. Using the criteria set (see the Method section), we summarized the most salient associations. The associations suggested dynamic affective states that teachers experienced during SBL when interacting with AI-powered virtual agents. The four most supported rules indicated two positive association outcomes and two negative association outcomes. Specifically, for the *positive emotional states*, preservice teachers managed to transition from "the combination (itemset) of satisfaction and frustration to excitement" (e.g., {Satisfaction, Frustration} => {Excitement}, confidence = 0.6, support = 0.01, lift = 1.99). For the *negative emotional states*, preservice teachers transitioned from "the combination (itemset) of anger and neutral to anxiety and uncertainty" (e.g., {Anger, Neutral} => {Anxiety and uncertainty}, confidence = 0.6, support = 0.02, lift = 1.30).

Table 1
Preservice Teachers' Emotions Coding Scheme

Sentiment classification	**Emotions**	**Freq***	**Emotions**	**Freq***	**Emotions**	**Freq***
Positive	Joy	371	Excitement	109	Satisfaction	311
Neutral	Neutral	404				
Negative	Anger	23	Frustration	20	Anxiety and uncertainty	141

***Freq = Total frequency of the *Emotions* code across participants**

RQ2: Dialogic teacher talks

For the teacher talk (Table 2 showed the frequency in detail), data mining resulting in 281 association rules. We presented the most salient and confident association rules based on the indexes set in the Method section. Several association rules supported our design conjecture of ambitious teaching practices with AI-powered virtual students in SBL environment. In particular, the desired talk moves of "orchestrate ideas" was associated with ambitious teaching practices such as 1) the combination of "builds on ideas," "acknowledges or praises," and "evaluates" (e.g., {Builds on ideas, Acknowledges or praises, Evaluates} => {Orchestrates}, confidence = 0.78, support = 0.03, lift = 1.79); 2) the combination of "builds on ideas," "counter-argues" (e.g., {Builds on ideas, Counter-argues}=> {Orchestrates}, confidence = 0.57, support = 0.05, lift = 1.30) and 3) the combination of "acknowledges or praises," "evaluates," and "probes" (e.g., {Acknowledges or praises, Evaluates, Probes}=> {Orchestrates}, confidence = 0.6, support = 0.01, lift = 1.37).

Table 2
Dialogic Teacher Talks Coding Scheme

Pedagogical stages	**Teacher talks classification**	**Freq***	**Teacher talks classification**	**Freq***	**Teacher talks classification**	**Freq***
Initiation	Displays	34	Explores	182	Present	25
	Acknowledges or praises	38	Evaluates	159		
Consensus building	Counter-argues	40	Presents	77	Builds on ideas	370
	Probes	250	Orchestrate	155	*Other*	48

*Freq = Total frequency of the *Teacher talks classification* across participants

Discussion and conclusion

In this exploratory case study, we evaluated two important factors contributing to productive teaching practices and endeavors——teachers' emotions (e.g., Hargreaves, 1998) and dialogic teacher talks (e.g., Mikeska et al.,

2022). In terms of teachers' emotions, we found that positive emotional states were fostered as a result of preservice teachers' interactions with AI-powered virtual students in VR for SBL. Notably, we also observed that inducing preservice teachers' reasonable frustration with AI-powered virtual students is beneficial as it challenges their pedagogical practices, ultimately leading to successful and exciting teaching practices for the preservice teachers, this finding adds to Zembylas's (2002) study of emotions in science teaching. Specifically, we maintain that preservice teachers' persistent efforts to refine their pedagogy to address AI-powered virtual students' learning states helped them navigate their teaching practices in relation to their emotions. Further, we also found that dialogic teacher talks with argumentation- and discussion-focused patterns are more desirable for ambitious teaching enactments (Bybee, 2009; Windschitl et al., 2018). Preservice teachers' orchestration of classroom discourse was mainly based on discussion-focused enactments in SBL with AI-powered virtual students. The results inform the intentional design of AI-powered virtual students in SBL, emphasizing the importance of fostering diverse emotions among teachers and enabling productive dialogic teacher discussions.

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