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Maintaining fidelity in mixed reality simulation: Insights from simulation specialists at a South African university

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Background: Preservice teacher education faces a persistent theory–practice divide, particularly in programmes where coursework and work-integrated learning are treated as separate components. Mixed reality simulation (MRS) offers a promising supplement to practice learning, providing preservice teachers with realistic, low-risk practice learning opportunities. Central to the success of MRS are simulation specialists, who control avatars to create authentic classroom interactions. Yet, little is known about their experiences in maintaining fidelity during simulations.

Aim: This study explored simulation specialists' experiences of maintaining fidelity in a mixed reality simulation intervention in preservice teacher education.

Setting: The research was conducted in the Department of Childhood Education at a South African university within an ongoing MRS project.

Methods: A qualitative, interpretive design was followed. Data were generated through semi-structured focus group interviews with 10 simulation specialists across three academic years (2023–2025). Inductive thematic analysis was used to analyse the data.

Results: Four themes emerged: (1) conveying authentic emotions and complex classroom dynamics was constrained by simulation technology; (2) specialists sometimes prioritised supporting preservice teachers over fidelity; (3) cultural contextualisation enhanced fidelity but required significant preparation; and (4) confidence in role performance improved over time, strengthening fidelity.

Conclusion: Maintaining fidelity in MRS requires balancing technical, pedagogical, and cultural factors while resisting the urge to guide preservice teachers. Training and ongoing support are essential for specialists to maintain fidelity in simulations.

Contribution: The study provides novel insights into the under-researched role of simulation specialists in MRS, highlighting the skills, challenges, and cultural adaptations required to maintain fidelity in simulations.

Keywords: mixed reality simulation; fidelity; simulation specialist; preservice teacher education; practice learning.

Introduction and background

Teacher education programmes have long been challenged by what scholars describe as the persistent theory–practice divide, referring to the gap between the theoretical knowledge preservice teachers learn at university and the practical demands of classroom teaching (Darling-Hammond et al. 2017; Gravett 2012; Gravett & Ramsaroop 2017; Mavhunga & Van der Merwe 2020). This divide is often because of the structural organisation of teacher education programmes, which typically separate coursework from classroom practice or, in the South African context, work-integrated learning (Gravett 2012; Gravett & Jiyane 2019; Korthagen 2010). As a result, many preservice teachers enter the profession feeling underprepared for the complexities of teaching, particularly in areas such as managing learner behaviour, designing meaningful assessments and adapting lessons to accommodate diverse learner needs (Darling-Hammond 2014; Gholam 2018; Kennedy 2016; Zeichner 2010).

In response to this enduring challenge, scholars have argued for the inclusion of practice learning, which can be defined as structured, practical opportunities within teacher education programmes that allow preservice teachers to apply pedagogical content knowledge in settings that closely resemble actual classrooms (Ball & Forzani 2009; Grossman et al. 2009; Lampert et al. 2013).

Practice learning is increasingly recognised as a promising way of bridging the so-called theory–practice divide (Darling-Hammond 2014; Gravett 2012; Gravett et al. 2023; Zeichner 2010). Practice learning activities typically include micro-lesson teaching and school placements or work-integrated learning, although the extent to which they effectively bridge the divide depends on how intentionally and systematically they are designed and implemented.

Although practice learning holds promise, traditional forms, such as those mentioned above, often fall short of fully preparing preservice teachers for classroom realities. For example, Allen and Wright (2014) observed that micro-lesson teaching, where preservice teachers deliver scripted lessons to peers in small, controlled settings, is largely ineffective because it does not expose them to realistic classroom challenges, such as diverse learner needs, behavioural issues, or in-the-moment lesson adaptations. Similarly, McDonald, Kazemi and Kavanagh (2013) argued that micro-lesson teaching oversimplifies teaching and does not prepare preservice teachers for the unpredictability and complexity of real classrooms. In the case of work-integrated learning, particularly in the South African context, Gravett and Ramsaroop (2015) observed that school placements often take place in under-resourced schools with limited mentoring and inconsistent support for preservice teachers, which considerably reduces its effectiveness. These limitations highlight the need for more authentic practice learning experiences.

One promising approach is the use of mixed reality simulations (MRS), which combines physical and virtual elements to create immersive learning environments where preservice teachers can practice core teaching skills, such as questioning and managing learner behaviour in a safe and controlled setting that closely resembles a real classroom (Dieker et al. 2014; Gravett et al. 2023; Nel, Dieker & Marais 2024; Schutt, Miles-Keogh & Linegar 2022). During these simulations, trained simulation specialists control avatar learners, who respond in real time as actual children would, enabling preservice teachers to engage in authentic and realistic practice learning activities.

At the heart of effective MRS lies the concept of fidelity, which refers to how closely a simulation resembles the real world (Hughes et al. 2015; Rothgeb 2008). Paige and Morin (2013) described three aspects of simulation fidelity: physical fidelity, which relates to the equipment and environment; psychological fidelity, which reflects how believable the simulation feels to participants; and conceptual fidelity, which concerns how accurately the simulation represents real professional challenges and contexts. Ensuring the right level of fidelity across these dimensions is important for creating practice learning experiences that closely resemble actual classroom teaching.

Central to maintaining fidelity in MRS are the simulation specialists, also known as digital puppeteers, who control avatar behaviours and responses during simulation sessions. These specialists play a vital role in creating realistic classroom scenarios by adjusting avatars' movements, voices, and personalities to mimic authentic learner behaviours (Dieker et al. 2014; Schutt et al. 2022). Their skill in sustaining fidelity is essential for ensuring that simulations closely reflect actual classroom teaching.

Although MRS are increasingly used in preservice teacher education programmes, there is a notable dearth of research on the experiences of simulation specialists in maintaining fidelity during mixed reality sessions. Most studies focus on preservice teachers' experiences or learning outcomes, rather than the perspectives of those who are responsible for creating and managing the simulated learning environment. Yet, simulation specialists play an important role in ensuring that the simulation mirrors the complexity and authenticity of real classroom interactions. Without insight into their experiences, there is a lack of understanding of the processes, challenges and professional judgement involved in maintaining fidelity, which is a key determining factor of the educational value of simulations. This highlights a key gap in the literature regarding how fidelity is achieved in MRS for teacher education.

This gap is especially significant in a context such as South Africa, where cultural, language, and socioeconomic factors require simulation scenarios and avatar behaviours to be carefully adapted to reflect local classroom realities. Understanding how simulation specialists experience maintaining fidelity in such contexts is therefore vital for the meaningful use of MRS in teacher education, both locally and in other diverse settings.

This study addresses this gap by exploring the experiences of simulation specialists involved in a MRS intervention at a South African university. Specifically, the research is guided by the following question: *How do simulation specialists experience maintaining fidelity during a MRS intervention?* The objective of the study, therefore, was to explore how simulation specialists experience and make sense of maintaining fidelity during a MRS intervention. By focusing on this underexplored perspective, the study contributes to a more comprehensive understanding of what it takes to design and facilitate high-fidelity MRS that are contextually relevant and pedagogically sound.

Literature review: Mixed reality simulation in teacher education

Mixed reality simulation is a promising innovation in teacher education, providing preservice teachers with opportunities to practice teaching in realistic and controlled classroom settings. The technology blends physical and virtual elements to create immersive environments where preservice teachers teach lessons to avatar learners, which are controlled in real time by trained simulation specialists (Lindgren et al. 2016). Several platforms have been designed for this purpose, with TeachLivE, which was developed at the University of Central

Florida, being one of the most widely used (Dieker et al. 2014). TeachLivE offers a virtual classroom with five avatar learners, each designed with unique personalities and behaviours. Because simulation specialists control the avatars' responses, classroom interactions are dynamic and often unpredictable, closely reflecting real teaching experiences (Nel, Marais & Dieker 2020).

The theoretical foundation for MRS in teacher education is rooted in social constructivist learning theory, which emphasises the importance of situated, experiential learning (Brown, Collins & Duguid 2005; Lave & Wenger 1991). This framework, which also guides this study, suggests that learning is most effective when it occurs in contexts that closely reflect the real-world settings where knowledge and skills will be applied. Mixed reality simulations provide such authentic practice learning experiences by immersing preservice teachers in environments that resemble the complexities of real classrooms, allowing them to refine their teaching skills through repeated, guided practice while receiving immediate, actionable feedback from a teacher educator or coach to support their development (Gravett et al. 2023).

Research on MRS in teacher education highlights several benefits for preservice teacher development. Studies have shown improvements in classroom management skills (Mahon et al. 2010), questioning techniques (Gravett et al. 2023; Schutt et al. 2022), and improved confidence in supporting diverse learner needs (Peterson-Ahmad, Pemberton & Hovey 2016). The technology provides preservice teachers with opportunities to practice targeted teaching skills repeatedly without the risk of negatively impacting real learners' learning (Hughes et al. 2015; Nel & Marais 2023). Unlike traditional work-integrated learning placements, where experiences vary significantly based on school context, mentor teacher quality, and other contextual factors, MRS provide consistent practice learning opportunities focused on developing specific pedagogical skills (Grossman et al. 2009).

The role of simulation specialists in ensuring fidelity during MRS is vital, yet under-researched. Often referred to as *digital puppeteers*, these specialists control the behaviours, movements, voices, and responses of avatar learners to create authentic teaching scenarios (Gordon et al. 2001; Nel et al. 2020). Their work requires both technical expertise in operating the simulation software and pedagogical knowledge to enact realistic learner behaviours that mirror those encountered in actual classrooms. Training for simulation specialists typically focuses on improvisation, character development, and scenario management (Nagendran et al. 2014). Simulation specialists must consistently portray distinct avatar personalities while simultaneously adapting in real time to the varied teaching approaches of different preservice teachers. This requires extensive preparation and ongoing professional development to maintain high levels of fidelity across simulations.

The literature on simulation specialists' experiences is limited, with most studies focusing on the technical aspects of the simulation delivery rather than the human aspects required to maintain fidelity. Existing research has explored training protocols for specialists (Dieker et al. 2014) and technical considerations in scenario development (Schutt et al. 2022), yet little attention has been given to specialists' own perspectives on their experiences in creating authentic teaching scenarios and maintaining fidelity during simulations. This gap is particularly important given the growing use of MRS in preservice teacher education programmes. Understanding how specialists experience navigating cultural, language, and contextual factors to maintain fidelity during simulations is therefore vital. This study addresses this gap by exploring how simulation specialists experience maintaining fidelity within a South African preservice teacher education context.

The mixed reality simulation intervention and the role of the simulation specialists

This study, which explored the experiences of simulation specialists in maintaining fidelity during simulations, forms part of an ongoing MRS project in the Department of Childhood Education at a South African university. The project investigates a MRS intervention designed to enhance the practice learning opportunities for preservice teachers (Gravett et al. 2023). Using Mursion software, teacher educators engage Bachelor of Education students specialising in the Foundation Phase (FP) (Grades R–3) and Intermediate Phase (IP) (Grades 4–7) in virtual classrooms to practise core teaching skills, such as questioning and classroom management. The simulation classrooms consist of five avatar learners, each with a distinct personality, behaviour, and prior knowledge that reflects typical South African learners. The avatars, who were given local names, are controlled by local simulation specialists who respond in real time to the preservice teachers' lessons.

Second- and third-year students each teach three 10-min lessons in the virtual classroom, which is displayed on a big screen in a micro-lesson venue on campus. The main focus is on developing questioning techniques, identified as essential for effective teaching in both phases, while also giving preservice teachers practice in managing learner behaviour and responding to diverse learner needs. After each lesson, the preservice teachers take part in a reflection and coaching session led by a senior student in the faculty. Simulations are controlled from a separate venue on campus, where each specialist controls all five avatars using a simulation station. This station includes a laptop, which runs the Mursion software, a headset for voice modulation, and an Xbox controller to switch between avatars and manage their movements and actions.

The fidelity of the mixed reality sessions depends on the simulation specialists, who are postgraduate students from the same institution who are trained to operate the avatar

learners. Drawing on their knowledge of the local schooling context, they must ensure that the avatars' behaviours and responses authentically reflect South African learners.

Training the simulation specialists

Simulation specialists were trained internally by the first author of this study, who was responsible for introducing them to the Mursion-based MRS platform. As none of the simulation specialists had prior experience with the simulation software, the training covered both the technical aspects of using the platform and the more complex task of taking on different learner personalities and responding authentically in real time. The process involved an intensive 5 days of formal training before the simulation sessions began, followed by ongoing mentorship and support during the sessions.

Training began with technical skills, which included learning how to use the Mursion software and controlling multiple avatars at once by managing their movements and verbal responses in real time. Most of the specialists were unfamiliar with the Xbox controller, which is used to control avatar behaviours, and early training sessions revealed how difficult it was to direct actions such as raising hands or participating in peer discussions. With practice, however, they became more adept at controlling the avatars.

The second phase of the training focused on developing and portraying the unique personalities of each avatar learner. The trainer modelled how to embody each distinct avatar. For example, Emily, a strong but occasionally disruptive learner; Shaneez, a high-achieving yet reserved learner; Molemo, an inquisitive and talkative learner; and Alfred, who becomes easily overwhelmed and requires considerable support. Specialists also learned to simulate realistic classroom dynamics by strategically introducing disruptions to teaching and learning, as well as responding effectively to preservice teachers' questioning techniques.

Training was ongoing and included in-the-moment feedback, reflection, and modelling during simulations. Over time, the trainer observed noticeable progress as the specialists transitioned smoothly between avatars, used different gestures intentionally, and delivered realistic learner responses. Eventually, the trainer assumed a more supportive role, allowing the specialists to run sessions independently.

Fidelity was prioritised throughout the process. The simulation specialists incorporated familiar South African languages and consistently portrayed behavioural issues, learning difficulties, and misconceptions found in typical South African classrooms, enabling preservice teachers to encounter classroom scenarios reflective of their own experiences. This was important because realistic and contextually relevant simulations help preservice teachers relate to the scenarios, practise appropriate teaching strategies, and build confidence in handling the complexities of real classroom teaching.

Research methods and design

This study followed a generic qualitative research design, which is well-suited for exploring participants' experiences and perspectives within specific contexts (Merriam & Tisdell 2016). This design type was considered most appropriate for exploring the simulation specialists' experiences in maintaining fidelity during MRS sessions, as it allowed for a flexible exploration of their perspectives without relying on predetermined theoretical assumptions (Caelli, Ray & Mill 2003). The research approach was interpretive in nature (Schwartz-Shea & Yanow 2012), focusing on generating insights into how simulation specialists maintain fidelity during MRS.

The study used purposive sampling to select 10 simulation specialists who facilitated MRS sessions over three academic years (2023–2025). Participants were selected because they had completed the simulation specialist training programme and were actively involved in the mixed reality intervention, ensuring that they had direct experience relevant to the research focus. All participants were postgraduate students at Honours or Master's level, specialising in Childhood Education at the university where the study took place, and had been specifically recruited and trained for their roles in the simulation intervention. At the time of data collection, all participants had completed the simulation specialist training programme and had experience in facilitating multiple sessions with different cohorts of preservice teachers across English and Mathematics.

Data were collected through semi-structured focus group interviews with the simulation specialists in each academic year (2023–2025), which were conducted after the preservice teachers had completed all three of their simulation lessons. Participants were invited to join the focus group interviews via email, which included information about the study's purpose and the voluntary nature of participation. The interviews followed a semi-structured schedule focusing on key areas related to maintaining fidelity in MRS, including participants' understanding of their roles, experiences in simulating realistic learner behaviours, challenges encountered, strategies developed to address these challenges, and their perceptions of how accurately the simulations reflected real classroom settings.

Focus group interviews were conducted after all the simulation sessions were concluded in a specific semester. The timing was deliberate, allowing participants to reflect on their experiences after facilitating many simulation sessions. Each interview was held virtually on Microsoft Teams, allowing participants from different locations to join conveniently. The interviews were moderated by the first author of the article, who guided discussions using open-ended questions while allowing participants to elaborate and interact freely. Participants were encouraged to discuss and reflect on their experiences, share examples and respond to one another's perspectives. Focus groups were chosen over individual interviews to encourage discussion and interaction

among participants, which can generate richer insights by drawing on diverse perspectives and experiences (Krueger 2014). The focus group setting also enabled the participants to build on each other's responses, providing a more nuanced understanding of their collective experiences of maintaining fidelity during simulations. Each focus group interview was audio-recorded on Microsoft Teams with participants' consent and lasted approximately 90 min.

The focus group interviews were transcribed verbatim and analysed using inductive thematic analysis, following the approach put forward by Braun and Clarke (2006). This approach identifies patterns of meaning across datasets through a systematic process of familiarisation, coding, categorisation, refinement, and final theme generation. The analysis began with multiple readings of the transcripts to become familiar with the data and note initial areas of interest. The researchers then conducted line-by-line coding, highlighting meaningful segments of text and assigning descriptive codes. Codes were developed inductively, without predetermined categories, allowing them to emerge naturally from the data. Next, the codes were reviewed and grouped into provisional categories through an iterative process of comparison and contrasting. After several rounds of refinement, four final themes were generated, which are presented and discussed in the following sections.

Throughout the analysis, the researchers remained reflexive about their own assumptions and potential biases. Being involved in the broader MRS project, they recognised their insider position and took care to ensure that the analysis was guided by participants' perspectives rather than preconceived expectations (Schwartz-Shea & Yanow 2012).

Research findings

The analysis of the focus group interviews with simulation specialists identified four themes that describe their experiences of maintaining fidelity in MRS. These themes highlight the challenges they faced, the strategies they used, and the important role they play in creating realistic learning experiences for preservice teachers.

Theme 1: Simulation specialists' ability to convey authentic emotions and complex classroom dynamics was impacted by the simulation technology

The simulation specialists' experiences highlighted the challenge of conveying realistic and authentic learner emotions during simulations, making it difficult to maintain fidelity. This was particularly evident when portraying the full range of emotional responses seen in real classrooms. The simulation specialists explained that, while they could control basic avatar movements, basic facial expressions, and verbal responses, conveying subtle emotional nuances proved difficult given the Mursion platform's technical limits. One participant observed, 'It will be great if the avatars were able to move around the classroom or to even throw stuff at each other' (Participant B, FP Sim Specialist, 2023). Another agreed, saying:

> 'Real kids are chaotic, we need avatars that are able to go up and down, even going as far as putting things into their mouths for no good reason, like glue sticks or even papers.' (Participant C, FP Sim Specialist, 2023)

Some specialists felt that they needed more training or experience to convey emotions effectively. One said:

> 'I personally feel like I still need more training or experience to find a way to show real emotions through the avatars.' (Participant E, IP Sim Specialist, 2024)

Similarly, another participant explained:

> 'Even though I know there are some expressions on Mursion for the avatars, during a session I always forget to switch between the controls, and I end up using the off-task function or the X-function to show agitation.' (Participant G, FP Sim Specialist, 2024)

The difficulty in portraying emotions was especially clear when specialists tried to show learner distress, excitement, or complex social interactions. Participant G, FP Sim Specialist, 2024 commented, 'The avatars don't always do unexpected things like real learners do'. Another said, 'We haven't figured out how to show avatars getting super upset or crying' (Participant D, FP Sim Specialist, 2023). Similarly, Participant F, IP Sim Specialist, 2024 added, 'I am not even sure I am allowed to scream or cry during a session as an avatar'. Participants also noticed that the controlled nature of the simulation made it difficult to replicate the spontaneous emotional responses typically found in real classrooms. As one specialist reflected, 'Sometimes I forget my role of being a child, and the avatars' answers can seem too perfect. We, or should I rather say, I need to mix it up a little' (Participant C, FP Sim Specialist, 2024).

These limitations created a tension between the goal of providing authentic practice learning experiences and the technical constraints of the simulation technology. Specialists often had to decide which aspects of emotional authenticity to prioritise, frequently focusing on observable behaviours rather than the full complexity of emotions found in primary school classrooms.

Another constraint the simulation specialists faced in maintaining fidelity was managing multiple avatars at once to create realistic classroom group dynamics. The participants pointed out that real classrooms are full of overlapping discussions, interruptions, and side conversations, which were difficult to replicate during the simulations. As one specialist explained:

> 'Sometimes I wanted to make it more realistic, so two avatars would try to talk over each other. But the system lags, or my controls mess up, and it just sounds awkward.' (Participant G, FP Sim Specialist, 2024)

Another added:

> 'There's no way to make that background noise you have with a big class, so the teacher isn't practising, like, ignoring side

> conversations while focusing on the main activity.' (Participant F, IP Sim Specialist, 2024)

Because the simulation technology allows only for sequential avatar responses, specialists found it difficult to recreate the overlapping talking and learner behavioural challenges typically found in real classrooms. As one participant put it, 'Honestly, in the real world, there would be, like, three kids shouting out at once. Our system only lets me answer one at a time' (Participant F, IP Sim Specialist, 2024). This limitation was particularly important because classroom management often involves handling multiple distractions at once. Another participant observed, 'We don't really get into, like, group noise or kids chatting, so the teacher doesn't really practise managing that kinda stuff' (Participant B, FP Sim Specialist, 2023).

Specialists also struggled to simulate realistic movement and spatial dynamics. In real classrooms, learners shift around, lean back, pass each other notes, or switch seats, such behaviours add to the complexity of teaching. The simulation software makes it possible to mimic some actions, but in a much more limited and less spontaneous way. As one participant said, 'Kids in real classrooms move around, get up, switch seats. I could only make them move in basic ways. It's nothing like actual classroom energy' (Participant G, FP Sim Specialist, 2024).

Technical delays sometimes disrupted the flow of the lessons taught by the preservice teachers. Although the system allows for synchronous interactions, technical glitches occasionally interrupt the sense of realism. One participant explained, 'If the network is a bit slow, there's that weird delay, and it feels less like you're in a real class. That throws everyone off a bit' (Participant C, FP Sim Specialist, 2023). Another added:

> 'It's so awkward when instead of the avatar voices, it's my own voice coming through for all the avatars due to connectivity issues, and you could see the student teachers' eyes widen on Zoom, as if they now recognise that it's me behind the screen. I think it really affects the realness of the whole experience.' (Participant E, IP Sim Specialist, 2024)

Despite these constraints, the simulation specialists developed creative ways to try and maintain fidelity during simulations. As one participant shared:

> 'We tried to use our voices to create excitement and distractions or have two avatars ask silly questions at once to challenge the teacher. For me, my avatars of choice were Emily and Molemo.' (Participant G, FP Sim Specialist, 2024)

They also learned to design scenarios that targeted specific skills rather than trying to capture the full complexity of a classroom. As one participant explained:

> 'You have to really balance what's possible with Mursion and which teaching skill you want to test, so sometimes we focused more on questioning, not classroom management, because the software couldn't do it all.' (Participant A, FP Sim Specialist, 2023)

Theme 2: Simulation specialists found it difficult to maintain fidelity, as they sometimes wanted to support the preservice teachers rather than respond as real children would

Simulation specialists described the challenge of balancing fidelity with the need to meet learning objectives within the time available for each lesson (10 min). This meant making quick decisions in real time, like when to introduce challenges, how to respond to different teaching approaches, and when to stay true to realistic learner behaviour or adjust it to support the preservice teacher's learning.

Participants explained that complete realism was not always the most helpful. When preservice teachers were struggling with teaching basic concepts or techniques, the simulation specialists sometimes stepped in to guide them. One specialist opined:

> 'I would use one of the vocal and smart avatars like Emily or Molemo to ask a clarifying question, suppose the student didn't address something I felt was important in the lesson.' (Participant G, FP Sim Specialist, 2024)

Another added, 'As a teacher, I felt it was necessary to use the avatars to correct the students when they were teaching because sometimes, they were absolutely teaching the wrong things' (Participant F, IP Sim Specialist, 2024). These examples show how the simulation specialists sometimes used the avatars to guide or redirect lessons in ways real learners might not, creating a tension between authenticity and support, as their role was meant to be limited to portraying learners only.

This tension was especially clear when preservice teachers made serious mistakes or became frustrated. Specialists had to choose between sticking to realistic learner behaviours, which could make the situation harder, or softening their responses to help the preservice teachers regain confidence during their teaching of the lesson. One participant explained:

> 'It was fun to come up with scenarios that really made student teachers think on their feet, but sometimes you have to know when to pull back and not make it too difficult.' (Participant E, IP Sim Specialist, 2024)

Another commented:

> 'The avatars I choose to use in a session are based off the energy I get from the student teachers, if they are visibly agitated with the learners, I will definitely use the loud and unruly avatars, and if the students are well-prepared and are nice, I will then use the smart and respectful avatars.' (Participant G, FP Sim Specialist, 2024)

Time pressure added another layer to this balancing act. With short sessions, specialists felt they had to prioritise helping the preservice teachers achieve their lesson objectives, even if it meant losing some of the natural complexity of a real classroom. As one participant observed: 'It's sometimes hard to get the simulation to feel as chaotic as a real class because

of the allocated time per session' (Participant C, FP Sim Specialist, 2023).

Specialists also explained that they adjusted their approach based on the confidence of each preservice teacher. Those who appeared more confident were given more demanding and realistic scenarios, while nervous or less prepared preservice teachers received more supportive interactions. This required the specialists to quickly read the situation and adapt their responses accordingly.

Finally, the simulation specialists highlighted the need to keep avatar personalities consistent across the sessions. While adapting to individual learning needs, they also had to maintain coherent characters, ensuring that Emily, Molemo, or Alfred behaved in recognisable ways from one simulation lesson to the next.

Theme 3: Cultural contextualisation during simulations enhanced fidelity, but required significant preparation

The participants emphasised the importance of adapting the behaviours and responses of the avatars to reflect authentic South African learners, observing that this required careful preparation and ongoing attention to detail. They recognised that creating culturally relevant classroom settings was key to maintaining fidelity during simulations.

Simulation specialists described intentionally incorporating South African cultural references, local expressions, and contextually relevant behaviours into their simulations. One explained, 'Sometimes I would use Zulu sayings I heard growing up … The student teachers would immediately recognise them, and I think that made them relax a bit' (Participant A, FP Sim Specialist, 2023). Others drew on their own school experiences: 'I occasionally used my own experiences as a learner in a township school … It helped somehow with my sessions' (Participant F, IP Sim Specialist, 2024). Another added, 'I often slipped in Pedi phrases … It gave the avatars a flavour that I think connected with some of the student teachers' (Participant C, FP Sim Specialist, 2023).

Cultural adaptation went beyond language to include shared experiences of growing up and schooling in South Africa. One participant recalled using behaviours seen on television as a child growing up in South Africa: 'Sometimes I had Molemo do the same to make the experience come alive … though it annoyed the student teachers a bit' (Participant D, FP Sim Specialist, 2023). Another stated:

> 'I try to bring in the way learners call out to each other or respond when they get into trouble … It feels true to how children actually behave in South African classrooms.' (Participant F, FP Sim Specialist, 2025)

However, not all specialists initially had the cultural knowledge needed to do this effectively. One reflected:

> 'I had to be careful … Zulu or Pedi jokes that made sense to me could be confusing for someone from another culture. It took time to balance those details so everyone could connect.' (Participant G, FP Sim Specialist, 2024)

Another added, 'You can't just use any slang or accent; you have to listen to the student teachers and figure out which phrases make sense for them' (Participant E, IP Sim Specialist, 2024).

While specialists agreed that cultural adaptation enhanced the realism of the lessons, they also acknowledged the effort that it requires. As one specialist observed, 'By mentioning food or music from my community, I could reconnect the student teacher with the learners when she was focused on her lesson plan' (Participant H, FP Sim Specialist, 2024). Another said, 'At first, I only used my own background, but over time I realised I needed to learn about other people's cultures to connect with all student teachers' (Participant F, FP Sim Specialist, 2025).

Specialists also recognised the risk of stereotypes. One reflected, 'I worried about overdoing it or making the avatars cliché … I'd rehearse beforehand to check if something felt too much or too fake' (Participant G, FP Sim Specialist, 2024). To address this, they found reflection sessions helpful. One explained, 'Reflecting after sessions helped me spot where I lost the plot and gave ways to avoid it next time … We should have reflective sessions weekly' (Participant E, IP Sim Specialist, 2024). Another suggested including coaches in these reflections, as they have insider knowledge of the preservice teachers, which could help improve the realism of the sessions (Participant G, FP Sim Specialist, 2024).

Theme 4: Simulation specialists embraced the 'learner role' and grew more confident in their portrayals over time, enhancing the fidelity of the simulation sessions

As the simulation specialists became more confident in acting as learners, many moved from feeling unsure about how much to support the preservice teachers (see Theme 2) to fully taking on child-like behaviours. They found this both enjoyable and helpful for their work as simulation specialists. Getting into this role allowed them to respond more naturally and spontaneously, which made the simulations feel more realistic, while training helped to ensure they stayed true to how learners would actually behave, which enhanced the overall fidelity of the simulations over time.

One specialist reflected on how enjoyment sometimes challenged their initial understanding of their role as a simulation specialist: 'Sometimes I was having so much fun playing Molemo that I'd forget I'm supposed to be, like, "testing" the teacher. I'd just let myself really become him' (Participant B, FP Sim Specialist, 2023). Others described a shift from rigid professionalism to more natural, child-like responses:

> 'At first, I was super focused on doing it right. Should I help the teacher? Should I make the scenario hard? But then I realised, I'm just here to be a kid … it got really fun. Like, I'd be giggling at a silly answer or making up stuff on the spot.' (Participant F, IP Sim Specialist, 2024)

These experiences show how growing comfort with role-playing as children enhanced the simulation specialists' ability to maintain psychological fidelity through the avatar learners they portrayed.

The immersive nature of the role occasionally blurred the boundaries between specialists' personal and professional selves and their avatars. One participant observed: 'After a while, I'd catch myself saying things the avatar would say outside simulation, or thinking in that character, even with friends' (Participant F, FP Sim Specialist, 2025). Another observed how this flexibility extended to team interactions: 'Sometimes during breaks, we'd all be joking as the avatars, and it just carried over. It actually made us closer as a team' (Participant E, IP Sim Specialist, 2024). These examples suggest that the simulation specialist's personal investment in their roles as avatar learners contributed to more consistent and believable portrayals of their personalities, enhancing fidelity across the sessions.

Training played a critical role in reshaping specialists' understanding of their responsibilities. Many initially saw themselves as mentors or coaches rather than authentic learners (see Theme 2). One explained:

> 'Before the second training, I thought my job was almost like a coach, helping the student teachers. But after getting feedback, I saw I needed to just react like a real learner, not guide them too much.' (Participant G, FP Sim Specialist, 2024)

Another observed, 'The trainer told us, you're not their coach, you're their class! And be the kid, not the teacher. That changed how I approached every session' (Participant H, FP Sim Specialist, 2024). This reframing helped the specialists maintain conceptual fidelity by focusing on authentic learner responses rather than providing specific support during the preservice teachers' lessons.

Overall, as the simulation specialists became more comfortable in their roles, the fidelity of the simulations improved. Their willingness to act in playful, child-like ways made their responses more natural and better reflected how real learners might behave in actual classrooms. Enjoying the role also helped them stay motivated and engaged across sessions, which supported consistent and believable portrayals of real learners over time.

Discussion

This study explored the experiences of simulation specialists in maintaining fidelity during MRS used in preservice teacher education. The findings capture the simulation specialists' experiences, highlighting both the strengths and limitations of current simulation technology and emphasising the skills and knowledge required to simulate authentic learner behaviour and maintain fidelity during simulations. The study addressed a gap identified by Ade-Ojo et al. (2022:872), who noticed the need for 'conceptual research … into simulation in education, how to conduct a simulation and what fidelity means in this context'. Enhancing simulation specialists' skills through targeted training could help them to maintain fidelity more effectively, thereby improving preservice teachers' practice learning experiences and bridging the gap between theory and practice in teacher education.

The simulation specialists in this study initially found it challenging to convey authentic emotions and complex classroom dynamics through the avatar learners. Their experiences reflect broader difficulties in simulation-based education, where psychological fidelity, or the believability of participants' experiences, often proves more difficult to achieve than technical or physical fidelity (Paige & Morin 2013; Rothgeb 2008). The simulation specialists reported that sequential avatar responses could not fully capture the simultaneous conversations that are typical of a real classroom, limiting their ability to replicate large classroom dynamics and emotional complexity in their simulations. This has important implications for teacher education programmes that utilise MRS as part of their preservice teacher preparation, as teaching involves navigating learners' emotional needs, managing classroom interactions, and adapting to unpredictable situations (Hargreaves 2000; Van der Merwe 2022). Despite these challenges, the specialists' awareness of these limitations and their proactive adaptation strategies suggest that enhanced training in emotional portrayal could improve fidelity and the overall learning experience of the preservice teachers involved.

Specialists also described the tension between maintaining fidelity and supporting preservice teachers. At times, they wanted to guide and support the preservice teachers rather than respond as real children would, requiring continuous real-time decisions about when to prioritise realism versus supporting the preservice teachers who were struggling to deliver effective lessons. This highlights the pedagogical knowledge needed to deliver effective simulations (Gaba 2007). By adjusting scenario difficulty and their responses to individual preservice teachers' needs, the simulation specialists were able to provide scaffolded and personalised learning experiences, demonstrating that simulations can complement traditional practice learning while accommodating preservice teachers' different approaches to lesson enactment (Budin 2024; Wood, Bruner & Ross 1976).

Cultural contextualisation played a key role in enhancing the fidelity of simulations. The simulation specialists spent a lot of time preparing culturally authentic scenarios, including familiar languages, behaviours, and classroom routines. Research shows that culturally relevant learning experiences can boost engagement and learning outcomes (Gay 2018). For preservice teachers preparing to work in South Africa's diverse classrooms, these scenarios offer useful exposure to real classroom challenges and dynamics. At the same time, the amount of preparation needed raises questions about sustainability and resources, highlighting the importance of careful planning when implementing culturally relevant simulations.

Over time, the simulation specialists became more comfortable in their learner roles, moving from rigid simulations of learners to more natural, child-like portrayals. This increased confidence enhanced the psychological fidelity of the simulations, as avatars responded more spontaneously and authentically to the preservice teachers' lessons. Enjoyment and engagement in their role as learners supported this shift, demonstrating the value of role immersion in creating authentic learning experiences (Lindgren et al. 2016). The training that the simulation specialists underwent helped them to shift from acting as coaches to fully embodying the learners' personas. The training, therefore, was a vital component in maintaining conceptual fidelity, ensuring that the simulation specialists' responses reflected learner behaviours rather than providing unintended guidance. While negotiating their professional identity in the learner role can be challenging, specialists reported that it ultimately strengthened the fidelity of the simulations, highlighting the importance of ongoing support and reflection. The identity blurring described by the specialists, while potentially challenging professional boundaries, appeared to enhance rather than compromise fidelity during the simulations. This phenomenon aligns with research on simulation-based education that suggests facilitator investment in roles can improve the authenticity of learning experiences (Alinier & Oriot 2022; Huang, Chen & Tseng 2025). However, the findings also highlight the importance of ongoing training and support to help simulation specialists navigate these identity negotiations while maintaining fidelity in simulations.

Maintaining fidelity in MRS requires specialists to juggle technology constraints, emotional expression, cultural relevance, learning goals, and their own professional role simultaneously. This underscores that the role of simulation specialists extends beyond operating simulation technology to encompass pedagogical, cultural, and performative expertise, or 'acting' (Munshi, Lababidi & Alyousef 2015). The South African context of this study adds to the limited literature on simulation-based teacher education in developing simulations tailored to specific educational contexts, offering insights into culturally responsive and adaptive strategies that can inform implementation elsewhere.

While MRS cannot fully replace authentic classroom experiences, they offer valuable practice learning opportunities that complement traditional experiences, such as work-integrated learning and micro lessons (Budin 2024). When well designed and delivered by trained specialists, simulations can provide engaging, culturally relevant, rich learning experiences, supporting preservice teachers in bridging the theory–practice gap.

Conclusion

This study provides insights into the experiences of simulation specialists in maintaining fidelity during MRS for preservice teacher education. The findings highlight the complexity of their role, showing that maintaining fidelity requires balancing technical constraints, session objectives, cultural relevance, and their professional role as simulators.

Simulation specialists faced challenges in conveying authentic emotions and capturing the complexity of classroom dynamics, as the simulation technology could not fully replicate the complexity of real classrooms. At the same time, they struggled to maintain fidelity when they felt the need to support preservice teachers, sometimes responding in ways that real learners would not, which required constant judgement to balance realism with support for the preservice teachers. Cultural contextualisation enhanced the fidelity of the simulations, providing preservice teachers with meaningful exposure to the dynamics of diverse South African classrooms, but preparing these scenarios demanded significant time and effort. Over time, specialists grew more confident in their learner roles, embracing playful, child-like behaviours that allowed for more spontaneous and authentic responses, ultimately improving the fidelity of simulation sessions.

These findings indicate that maintaining fidelity in MRS is a multifaceted challenge requiring technical skill, pedagogical knowledge, and cultural understanding. While the current simulation technology offers valuable opportunities for preservice teachers to practice teaching in safe and controlled environments, it cannot fully replicate the emotional depth, social interactions, or cultural nuances of real classrooms. This suggests that even when simulation specialists demonstrate high levels of competence, their ability to maintain fidelity in simulations is inherently constrained by the limitations of the technology and the simulated context. As such, fidelity is always negotiated rather than fully achieved.

To address these challenges, training for simulation specialists should focus on authentic emotional portrayal, cultural adaptation, and staying true to their learner role rather than guiding preservice teachers. Ongoing professional development can help refine these skills, and institutions should customise simulation scenarios to their specific educational and cultural contexts instead of relying on generic content.

Despite these limitations, this study shows that when implemented thoughtfully, MRS can provide meaningful, scaffolded practice that complements traditional classroom experience, accommodate diverse teaching approaches, and help bridge the theory–practice divide in preservice teacher education.

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Competing interests

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CRediT authorship contribution

Pumzile Mello: Conceptualisation, Methodology, Formal analysis, Investigation, Writing – original draft. Dean van der Merwe: Conceptualisation, Methodology, Writing – review & editing, Supervision. All authors reviewed the article, contributed to the discussion of results, approved the final version for submission and publication, and take responsibility for the integrity of its findings.

Ethical considerations

Ethical clearance for this study was obtained from the Faculty of Education Research Ethics Committee at the university where the study took place (ethics clearance numbers: 1-2022- 041; 1-2025-078). All participants provided written informed consent before taking part in the focus group interviews. The consent process included an explanation of the study's purpose, the voluntary nature of participation, measures to ensure confidentiality, and participants' right to withdraw at any time without negative consequences.

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Data availability

The data that support the findings of this study are available from the corresponding author, Dean van der Merwe, upon reasonable request.

Disclaimer

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