Creation of A Mixed-Reality Simulator Professional Development Module to Attend to the Unique Needs of International Teaching Assistants in Active Learning Classrooms

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Abstract

International teaching assistants (ITAs) bring cultural perspectives and language diversity to university programs. However, ITAs can be underserved through traditional professional development initiatives. A mixed-reality teaching simulator module was created to attend to the unique needs of chemistry ITAs and prepare them for active learning instruction. To create the module, seven ITAs were interviewed about their professional development needs. ITAs most commonly wanted to practice asking and answering student questions, engaging disengaged or disrespectful students, and navigating language difficulties with students. The mixed-reality simulated teaching module provided opportunities for ITAs to rehearse one or more of the three focus areas. Three ITAs tested the simulator and reported that using the simulator for professional development with cultural and linguistic layers would be beneficial both to existing and new ITAs. These research findings set the foundation for generating a transformative set of training materials that institutions can use to reduce teaching anxiety and increase the effectiveness of ITAs in the classroom, thus enhancing student learning through more effective active learning instruction.

Keywords: international teaching assistant, professional development, chemistry education research, teaching assistant training

1. Introduction

1.1 Graduate Teaching Assistants (GTAs) in Chemistry Classrooms

GTAs are a critical component of many undergraduate science, technology, engineering, and mathematics (STEM) courses, especially in large institutions, where they often facilitate laboratory and recitation sections (DeChenne et al., 2012; Golde & Dore, 2001; Lang et al., 2020). Student-GTA interactions influence students' pursuit of and continuation in STEM degrees (O'Neal et al., 2007; Seymour & Hewitt, 1997; Tobias, 1990). Professional development improves GTA instruction practices (Cho et al., 2010; Dragisich, Keller, Black, et al., 2016; Mutambuki & Schwartz, 2018), but models for chemistry GTA professional development vary across universities, ranging from reviewing safety techniques to pedagogical instruction (Dragisich, Keller, & Zhao, 2016; Rushin et al., 1997; Torvi, 1994).

As classroom instruction evolves due to reform efforts, so do the tasks that GTAs are being asked to perform (Gardner & Jones, 2011; Wan et al., 2020). Faculty members are facilitating more active learning in the classroom as a way to increase student success and retention (Freeman et al., 2014; Kurdziel & Libarkin, 2003; Lund & Stains, 2015; Olson & Riordan, 2012). As a result, GTAs are often expected to shift their teaching pedagogy from direct instruction to facilitating active learning (Lee, 2019; Parker et al., 2015). Active learning describes a range of instructional methods that engage students, from modifying a course to be a flipped classroom to using clicker questions during a lecture (Crimmins & Midkiff, 2017; Freeman et al., 2014; Paulson, 1999; Ryan & Reid, 2016).

Inquiry-based instruction is a notable active learning method in the field of chemistry. In inquiry-based labs, students are given a question or problem to solve, but not the steps by which to proceed (Kipnis & Hofstein, 2008; Russell & Weaver, 2011). This is unlike verification labs, which provide steps to follow like a recipe in a cookbook (Mohrig, 2004). The role of the instructor in inquiry labs changes from a provider of knowledge to a facilitator of learning activities. GTAs need a complex set of skills to effectively implement inquiry instruction, such as shifting roles and

responsibilities, navigating emotions associated with change, and helping students think through actions. Without explicit professional development on inquiry-based teaching and learning, GTAs rely on prior learning experiences as they traverse new teaching environments (Volkmann & Zgagacz, 2004; Wheeler et al., 2017). Because GTAs come from a variety of places and backgrounds, their prior experiences lead to inconsistent instructional practices in the absence of additional training.

1.2 International Teaching Assistants (ITAs)

Scholars from around the world come to the United States of America (USA) to attend graduate school. In the 2019–2020 academic year, there were 374,435 international graduate students in the USA, 47.2% of whom were in STEM fields (*OpenDoors: Fast Facts 2020*, 2020). With cultural amalgamation, it is expected that international graduate students will face unique challenges when teaching. One study of Saudi graduate students found it was common to have positive interactions with faculty and staff, yet still face discrimination or lack of understanding from students (Yakaboski et al., 2018). Perrucci and Hu (1995) found that international graduate students' satisfaction is strongly correlated to contact with USA students, language skills, and perceived discrimination. These issues can be mitigated when students are able to find support within their departments and peer communities (Rodríguez et al., 2019). These authors proposed that department-provided professional development would help navigate interactions with students and create a more positive teaching experience.

Professional development is beneficial for all GTAs and is particularly effective when it addresses cultural and educational backgrounds that ITAs bring to teaching (Jia & Bergerson, 2008; Smith & Simpson, 1993). Training can be effective in minimizing language barriers in the classroom (Gorsuch, 2011; Li et al., 2011), but these barriers are not the only obstacles ITAs face while teaching (Dragisich, Keller, & Zhao, 2016). Being unfamiliar with the USA's academic system can pose difficulties with adjustment (Adebayo, 2020; Smith, 1993). Adebayo (2020) found that many ITAs experienced students' disrespectful classroom behaviors based on classroom norms from their home countries. This can be a discrepancy in the initial expectations ITAs had of teaching. The current literature suggests a link between intercultural competence and improved teaching behaviors and beliefs (Gorsuch, 2012; LeGros & Faez, 2012). Training without attention to cultural and linguistic diversity is insufficient for many chemistry GTAs (Hoekje & Williams, 1992; Li et al., 2011; Rubin, 1993). To create a fully rounded GTA training program, more research regarding the impact of diversity on teaching behaviors and beliefs is needed.

1.3 Departmental Support and GTA Mental Health

Additional mental stress forms when GTAs are expected to be a pillar in undergraduate instruction but are not sufficiently supported through training (Dragisich, 2020; Musgrove et al., 2021). Anxiety and GTA mental health are receiving greater attention on a national level, and it is becoming evident that graduate student mental health is extremely poor. The situation is even being called a 'crisis' (Evans et al., 2018; Rohlfing et al., 2021). GTAs report that a lack of teaching guidance as well as negative reinforcement from undergraduates, like being rude, have negative effects on mental health (Gin et al., 2021). ITAs experience additional types of anxieties and mental health burdens as they traverse teaching in a foreign language (İpek, 2016).

Chemistry departments across the USA are working with their graduate students to create supportive environments by empowering their students to seek mental health resources their campuses provide (Charles et al., 2021; Mousavi et al., 2018) and creating policies and programs to support graduate education (Rohlfing et al., 2021). Specifically, graduate students state that confidence about teaching and having concrete teaching tasks improves their mental health (Gin et al., 2021). Reducing teaching-related anxiety for ITAs is one small way to reduce graduate students' stress and anxiety.

Perfectionism and anxiety can manifest in graduate students when they are striving to be the best (Jiao & Onwuegbuzie, 1998). Gudykunst (1995) developed anxiety/uncertainty management (AUM) theory to describe the anxiety felt when individuals interact with people outside of their culture. Gudykunst believed that to effectively communicate, anxiety and uncertainty must be reduced. This idea was based on uncertainty reduction theory (URT), which Berger and Calabrese (1975), formulated. However, AUM also incorporates anxiety.

AUM theory assumes that the basic processes of communication are the same across cultures: strangers will trigger both interpersonal and intergroup anxiety, and when uncertainty and anxiety fall between an individual's minimum and maximum acceptable levels, effective communication can take place (Gudykunst, 1995). Experience gained through professional development before entering the classroom is one way to lower anxiety and uncertainty to acceptable levels for communication (Gresham, 2018).

1.4 Rehearsal-based Professional Development for GTAs

There is a variety of rehearsal-based strategies for preparing for teaching. In chemistry, instructional techniques like facilitating class discussions have been modelled on rehearsal-based professional development for GTA. This type of practice is effective overall (Becker et al., 2017; Cascella & Jez, 2018), but the effectiveness depends on the participating teachers' abilities to act like students and provide realistic feedback (Remesh, 2013). Using rehearsal-based training with fully immersive role-playing performances allows for a more authentic environment. A rehearsal-based simulator can better reflect students in the classroom by having a trained interactor act out research-based actions and discourse (Geraets et al., 2021). With intentional phrasing and literature-based student reactions, the practice environment can be extremely realistic for GTAs and contain less variability during rehearsals.

TeachLivE is one example of a mixed-reality classroom simulator developed to train pre-service and in-service primary and secondary teachers (Hayes et al., 2013). It has been used to prepare high school algebra teachers for the classroom among other professional developments (Dieker et al., 2014). The simulator works by having participating teacher face a large screen and interact with avatar students while engaging in real-time discourse. The simulator can be set up for interactions with elementary through post-secondary student avatars in a variety of classroom settings, like a chemistry laboratory. Participants interact with the students and practice instruction and classroom management skills. The benefit of using a mixed-reality simulator is that when a practicing teacher makes a mistake, it poses no harm to real students; the teacher can simply try again (Dieker et al., 2016). TeachLivE has been shown to improve delivery of targeted skills after intervention via the simulator, but its lasting impact is still being investigated (Dawson & Lignugaris/Kraft, 2017; Geraets, 2021). Simulators have also been used to prepare teachers for diversity in the classroom. Regalla et al. (2015) used English language learner avatar students for pre-service teacher professional development so that new teachers felt prepared before engaging with English learners in their classrooms. The vast majority of diversity-focused instructional training sessions emphasize the diversity of the student population and rarely focus on the diversity of the instructors.

At a large south-eastern research university in the USA, all GTAs assigned to target courses in chemistry, physics, and mathematics participate in mixed-reality simulator modules as part of their departmental professional development. This technology is currently being used to alleviate feelings of anxiousness in undergraduate students by helping GTAs practice cold calling and error framing (Doty et al., 2020). It is also being used to help GTAs increase their pedagogical knowledge and classroom management skills. It is unclear how the simulator can support the needs of ITAs, which leads us to the following research questions.

1.5 Research Questions

Considering the prevalence of GTA use in STEM courses and the lack of knowledge of how simulated environments in professional development can be adapted to provide targeted support to ITAs, the following questions guide our research:

1. What are the unique needs of ITAs during professional development and what influential factors should be considered when designing a simulator module?

2. How can a simulator be modified for ITAs to implement professional development training and enhance teaching comfort?

2. Method

2.1 Positionality

The variation of academic positions within our research group contributed to different power dynamics between ourselves and our participants. EKHS had supervised most of the participants in this study as a GTA at one point in their academic careers. AJS was both a researcher and a peer to the participants in this study. MK and IN occupied non-leadership roles in the department and were unknown to the participants beforehand. After this research concluded, AJS became a supervisor to two of the participants.

2.2 Frameworks

Intervention 1: Background Interview was developed using expectancy value theory, which uses a person's observations about a task's expected success and the value that person places on that task to speculate about the person's choices of whether or not to engage in the task (Eccles, 1983; Eccles & Wigfield, 2002). Intervention 1: Background Interview was designed to discuss GTA expectations and values placed on both teaching and professional development. As more ITAs were interviewed, however, anxiety and uncertainties related to teaching became more prevalent. AUM theory was incorporated for Intervention 2: Module and Post-Interview to adapt to the

specific focus on anxiety that emerged.

2.3 Population

ITA selection used a purposive sampling model and was focused on individuals who had both completed their undergraduate degree in a country outside of the USA and had a native language other than English in hopes that any communication they had with their American undergraduate students would be considered intergroup (an AUM theory assumption). The project involved interviews with a total of seven ITAs over a 6-month period. Participant 1 (P1) was from Eastern Europe, P2 from west Asia, P3 from western Asia, P4 from northern Asia, P5 and P6 from Central America, and P6 from South America. This research was conducted at an R1 Hispanic-Serving Institution within a chemistry department that was actively recruiting graduate students from Central and South America.

2.4 Intervention 1: Background Interview

The project authors interviewed seven ITAs in semi-structured interviews that lasted approximately one hour each. In the first part of the interview, the ITAs were asked about the influence that culture and language have on the way they teach. In the second half, the ITAs discussed their anxieties and were asked about what skills they would find valuable practicing in a teaching simulator. The interview had a broad range of questions to explore possible simulator topics, including targeted questions about expectations and anxieties in the classroom that aligned with expectancy value theory and AUM theory. Interview questions that aligned with the theories included what the ITAs found to be difficult or easy in terms of skills used in the classroom as well as what their expectations and predictions were of the outcomes from using the skills. The interview protocol included open-ended questions as well as prompts to choose teaching practices from a pre-determined list. The researchers used this information to develop a mixed-reality teaching simulator module geared toward the wants and needs of the ITA population in this study.

Interview data were analyzed using a modification of Colaizzi's seven-step iterative theming procedure (Colaizzi, 1978). The interviews were transcribed and de-identified. Two members of the research team read and individually themed the interviews by extracting significant statements and formulating meanings from the direct quotes. They were aggregated into clusters of the themes, and then the two researchers compared themes until agreement was reached. After complete agreement was reached, the researchers developed exhaustive descriptions of each theme. The last step was to return the themes to each participant for feedback. As an alternative, we asked questions about the themes chosen for the module during Intervention 2: Module and Post-Interview.

2.5 Module Development

The simulator module, created to attend to the needs of the ITA population, was based on Geraets et al.'s (2021) work, which described how to create professional development simulator modules for training chemistry GTAs. The research used the chemistry lesson from an existing simulator module to authentically mimic a general chemistry laboratory session with evidence-based student conceptions incorporated into the avatar responses (Geraets, 2021). The chemistry content of the module simulated a titration experiment where the avatar students were working to create their own procedures to answer the following key question: Which antacid is the best at neutralizing stomach acid? The question was intentionally left vague to encourage a variety of student answers. Ultimately, the GTA was supposed to guide the students towards a back-titration experimentation method to determine how much acid is neutralized by an antacid tablet. The simulation took place during the planning stages for this experiment.

To customize the module, the research layered avatar dialogue that focused on relevant cultural and linguistic discourse. This included pre-determined avatar phrases based on attitudes and actions described in both ITA and second language literature as well as Intervention 1: Background Interview that aligned with the avatar students' backgrounds (Dieker et al., 2016). Based on Intervention 1: Background Interview, the three most requested areas ITAs wanted to practice were responding to student questions, engaging disengaged or disrespectful students, and navigating explicit difficulties understanding speech. The simulator was designed to incorporate all three areas, any of which could be emphasized to tailor the session to individual ITAs.

2.6 Intervention 2: Module and Post-Interview

Three ITAs (P2, P5, and P6) participated in the testing of the simulator module. All participants were given materials beforehand regarding the structure of TeachLivE, the seating chart and names of the avatar students, the chemistry concepts they would be teaching during their two 7-minute sessions, and guidance for navigating the instructional challenges of choice. When using the simulator, the participants taught the avatar students the same way they would teach their own students. The avatars could joke, get frustrated, and understand the background knowledge of the chemistry concepts being taught. There were five avatar students in two groups. Group one was composed of Kevin, Sean, and Maria, whereas group two was composed of CJ and Ed. When using the simulator, it was adaptive to the

ITA participant by being able to shift focus so that the ITA could practice their requested skill. The simulator module was intended to supplement existing training, not replace it, but the value of the simulator was that it could focus on a skill a participant needed to practice.

The simulator had a dedicated location on campus, and it could also be used online through Zoom. This was the case during the COVID-19 pandemic for the Spring 2020 semester. This is ideal for any department that is interested in providing a similar experience for its students without requiring a full simulator setup at its institution.

P5 had used the simulator before for professional development, P6 had seen the simulator being used but not used it themselves, and P2 had never seen the simulator before. P5 wanted to rehearse asking and answering student questions, P6 wanted to practice working with disengaged and disrespectful students, and P2 wanted to practice a little bit of everything. The ITAs entered their "classroom" to find five avatar students on their screen, whom the research facilitator introduced to the ITAs. The ITAs were then prompted to work with the avatar students to plan their experiment for 7 minutes. After 7 minutes, a debriefing session occurred with a member of the research team, with a short reflection and goal setting for the second round of 7 minutes. The avatar students were reset after the first round, so the participant could either retry the same approach or choose a different strategy to practice their skills. When the ITAs were finished teaching, they joined another member of the research team for an interview about their simulator experience for future professional development.

The questions used in the interview portion of Intervention 2 were developed based on themes found in Intervention 1 to more explicitly focus on anxiety and uncertainty in the classroom, in alignment with the AUM framework that was incorporated after Intervention 1. Intervention 2 data were analyzed using the same method as Intervention 1. Two researchers individually pulled meaningful statements from the interviews and themed them into groups. When themes were compared before descriptions were produced, two themes were eliminated because they did not contain enough supporting statements.

3. Results and Discussion

3.1 Interview Themes Overview

Interventions 1 and 2 explored the wants and needs of ITAs for professional development. Table 1 and Table 2 display the extensive themes that came out of both interventions. Intervention 1 used open-ended questions regarding teaching, teaching anxiety, and culture. These themes were integrated into a rehearsal simulator module that was then used in Intervention 2.

Intervention 2 acted as a proof-of-concept for a simulator module that ITAs could use as supplemental professional development. When in the simulator, ITAs selected one or more of the skills to rehearse based on their personal needs. During the interviews, all three ITAs agreed that the module gave them sufficient opportunities to practice the skills they wanted to rehearse.

Table 1. Themes and example quotes from Intervention 1: Background Interview

Theme	Researcher Description	Example Quote(s)
GTAs have a lot of responsibility but no autonomy	ITAs thought that there is much responsibility associated with being a GTA, but they were not given many choices for how they could teach in the classroom.	P1: "I was actually very surprised like how much responsibilities TAs have here . . . I came here and all of a sudden I was THE main provider of you know their knowledge . . ."
Comfort comes from practice and planning	The more practice a GTA has in the classroom, the more comfortable and less anxious they will be teaching a class.	P5: "If you don't plan properly, then it's going to be . . . you're not going to have a clear goal."
Culture's impact on teaching is murky	Many ITAs did not believe that their culture had any influence on the way that they taught, but a few said that it did. P3 said that coming from a different culture helped them be more inclusive in the classroom. P4 thought that coming from a different culture would mean they would not be liked, but they found that was not true when they started teaching.	P3: "So in terms of culture, as someone who comes from another culture and is having the outsider experience in the US, I hope to be and try to be a more inclusive in my class . . . I try to engage with them, ask about like their names, the meaning of their names."
	The ITAs' own experiences in the classroom were what influenced many of their teaching practices and styles. P5 said that while the classroom culture in their home country was fairly similar, the interactions they had with their own instructors were less flexible. P7 even highlighted the differences in what they were allowed to do in the classroom, like bringing a backpack or eating.	P7: "I'll say as a culture, it can definitely influence. Because it will depend on the way that what we defined as good behavior or not acceptable behavior . . . Usually we don't accept in class to like have backpacks or you have to be just listen to the lecture."
Language as a motivator for preparation	Using English as a second language may have influenced the way ITAs interacted with students and prepared for their classes. ITAs who had taught before in English had different feelings about this.	P3: "So being someone whose language, first language, is not English has probably motivated me to prepare before a class whereas if my language was . . . English, I would probably just do it as I went."
Practice in the simulator	ITAs wanted to practice in the simulator if given the opportunity. They wanted to practice interacting with disengaged students (P1, P2, P3, P4, P6), responding to student questions (P2, P3, P7), determining what to do when students did not understand them (P5, P6), normalizing errors in the classroom (P3), and dealing with students pointing out a teaching assistant error (P7).	P1: "How to respond to students who are disengaged and not following instructions. So because my first semester here was, you know, it was like a shock."
Difficulties when teaching	ITAs mentioned calling on non-volunteering students (P1, P5), determining whether students truly understood material (P2), limiting the quantity of concepts (P3), predicting students' feelings (P4), normalizing errors (P5), engaging all students (P5, P6), answering student questions (P5), and teaching in the inquiry setting (P7)	P5: "I'm a little more rigid than I'm supposed to be in the sense of the skills for GTA, for example . . . normalizing mistakes or normalizing errors, I'm definitely not really good at that."
Respect is subjective	Respect was shown in the classroom in different ways. P6 was not comfortable with people being rude. They stated that ITAs may have different views of what is considered rude in the classroom, and that these views may not be the same as views of what is considered rude in the American classroom.	P6: "I'm not comfortable with people being rude, but I feel good when I'm with a bunch of students or when I'm teaching small group or one on one. I don't feel anxiety with any of that."

Themes were used to develop the simulator module used in Intervention 2: Module and Post-Interview.

3.2 ITAs Want to Practice Asking and Answering Student Questions, Interacting with Disengaged Students, and Navigating Speech-related Difficulties during Discourse

Intervention 1: Background Interview aimed to identify instructional skills used in active learning classes that ITAs considered both comfortable and uncomfortable. The most requested practice areas were responding to student questions, explaining in different ways, responding to disengaged or disrespectful students, and navigating speech-related difficulties, as Table 1 shows. The skill of navigating speech-related difficulties was based on Intervention 1's findings regarding when the ITAs were unable to understand their students, whether because of students' accents or slang, as well as students not being able to understand the ITAs.

Two themes of interest are how teaching comfort comes from practice as well as how culture affects teaching and teaching-related anxiety. The ITAs did not consider cultural expectations and norms from their home countries to be a major factor influencing how they taught. Overall, the culture from the country that an ITA comes from fades into the background in favor of prior classroom experiences when they were a student outside of the USA. The ITAs did not identify any ways in which the culture from their home country influenced the way they taught, but they did identify several ways in which their previous classroom and teaching experiences influenced their teaching. Because classroom culture is different around the world, practicing and experiencing American classroom culture—or even just the classroom culture at the university an ITA is attending—is beneficial to shaping their teaching practices.

The most common assignment for new GTAs at the target institution is the general chemistry teaching lab, where GTAs are asked to lead active learning. The ITAs interviewed were surprised by how much responsibility GTAs were given, such as grading, but how little autonomy they had over what or how they taught, because instructional materials such as lesson plans were prepared for them. In contrast, a recent paper by Gin et al. (2021) noted that rigid teaching experiences can reduce anxiety by being a structured task in the otherwise unstructured environment of graduate school. A balance must be found for each class and instructor regarding how much structure should be provided for the GTAs. Explicit transparency may be needed for GTAs to understand how the course structure is set up to support their success.

3.3 The Simulator Module is Adaptive and Prompts ITAs to Successfully Practice Their Personalized Skill in the Simulator

Participants 2, 5, and 6 practiced in the simulator, as described in the Methods section. P5 practiced asking and answering student questions and encountered several group dynamics issues within the group composed of Sean, Maria, and Kevin. During the session, Maria had a correct idea about how to design the procedure, but Sean second guessed the group's plans.

"P5: What do you think, Maria?

*Maria: **sighs** It's a base.*

P5: Why do you think it's a base?

Maria: Um, I mean, it is, it's a weak base and it's gonna react like a base. That's what I've been trying to explain, but they won't believe me." (P5 Intervention 2: Module)

P5 then went on to explain to Sean, who believed that a base needs an "OH" group, that this is not always correct. The example quote showed P5 successfully asking and answering student questions while also helping groups interact well together. This ITA effectively rehearsed the content-related questions but did not attempt to mediate the one exchange that came up that could be interpreted as disrespectful during their simulator session and did not address it during their post-module interview either.

Participant 6 wanted to practice interacting with disengaged and disrespectful students. Disrespect manifested in the simulator as an avatar student pointing out the ITA's pronunciation variances. Explicit confrontation of pronunciation did not come up during P2 or P5's sessions. Calling out pronunciation was closely related to avatar CJ's personality profile (Dieker et al., 2016). The interaction occurred in the context of CJ being confused with what P6 was saying, but the direct way in which CJ pointed this out could be considered rude.

While in the simulator, P6 did not address the comment about the confrontation regarding mispronunciation; rather, they corrected their language and moved on. In fact, P6 discussed this instance in their interview as a learning experience and an opportunity to improve their pronunciation:

"P6: So you have the negative ion (pronounced eon) that is the chlorine and you have the positive ion (pronounced eon), that is the sodium. So therefore a salt and -

CJ: Eon? What do you mean eon? Yeah. Wait, I'm not following. Eons?

P6: Yeah. Um, an ion (pronounced correctly), you know?

CJ: Oh yeah. Ions! Okay. I got it.' (P6 Intervention 2: Module)

'I felt that I have to improve . . . my speech because sometimes I don't pronounce the words enough right for the [simulator] to understand me . . . I felt that stronger than I felt it when teaching real students." (P6 Intervention 2: Post-Module Interview)

Participant 2 wanted to practice the techniques all together. They had taught organic chemistry recently and explained acids and bases in an organic chemistry context rather than a general chemistry context, which made the avatar students ask P2 for more clarification. Realizing they needed to adjust their explanations, P2 reframed their responses during the second teaching session and successfully rehearsed asking and answering student questions. The participants told researchers they were able to practice their desired skills in the simulator, and the researchers confirmed this through analysis of the module recordings.

3.4 The ITAs Believe that the Simulator is Beneficial for Professional Development and Would be Useful for New ITAs

Immediately following the simulator activity, the participants were interviewed regarding their experience, and the meaningful statements were developed into themes in Table 2. In many ways, the ITAs thought that the simulator was realistic in that the avatar students behaved like their real students and that the environment was similar to the chemistry labs. This finding agreed with that of previous studies that showed the simulator was effective in supporting authentic practice for chemistry GTAs (Geraets et al., 2021). The main difference the ITAs mentioned was that they felt like they did not need to control their facial features in the simulator as much as they would with their own students because they did not think that the avatar students could see them. All three ITAs said that if they were given the chance to practice again in the simulator, they would, and that they felt like the simulator would be beneficial for new ITAs.

"Yes, I think it would definitely be helpful. Because . . . the personalities of the simulated students work because one is very adamant. The other one's very shy. So this kind of prepares the TAs for the six kinds of stream personalities." (P5 Interview)

Creating adaptable, rehearsal-based professional development tailored to the needs of ITAs ensured that participants rehearsed the teaching skills that they needed to practice rather than general teaching skills that are important to professional development leaders.

Table 2. Themes from Intervention 2: Module and Post-Interview

Theme	Description	Example Quote(s)
Simulator felt like the classroom but had some key differences	Most of the ITAs said that the simulator felt much like their own experiences in the classroom, but P5 mentioned that practicing in the simulated environment was less believable because they would not hide the faces they made when teaching the avatar students. Two of the ITAs said that they anticipated feedback in the simulator from a supervisor or that their pronunciation errors were more noticeable, which was different than the classroom.	P5: "So it's somewhat challenging . . . if you get an incorrect answer, you kind of don't want to flinch to kind of show that it's a wrong answer, right?" P5: "It's good practice, though, but I do feel that it's different from real life. In real life, there's a lot more use and you can really relate better to students that way as well as students also pick up on your cues?"
The avatars behaved like real students	P2 thought that the avatar students were too repetitive. P5 thought they were enough like real students to practice with, but that their own students were more relatable because the personalities of the avatars were exaggerated. P6 thought that the avatars were very much like their own students.	P6: "I totally forget that they weren't real. I could like think they were real students. Because the way they answered the way that they asked you to clarify the way they say "No, I didn't know that."
Simulator was good for supplementary learning	The ITAs stated that the simulator could never replace learning how to teach in a classroom, but that it was very helpful for supplementary practice of the strategies their supervisor requested.	P2: "Yes of course . . . not completely 100% substitute . . . But it can be very great supplementary stuff . . . but I believe that it isn't perfect."
The ITAs would practice in the simulator again	If they were to practice in the simulator again, P2 would want to be more prepared, P5 would want to practice with disengaged or disrespectful students, and P6 would like to practice the language barrier.	P5: "I would practice the other areas of focus . . . I didn't have any of disengaged or disrespectful student? So, I don't know, just if I get the opportunity, I would like to practice that."
Confidence may be affected by the simulator	P2 did not think that their confidence was affected by the simulator because they already had high confidence. P6 thought that using the simulator would greatly improve their confidence in the classroom.	P6: "As I felt it really real, I think it's a very good way to practice and equally improve my confidence."
Current ITAs believed that the simulator would be effective for new ITAs	All three ITAs interviewed thought that the simulator would be beneficial for future ITAs.	P5: "Yes, I think it would definitely be helpful. Because I feel like the simulator is a little bit more stressful in the way that the personalities of the simulated students . . . so this kind of prepares the TAs for the six kinds of stream personalities."

Participants 2, 5, and 6 used a simulator to practice teaching a general chemistry lab and then answered interview questions. The ITAs believed that the simulator would be useful for future ITAs and would either improve or maintain their confidence.

The two themes that the ITAs believed in, that their real students would react well to the skills they practiced in the simulator and that their confidence would be either improved or would stay the same after using the simulator, aligned well with the two theoretical frameworks chosen to design this study. Expectancy value theory leads to the assumption that if ITAs have an expectation of success at a task, or in this case a teaching skill, they will place more value on the completion of the task. Successfully using the skills within training allows for an increase of value placed on the teaching skills within ITAs' classrooms. It also acts as a confidence boost for ITAs with low confidence. AUM theory shows that improved confidence is correlated with reduced anxiety, which is a main goal of future

studies related to the current research. These findings show that ITAs can use rehearsals to shift expectations and values they have in classroom skills, and that they can implement the skills in the simulator. If ITAs are able to find success in the simulator, this can change how they feel about success in the classroom without putting students at risk.

4. Conclusion

Training initiatives commonly support GTA development as instructors but often fall short in supporting this development in the context of the increasing diversity of teaching assistants themselves. ITAs have unique needs that can be met through support and interventions, and a rehearsal-based simulator module is a promising intervention. With the simulator, there is structure to provide an authentic evidence-based teaching experience while still being flexible enough to allow ITAs to focus on the skills that they wish to practice or feel they need more experience with to enhance classroom comfort.

Using a teaching simulator can be a way to create adaptive resources tailored to the individual needs of each teaching assistant. Because ITAs come from all over the world, their training should be designed specifically to adapt to their experiences. The current researchers encourage professional developers to make their training adaptive and responsive. This research showed that three ITAs with different training needs were able to practice using one simulator module. The chemistry content stayed the same, but the nuances of the avatar responses and how various training opportunities were presented were reactive and adaptive for each new session. This research acknowledges that there is more work to be done, but this first step shows that this type of GTA training can be a desired and valued method of professional development for ITAs.

Layering the simulator module with cultural and linguistic aspects extends an existing GTA project intended to allow for a more inclusive and needs-based teaching rehearsal to support ITAs. The focus on attending to the linguistic and cultural aspects of teaching aims to decrease teaching-related anxiety and orient GTA expectations of what the teaching environment will be like in an American university. The three ITAs interviewed agreed that a mixed-reality simulator module would be beneficial for future ITAs. New and existing ITAs would be able to practice teaching techniques that they felt they should enhance on their own and that skills instructors had requested they enhance. Ideally, more experience would give ITAs a chance to practice varied teaching techniques and have more instructional resources at their disposal when teaching. The ITAs that participated in this research and the accompanying interviews valued the simulator module and professional development enough to not only request to participate again but also recommend the sessions to new ITAs. The confidence that can be gained by practicing in the simulator before entering a classroom setting or for additional training has the opportunity to lower teaching anxiety and lead to more effective communication. Knowing that the simulator can be viewed as a realistic classroom environment leads to a continued thirst for more knowledge regarding both anxiety and communication between ITAs and their students.

4.1 Limitations

The small participant pool in this study does not lend itself well to the transferability of the findings. The participants were self-selected volunteers. Their self-selected nature was not in opposition to the spirit of the training because the goal was to create support for ITAs who desired it. To provide insights into more GTA experiences, a larger participant pool is needed that addresses transferability between institutions and even disciplines. The ITA population in the USA as a whole as well as the population at the target university were different than the participants who volunteered for the research project. The skills requested by the ITAs can be easily adapted to new contexts with input from experts, such as physics or mathematics professors in charge of GTAs at different institutions.

Another limitation may be related to ITAs' interpretation of culture. Relating both the definition of culture as well as aspects of their personal identities to their teaching was difficult. It was easier to see concrete examples of the similarities and differences between undergraduate experiences of how the ITAs currently teach rather than relying on a cultural comparison among the educational systems in different countries. More effective instruments must be developed to navigate the identities and relationships of which our participants are not always aware.

Not all of the ITAs who participated in Intervention 2: Module and Post-Interview were general chemistry GTAs. Although this provides a broader range of teaching practices used in the past, it can complicate the language used in the simulator. One example of this was Participant 2's use of the organic chemistry terms "nucleophile" and "electrophile" when discussing acids and bases. This language was outside of the vocabulary boundaries of the simulator design and caused confusion for the avatars. This is a minor issue because real students in the classroom, who had not taken classes like organic chemistry yet, would be similarly confused.

Although the research made changes to enhance ITA support in the simulator, there were no adjustments to the simulator preparation, including documents related to the simulator and laboratory lesson. This was likely insufficient for new ITAs. Future research will change the way that the resources are presented to GTAs to allow for better preparation before simulator modules.

4.2 Future Directions

The research findings can be used to conduct more research on the needs of ITAs. This will allow for a better understanding of what ITAs in chemistry need and want to practice and what types of feedback are the most useful. The data gathered from the two interviews will be used to create a new simulator module and learning materials for widespread implementation. The authors hope to use the findings to leverage the virtual and adaptable nature of this training to reach a broader national and international audience of participants. The simulator module functionality and efficacy will be verified within a professional development course for chemistry GTAs. Current and future research will continue to focus on teaching practices that heighten anxiety for ITAs or GTAs by creating and implementing professional development to mitigate that anxiety.

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