Jl. of Technology and Teacher Education (2021) **29**(3), 257-277

Editorial: Conceptualizing a Shared Definition and Future Directions for Extended Reality (XR) in Teacher Education

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Scholarship on extended reality (XR) in teacher education is emerging at an increasing rate. As additional forms of XR become more common in the profession, there is a need for teacher educators to consider how the various forms of XR-based representations of practice are conceptualized. The papers in this special issue of JTATE on XR in teacher education each define XR in similar ways, but often with different terminology. In this editorial, we note how such definitions are characteristic of much of the good scholarship on XR in teacher education. With this in mind, this editorial focuses on how the field may begin to consider defining XR within the boundaries of perceptual capacity—a concept that align with definitions in various other professional fields and with theory and practice in teacher education.

INTRODUCTION

Extended reality (XR) is the umbrella term for the various forms of distinctive and overlapping technologies blending our digital and physical worlds. This includes virtual reality (VR), mixed reality (MR), augmented reality (AR), etc. It may showcase interactions with different technological devices including—but not limited to—VR headsets, mobile phones, tablets, computers, video recording and display equipment, or AR glasses. Although much of this technology may seem like science fiction, the reality is that XR is becoming more common in everyday use (e.g., *Google Maps* or *Pokemon Go*). It is also being used in various professions like medical practice (Andrews et al., 2019), medical education (Harrington et al., 2017), tourism (Kwok & Koh, 2020), manufacturing (Doolani et al., 2020; Fast-Berglund et al., 2018), geology (Çöltekin et al., 2020), and teacher education (Harron & Mason, 2021; Katz, 1999; Valai et al., 2020).

Applications of XR vary by profession, with teacher education presenting a particular set of needs and challenges. First, teacher education has a rich history examining how to represent, decompose, and approximate practice (Grossman et al., 2009). Such history could provide useful pedagogies and theoretical frameworks to illuminate how XR may be used; however, said history could just as easily obscure the potential for XR. Second, teacher educators are rarely well funded and pressed for content time and space; any integration of technology must consider both monetary and temporal costs (Carlson, 1995; Christ et al., 2017). Third, despite variations of XR being present in teacher education for decades (Katz, 1999), XR represents an unknown for many teacher educators. Novel solutions are often ripe for distrust in any profession, with educators (teacher educators amongst them) carrying scars of failed experiments in their classrooms.

Therefore, despite the prevalent adoption of XR in various professions, the skeptical teacher educator may justly ask whether it is worthwhile to invest their time, money, or energy either as a practitioner or scholar. In this editorial, we seek to provide some answers to this question. We do so by first conceptualizing XR in teacher education; we then describe current XR literature in teacher education, including the six manuscripts in this special issue of JTATE. We close the editorial with some provocation for the field of teacher education regarding how to conceptualize XR in our profession—both in terms of theory and practice.

CONCEPTUALIZING XR IN TEACHER EDUCATION

Why We Fundamentally Represent Practice

Grossman et al.'s (2009) seminal work distinguished between representations, decompositions, and approximations of practice. Within teacher education, a *representation of practice* provides teachers with opportunities to view teaching or evidence of students reasoning. Traditionally, this may involve standard videos of interviews with children, scanned work samples, still images of children exploring a concept, and so forth. *Decomposition of practice* engages teachers in analyzing and dissecting components of teaching within a representation. Traditional variations include course discussions around a video, marking up scanned examples of student work, etc. *Approximations of practice* allow PSTs to enact some form of practice in a way that approximates aspects of the profession without necessarily engaging in work with actual students. Examples include rehearsals of teaching (Lampert et al., 2013); written or spoken descriptions (Amador et al., 2017); and animated representations depicting what happens next (Kosko et al., 2014; Wieman & Jansen, 2016). As may be evident from the examples provided, teacher educators' use of representations, decompositions, and approximations interact with the medium of the representations. Afterall, the usefulness of a representation stems from its ability to present a viable version of teaching and/or learning (Grossman et al., 2009). So, before distinguishing XR from non-XR representations of practice, it is worthwhile to briefly clarify what it is teacher educators and educational researchers seek to convey.

Simply put, a representation of practice re-presents professional practice. The emphasis of re-presenting *practice* points to aspects of experience *in* a professional setting or *with* aspects of pedagogical significance. Such experiences are embodied for the teacher, meaning that "reactivation and reuse of processes and representations" are connected to perceptual experiences (Fincher-Kiefer, 2019, p. 10), which can form various perceptual symbols (Barsalou, 1999). *Perceptual symbols* and their systems identify "information from the environment and pass it along on to separate systems that support the various cognitive functions" Barsalou, 1999, p. 577). For example, *snow* is a perceptual symbol that is constructed through multiple senses (e.g., sight, taste, feel) and social contextualization (e.g., outside, winter, North, etc.). Within the teaching profession, *student-centered teaching* is another perceptual symbol in which teachers focus on students both in their descriptions of pedagogy (i.e., describing student actions in a video instead of the teacher's) as well as their physical enactments of pedagogy (i.e., physically looking at students engaged in the lesson rather than focusing primarily on classroom management; Zolfaghari et al., 2021). The state which the body acts, has acted in the past, or conceives it may act interacts with how we construct, process, or recall these perceptual symbols such that neural networks related to specific actions activate with the mere mention of an associated word (Beauchamp & Martin, 2007).

However, such perceptual symbols do not activate if there is no embodied experience to connect. For example, a person who has never experienced snow, nor seen/heard/felt a representation of it will have an entirely different understanding of snow as a symbol than someone who either has first-hand experience or has experienced a representation of it (e.g., a video or textual descriptions of it). Novices entering a teacher education program will likely have been in classrooms as a student; however, they may not understand the same sorts of experiential meanings assigned to terms as a teacher with classroom experience. To bridge the gap, teacher educators use representations of practice to re-present aspects to facilitate connections between perceptual symbols (e.g., student-centered teaching) and embodied experience. What makes some representations more successful than others is how closely they approximate key facets of the perceptual experience for a particular perceptual symbol. The ability for a representation to do so lay in its perceptual capacity.

Perceptual Capacity as a Lens for XR

Perceptual capacity is "a medium's capacity for aspects of the scenario to be perceivable" (Kosko et al., 2021, p. 286). All representations possess some degree of perceptual capacity. However, by blending physical and digital experiences, XR representations of practice have the potential for significantly enhanced perceptual capacity (Ferdig & Kosko, 2020). To illustrate this, consider the four video-based representations of the same hypothetical classroom scenario presented in Figure 1. In the standard video (example 1), the field of view is fixed such that anyone watching the video would see the same perspective at 0:33, 1:18, and 3:47 in the recorded lesson. For the single-perspective 360 video (example 2), viewers may now change their field of view, such that several teachers watching the same video might look at different groups of students at 0:33, 1:18, and 3:47. Yet, they are fixed at the same location in the classroom and cannot move from one side of the room to another. There is more that is perceivable and, thus, an increase in perceptual capacity for the representation; however, there is not unlimited perceptual capacity.

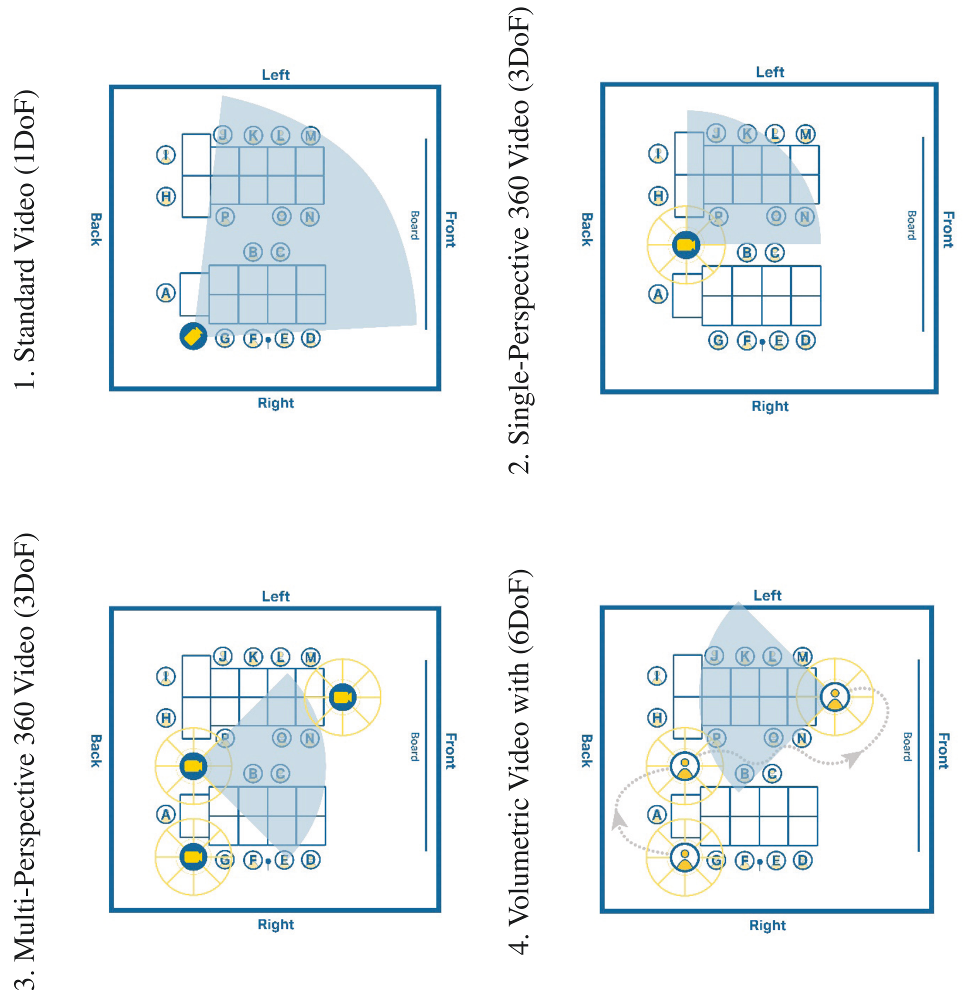


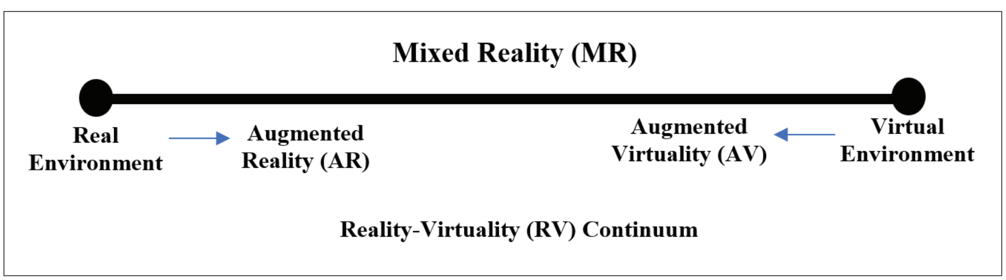
Figure 1. Illustrative Examples of Perceptual Capacity for Video-Based.

Multi-perspective 360 video (example 3 in Figure 1) increases perceptual capacity by including additional locations of 360 camera perspectives for a teacher "to virtually move around a class, from one group to another, and look in any direction at each group" (Zolfaghari et al., 2020, p. 317). Moving beyond multi-perspective 360 is volumetric video, which records a holographic representation of a scenario. Such representations allow the teacher to physically walk from one location to another, whereas multi-perspective 360 video requires viewers to 'transport' from one point to another. This is represented in example 4 where the teacher's path is illustrated as they move from one location at 0:33, to another at 1:18, and so forth.

In each of these four brief examples, the focus is only on what is *visually* perceivable. However, one may notice that what is visually perceivable interacts with the teacher's physical movements of their body beyond their eyes and ears. It is the ability to approximate multiple physiological resources that distinguishes XR from standard representations. For example, whereas standard video does have perceptual capacity, it is limited in the degree multiple sensory resources interact with a representation of practice. Improving perceptual capacity would require better blending of the digital and physical experiences (i.e., XR).

Augmented, Virtual, and Mixed Reality in Teacher Education

There are three dominant terms that fall under XR: virtual reality (VR), augmented reality (AR), and mixed reality (MR). Definitions of these terms often vary from one publication to another due to field of study, particular application of the technology, and interpretation of XR itself. The varying definitions may be due, in part, to early definitions that often excluded XR, as evidenced by Milgram & Kishino (1994; p. 283). Figure 2 shows the continuum Milgram & Kishino (1994) proposed to address virtuality and reality under the broad heading of mixed reality. While this was useful at the time, technological advances applied in various other fields has led to incorporation of similar terms with entirely different definitions within the scope of XR. A prime example of this in teacher education is the use of MR by scholars to describe PSTs interacting with animated avatars in a virtual environment. By contrast, an example of MR in the medical field is use of digital images/video overlaid on top of real-life in such a way that the digital and physical worlds interact (Andrews et al., 2019). The definitions both reside in the realm of XR but are otherwise quite different.



Note. This image is approximated from the original publication on p. 283.

Figure 2. Representation of Real vs. Virtual Environments on the Milgram & Kishino (1994) Continuum.

Variations in definitions may also be due to teacher educators referring to specific hardware as a way to define the form of XR. Although hardware devices may influence how AR, MR, and VR are experienced, we contend that the device one uses to access a medium should not be what primarily defines the specific form of XR (e.g., VR vs. MR). For example, both standard and 360 video may be viewed on flat panel devices (e.g., a laptop or desktop screen) or within a VR headset, but only one of these two mediums is considered XR (i.e., the 360 video experience on either type of device). Rather, we assert that the perceptual capacity of a representation should be used to both define whether it is XR and categorize the specific form(s) of XR.

In the prior section, perceptual capacity was exemplified by different forms of VR. VR is a digital re-presentation of an environment and can be animated (three-dimensional representations of VR) or recorded (360 video or holograms). As such, the perceptual symbols related to teaching should be more directly represented by embodied experience. Thus, the role of perceptual capacity in VR is to re-present aspects of a teachers' embodied experiences. This may be through a teacher adjusting their field of view or where in the classroom they focus (Roche et al., 2021; Walshe & Driver, 2019), listening to students both in front and behind them given ambisonic audio (Ferdig et al., 2020b), or conversing with students while they are approximating practice through simulations (Ke et al., 2020; Luke et al., 2021).

Perceptual capacity in AR and MR function differently because they integrate different perceptual symbols than the various forms of VR. Whereas the perceptual symbols represented in VR are more explicitly connected to sensory experiences, AR and MR integrate more abstracted forms in ways that are still connected to physical experience. Figure 3 illustrates this with two AR-based examples. The top image is a screenshot of a 360 video in which a text-based AR element is included explaining the context of why the teacher has placed something on the whiteboard. This contextual information is an abstracted form of experience that could have been included separate from the 360 video. By embedding it as an AR element, however, it is connected to the embodied experience of physically turning toward the whiteboard and examining the additional information associated with it.

Figure 3. Examples of AR Using Text-Based Digital Information (top) or Pictorial Information (bottom).

The second example of AR provided (bottom image in Figure 3) is a screenshot from a person's phone. Here, the person is physically on the campus of Kent State University where the historical events of the shootings on May 4, 1970 occurred decades ago (http://may4thxr.kent.edu/). Using an open-source, AR based application (https://glare.cs.kent.edu/), the geolocation of the person (and their phone) signals for them to use their camera. It then augments their phone's camera view to include a historic photo overlaying the individual's view. As with the text-based AR element, this photo-based AR element conveys an abstracted perceptual symbol. Specifically, the photo provides information about the May 4 shooting abstracted from experience (in this case a photo as events unfolded); however, this photo is used in a way that interacts with the person's physical experience.

As previously noted, MR has been defined differently across various fields. Prevalent use of hardware such as the *Microsoft HoloLens*, along with a larger amount of scholarship across multiple fields of study (e.g., Andrews et al., 2019; Huang et al., 2019; Strzys et al., 2017) points to a dominant definition of MR as facilitating an environment where "digital and real objects do not only co-exist, but moreover are also able to interact with each other in real-time" (Strzys et al., 2017, p. 1). With such a definition, AR and MR are considered as more similar than either is to VR because while VR attempts to bring an individual into a virtual environment, AR and MR both attempt to bring virtual objects into the physical environment. Whereas AR typically overlays digital information onto the physical world (see Figure 3), MR allows for interaction between the two. One potential application of MR in teacher education would be for PSTs to use the *HoloLens* while teaching at a field site. A *HoloLens* equipped with machine learning and artificial intelligence could use the built-in cameras to visually examine a student's facial cues for expressions of confusion when the PST provides an explanation. MR would use such input to signal to the teacher which students may be confused, thereby allowing digital input in the PSTs' decisions in the physical world.

Essentially, <u>the perceptual capacity of AR and MR rests on the form of information presented and how such information interacts with one's physical and embodied experiences</u>. The first example in Figure 3 (the one that includes textual information) may have a lower degree of perceptual capacity, whereas the second example in Figure 3 (the AR-based photo overlay) has a higher degree. Moreover, the hypothetical MR example of the PST in the field with *HoloLens* has an even higher degree than the prior two. This is not a function of text versus pictorial but in how much of an individual's sensory-based resources are engaged (i.e., a virtual presence in a recorded classroom vs. physically being in a location). Indeed, such distinctions also clarify how AR and MR differ from VR, and how XR representations differ from non-XR representations.

Specifically, whereas the perceptual capacity of VR converges perceptual symbols with embodied experience more explicitly, AR and MR does so with more abstracted perceptual symbols such that an embodied experience is augmented by (and interacts with) the abstraction. For example, a goal for PSTs in the field of mathematics teacher education is to be able to notice and accurately interpret a child's mathematical reasoning. A VR-based representation of practice may allow for PSTs to notice multiple visual and auditory examples of children's reasoning (i.e., children's physical actions and spoken explanations); it may also allow for a degree of interaction through digital avatars or agents. Such experiences mimic the perceptual symbols a PST would construct by being in a physical classroom. In contrast, an AR or MR-based representation of practice might provide textual or auditory information to the PST (e.g., a classification summary of children's reasoning on a key math concept) that informs how the PST interacts with the environment at-hand. Such data is a perceptual symbol abstracted from prior experiences (in this case, from various scholarship on children's reasoning) that enhances a PSTs' experience in their given environment. Thus, across the forms of XR, the manner in which perceptual experience is expressed or facilitated by a medium's perceptual capacity informs the type of XR one engages. We believe such considerations are useful in considering how XR has been used in teacher education and could inform how scholars consider it in the future.

EXEMPLIFYING XR IN TEACHER EDUCATION

Current Research Using XR in Teacher Education

Variations of XR have existed in teacher education for over 20 years. Applications have included 3D animated virtual classrooms using VR headsets (Katz, 1999; Ke et al., 2020), animated virtual environments with humans acting through computer-based avatars as viewed on computer screens (Garland et al., 2012; Luke et al., 2021; Meritt et al., 2015) or VR headsets (Lamb & Etopio, 2020), through 360 video recordings of actual classroom lessons and students on computer screens or headsets (Roche & Gal-Petitfaux, 2017; Theelen et al., 2019; Walshe & Driver, 2019; Weston & Amador, 2021), and through other variations of XR (Prestridge et al., 2021).

Despite the wide range of studies on XR in teacher education, "our knowledge about how we can use [extended reality technologies] and their impact on learning and teacher training is in its infancy" (Billingsley et al., 2019, p. 84). Part of this is due to the availability of such technologies and their development. For example, the first published use of 360 video (a form of VR) in teacher education was not until 2017 by authors Roche and Gal-

Petitfaux; moreover, the use of AR and MR in teacher education—as defined in this editorial—is rare. To better understand XR in teacher education, and particularly those manuscripts published in this special issue, we briefly discuss what forms of research have been conducted. We also address how these applications are situated in our proposed definition of XR representations of practice.

The earliest form of VR-based representations of practice included animations in a virtual environment. In many such cases, students are *avatars* which are controlled by humans acting out specific roles. Most common examples include *TeachLive* (Dieker et al., 2014) now *Mursion* (Dieker et al., 2019; Luke et al., 2021), *SimTeach* (Fischler, 2007), and applications of *Second Life* (Mahon et al., 2010; Wilks & Jacka, 2013). *SimTeach and Second Life* are virtual environments that are typically displayed on a flat screen (e.g., laptop); however, some variations include VR environments where headsets are worn (Lamb & Etopio, 2020). Students can also be *agents* in animated VR, whose actions are either dictated by artificial intelligence (AI) programming similar to chatbots (Ke et al., 2020) or are non-interactive (Huang et al., 2021). In each of these variations of animated representations of practice, there is an effort to approximate a sense of being there. Specifically, each conveys a degree of perceptual capacity to approximate specific embodied experiences of teaching actual students. Thus, each aligns with our definition of VR-based representations of practice. Important to note in this description of VR is that many scholars cited here have used Milgram and Kishino's (1994) conceptualization of MR, which includes VR. As previously noted, we have adopted a different definition while acknowledging that there is currently more than one accepted use of MR as a term[1].

Research on use of 360 video (sometimes referred to as 360° video or 360-degree video) in teacher education is recent, with Reyna (2018) noting that research in the field is not yet robust. Some scholars have studied PSTs' use of 360 video in the classroom for creating virtual field trips (Huh, 2020). They have also been used to create a sustainable system or model for career education content for primary school students (Assilmia et al., 2017). Most scholarship in this area, however, utilizes 360 video to facilitate PSTs' pedagogy or learning to teach (see Figure 4). The scholarship builds upon successes of 2D video and related simulations (e.g., Codreanu et al., 2021).

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1 Mahon et al. (2010), Luke et al. (2021), Wilks & Jacka (2013) and others use MR while also acknowledging their representations as a form of VR.

Note. In the image, only the field of view selected is viewable in the screenshot; however a PST could turn the camera perspective to the left or right (or up/down) as the video played.

Figure 4. Screenshot of a 360 Video with Textual Information Embedded.

Research has provided evidence of several ways in which 360 video can enhance teacher education. It can be used to build interpersonal skills (e.g., identifying and interpreting events in the classroom related to teacher/student relationships; Theelen et al., 2019), develop the ability to notice (Ferdig & Kosko, 2020), and support a more nuanced understanding of teaching practices while students re-live some classroom situation (Walshe & Driver, 2019). Evidence also suggests that 360 videos can be used to help students prepare for internship (Sato & Kageto, 2020), scaffold their internship experience (Roche & Roland, 2020), and even reduce anxiety (Theelen et al., 2020). Ibrahim-Didi (2015) suggested that such results happen because 360 video can lead pre-service teachers to feel physically present in the classroom situation being viewed.

Most current research on AR and MR in teacher education—though limited—focuses on teaching teachers how to use the technologies to convey content (e.g., Syawaludin et al., 2019; Williams, 2014). Others have addressed how to use AR and MR in education contexts with some implications for teacher education mentioned. For example, Strzsys et al. (2017) described the use of MR to facilitate undergraduate students' learning of a concept common in physics courses. Implicit in descriptions of what students might learn from using MR is a need for those teaching the courses to understand how to use the technology. Yet, beyond the technological implications for teacher education is a need for the field to better understand pedagogical aspects of using XR between teachers and students, as well as between teacher educators and current or future teachers.

JTATE's Special Issue on XR in Teacher Education

This editorial has—thus far—focused on conceptualizing XR, considered perceptual capacity as a means of defining and distinguishing between forms of XR (and non-XR) representations of practice, and explored how prior literature has studied aspects of XR in teacher education. Such a discussion has highlighted how most literature on XR in teacher education focuses on VR-based representations of practice. It has also proved the point that there is an overall dearth of literature on XR and teacher education. This, in short, was the impetus for the development of this special issue.

Two papers in this special issue reported on preservice teachers' 360 video recordings and subsequent reflection of their own teaching (Buchbinder et al., 2021, pp. 279-308; Weston & Amador, 2021, pp. 309-338). Buchbinder et al. (2021) used 360 video with small groups, while Weston & Amador (2021) used whole class teaching. In both studies, the authors noted how the technology allowed for PSTs to focus on student thinking in their reflective noticing. In one such case discussed by Weston & Amador, it seemed likely that the technology may have facilitated a shift from teacher-focused to student-focused noticing—something observed in prior research (Kosko et al., 2020). While this finding also contradicts some research that did not show a similar shift (e.g., Balzaretti et al., 2019), the authors address this by arguing for the importance of protocols in interacting with PSTs and 360 videos. As such, others seeking to use these technologies for recording PSTs' own teaching should consider how these scholars simultaneously supported their students by promoting meaningful student-centered noticing.

Two studies in this special issue also report on the use of 360 video vignettes for shared viewing amongst preservice teachers (Gandolfi et al., 2021, pp. 339-367; Roche et al., 2021, pp. 369-388). Gandolfi et al. (2021) found that what teachers notice interacts with their reported presence. This finding was similar to Prestridge et al. (2021) in this special issue, though different technologies were used. Roche et al. (2021) added that 360 video integration should be viewed along a continuum. This *easing in to XR* (also noted by Luke et al., 2021, in this special issue) might best occur by starting with standard video prior to becoming more immersed in 360 video.

The fifth article in this special issue focused on simulated teaching with virtual avatars. Luke et al. (2021) specifically examined roleplay and VR simulation of parent-teacher conferences (pp. 389-413). Their mixed method study showed no statistically significant differences in the order or continuum of XR introduction. However, their qualitative data provided evidence that role play (with peers) should precede VR simulation.

The final article examined preservice teachers' teaching of actual students within a virtual world. Prestridge et al. (2021) used a VR-based environment to have PSTs create their lessons (pp. 415-445). More specifically, the teachers used AR elements within their VR worlds to convey content and interact with students virtually. Students were visually present and interacted with AR embedded content as moving screens were fed by webcams. The authors suggest that interaction between students (i.e., copresence) and the interaction between the VR environment and AR elements are both important.

WHERE DO WE GO FROM HERE?

Some fields and professions are faster to accept and adapt to technological change, while others continue to lag behind. Unfortunately, education writ large—and teacher education more specifically—is not known for its rapid adaptions and evolution. The reason for this delay, particularly as it relates to XR, is not entirely clear. It is possible that many teacher educators simply believe that simulations (with digital or digitized students) are unnecessary because teacher education students have access to 'real' students.

The fallacy in this logic is mind-numbing, particularly given all the counter-evidence. For instance, pilots still use simulations even though they have access to real airplanes (Neal et al., 2020). Automotive designers still use simulations even though they have access to real cars (Fernandes et al., 2021). Doctors and nurses still train on simulations even though they have live patients (Beal et al., 2017). While we are not doubting the value of live engagement, simulations provide access to education strategies and outcomes that may not be accessible through only live performance. Moreover, what would happen if teacher educators ever lost access to live students for PST education? Those who thought this was a doomsday scenario were sadly awakened by the COVID-19 pandemic (Ferdig et al., 2020a). And, finally, those in teacher education who wait may be surprised to find others outside of teacher education (e.g., corporations) have stepped in to teach current and future teachers through innovative solutions (consider *Teach for*

America and the training of teachers for low-income placements when standard institutions could not meet the demand).

An obvious implication, therefore, is that we need more research and more practice exploring the use of XR in teacher education. However, a major caveat is that we need *specific kinds* of research on XR in teacher education. For instance, this special issue was well received in terms of the number of submissions that we reviewed. However, most of those submissions were rejected, as evidenced by having only 6 published in this special issue. To be fair, some were well-written and methodologically sound; they simply did not address teacher education. Many others, though, had significant problems. They included incorrect definitions of XR, AR, VR, or MR. Or, they were case studies that simply promoted specific commercial applications, somewhat proving the point that industry is ready to take over where teacher educators falter. Finally, some asked insignificant questions. For instance, we rejected several articles due to frustration from our reviewers on articles that simply asked if PSTs *liked* XR.

The truth is that XR is not a panacea for the problems or opportunities of teacher education. There are affordances and constraints of every educational technology (Ferdig, 2006). Said differently, XR is not always going to work in TE, particularly given the many definitions and variations of XR. We need, therefore, studies that critically and appropriately define and then examine the conditions in which XR can be used or should be avoided in teacher education. Definitions are important because there has been an ever-increasing amount of research in XR for teacher education that fails to adhere to any shared theoretical considerations of what makes these representations XR. This contrasts some of the consolidation of terms and concepts we have seen in other fields.

A more practical recommendation comes from work in this special issue. Both Roche et al. (2021) and Luke et al. (2021) pointed to a continuum of XR experiences. This continuum could refer to the introduction of XR content, moving from more standard technology (Roche et al., 2021) or experiences (Luke et al., 2021) to more immersive innovations and content. This continuum could also refer to the supplements (e.g., overlays or prompts) within varying technologies that attempt to make the tools more immersive (see Torres et al., 2020). The continuum—which deserves further exploration and study—potentially suggests that a gradual increase in perceptual capacity of representation may assist PSTs. It also suggests, as hinted at by Prestridge et al. (2021), that content in XR may serve as a form of interactivity. In other words, there must be something to attend to or interact with in the environment or the interactivity between digital and physical spaces breaks down.

Lastly, as noted by Weston and Amador (2021), XR can be used effectively to promote PSTs' professional education, but other more traditional technologies may work better in certain contexts. To reiterate an earlier point, XR is not a panacea. It is a tool that blends the physical and digital in particular ways. Some of these ways are useful for teacher educators in teaching future or practicing teachers, or to study the nature of teaching and teacher education. As more scholars recognize the benefits of XR in teacher education, we encourage them to consider recommendations and insights provided throughout this special issue, as well as the growing body of literature cited throughout.

Acknowledgments

The editors of this special issue (Kosko, Ferdig, & Roche) thank Dr. Richard Hartshorne (Editor of JTATE) and AACE for the opportunity to collect and publish research on XR in teacher education. The editors would also like to thank the JTATE Editorial Review Board and additional reviewers for their time and expertise in evaluating papers. This special issue would not have been possible without these contributions.

This editorial received support from the National Science Foundation through DRK-12 Grant #1908159 and the National Endowment for the Humanities Grant #MT-25880-18. Any opinions, findings, and conclusions or recommendations expressed in this paper are those of the authors and do not necessarily reflect the views of the National Science Foundation or the National Endowment for the Humanities.

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