Preservice Teacher Perceptions of Using 360° Cameras and Virtual Reality for Education Preparation

Stephanie Wendt, Tennessee Tech University, United States
Jason Beach, Tennessee Tech University, United States
Jeremy Wendt, Tennessee Tech University, United States
Kinsey Simone, Tennessee Tech University, United States
Delanie Elrod, Tennessee Tech University, United States

The Barcelona Conference on Education 2023
Official Conference Proceedings

Abstract
Using XR technological tools such as 360° cameras and virtual reality in education preparation has been found to be a beneficial way for preservice teachers (PSTs) to reflect on their teaching styles and experience the virtual classroom (Ardisara & Fung, 2018; Coffey, 2014; Ferdig & Kosko, 2020; Feurstein, 2019). Additionally, utilization of XR in PST training has been associated with increases in teacher-student engagement (Kosko et al., 2021), self-efficacy and confidence (Walshe & Driver, 2019), and interpersonal teaching behavior and style (Theelen et al., 2019). The purpose of this qualitative case study was to understand how preservice teachers perceived the use of 360° cameras and virtual reality to video record, review, and critique their own teaching and explore immersive learning experiences. Participants included preservice teachers enrolled in a course whose lessons were collected by 360° cameras, and data were their written self-reflections on their experiences. Data analysis included inductive analysis, sentiment analysis, and word clouds. Results indicated overall positive perceptions of teacher candidates towards using XR, including its use as a self-reflection tool which provided them with different perspectives and a better overall view of the classroom, their teaching, and student behavior. Results indicate that using XR as a self-reflection and learning tool in teacher preparation programs is beneficial to teacher candidates; further research could examine the pre- and post-benefits of using XR for reflection through assessments of teacher candidate performance.

Keywords: Preservice Teacher Perceptions, 360° Cameras and Virtual Reality, XR in Education Preparation, Qualitative Analysis

Introduction

Immersive, digital technologies such as augmented or virtual reality (AR/VR) allow for users to experience situations or contexts within engaging, virtual spaces, such as the virtual classroom (Dick, 2021). Furthermore, virtual experiences offered through AR or VR can allow educators and preservice teachers (PSTs) the opportunity to experience classroom settings without challenges such as travel or cost (Dick, 2021). Past research has indicated that using AR and VR technological tools such as 360° cameras and virtual reality in the education preparation of PSTs resulted in higher engagement with students (Kosko et al., 2021), increased self-efficacy and confidence (Walshe & Driver, 2019), increases in interpersonal teaching behavior and style (Theelen et al., 2019), and motivation for improvement (Coffey, 2014). Furthermore, PSTs have indicated that using these tools to observe their teaching was a beneficial way to reflect on their teaching style and view the entire classroom across different conditions (Ardisara & Fung, 2018; Coffey, 2014; Ferdig & Kosko, 2020; Feurstein, 2019; Kosko et al., 2021; Roche & Gal-Petitfaux, 2017; Seidel et al., 2011; Theelen et al., 2019; Walshe & Driver, 2019). The purpose of the current study was to understand how PSTs perceived the use of 360° cameras and virtual reality to (i) video record, review, and critique their own teaching; and (ii) explore immersive learning experiences in the classroom.We provide relevant background and our theoretical stance and perspective before presenting methods and results.

Digital, immersive technologies such as augmented reality (AR), virtual reality (VR), mixed reality (MR), and extended reality (XR) are being used across the United States for teacher training and within K-12 and higher education classrooms (Dick, 2021). For example, PSTs use 360° cameras and headsets to observe their own teaching or the teaching of others as a tool for learning, and classrooms may use other AR/VR platforms for students to virtually experience immersive simulations or field trips (Dick, 2021). Ultimately, immersive technologies provide a wide range of opportunities for users to interact with learning through realistic simulation in situations which may not be possible otherwise. The current study examined how PSTs perceived using 360° visual experiences, a component of VR, of themselves teaching as learning and reflection tools for their education preparation.

While the use of immersive technologies in the classroom is still relatively new, it is rapidly growing and globally expanding within the field of education (Dick, 2021). For the context of the current study, it is important to understand the differences in immersive technologies used, all of which exist across the virtuality continuum, or the spectrum of experiences between our physical world and the fully virtualized world (Tremosa, 2022). AR provides a view of the physical, real world through a digital lens, such as an image we see on a computer screen (ARM Blueprint Staff, 2022; Tremosa, 2022). VR replaces this view, in which the users are immersed within a pre-created virtual world. MR merges the real AR world with the virtual world of VR, such as through inserting virtual objects within real-world environments through the lens of a VR headset. VR, AR, and MR are all XR technologies, or any technology which adds digital elements to some reality to alter the user's experience. In the current study, PSTs used 360° cameras (AR technology) to record themselves teaching before using virtual reality headsets (VR) to watch their recording, resulting in an immersive MR experience for learning and reflection.

Augmented, Virtual, and Mixed Reality in Teacher Education

One primary factor of education preparation for PSTs is experience gained from observing and reflecting on their own teaching styles, as well as observations and lessons gained from others' teaching. PSTs can observe their own teaching through watching recorded videos of themselves in action within the classroom, such as through basic video recordings or watching 360° videos on platforms like virtual reality headsets. Research indicates that there are positive outcomes associated with watching oneself teaching compared to watching others teaching, including the ability to notice to a greater extent the different components of instruction and student learning (Coffey, 2014; Seidel et al., 2011). In the current study, 360° videos and virtual reality were used to allow PSTs to reflect on their own teaching and the use of XR in their education preparation. In addition to providing an opportunity for PSTs to be immersed in the observation of their own pre-recorded instruction for learning, XR technologies provide opportunities to PSTs to visualize content and remotely learn and collaborate with others; furthermore, they are accessible, in which their use eliminates travel or distance to observe a classroom setting (Golubenko, 2019). The use of immersive XR tools has become a beneficial and cost-effective way to enhance PST student development and learning (Lee & Hwang, 2022).

While the use of XR for self-observation in teacher education is used in various PST programs and has been examined in past research, (Ardisara & Fung, 2018; Coffey, 2014; Ferdig & Kosko, 2020; Feurstein, 2019; Kosko et al., 2021; Roche & Gal-Petitfaux, 2017; Seidel et al., 2011; Theelen et al., 2019; Walshe & Driver, 2019), XR has other beneficial roles in teacher education. For example, PSTs developed course lesson plans and coursework using virtual reality in one past study (Chen & Tsai, 2022). Virtual reality simulations can help PSTs to discover appropriate solutions for challenges or situations which they may encounter within the field. For example, VR simulations were created in one PST program for students to experience different types of encounters they may have with students' parents and to try different approaches in engaging (Faldet et al., 2021). Videos of students within the classroom can be recorded with 360° videos and then watched by PSTs using VR headsets, which allows them to be immersed into the virtual classroom (Loewus, 2017). Through observing the virtual classroom recorded with actual students, PSTs can practice being confronted with student behaviors and other situations, such as students' engagement with the teacher or the classroom setting in general. However, using real VR video can be very expensive and may not represent the general classroom if only featuring a select group of students.

While past research has indicated that PSTs perceived positive benefits in their education training through using XR technologies (Coffey, 2014; Kosko et al., 2021; Theelen et al., 2019; Walshe & Driver, 2019), it should be noted that integrating XR within PST programs requires finances and time, including the training and motivating of PSTs to use VR within their future classrooms (Casano-Calle et al., 2022). Furthermore, although the virtual reality generated through XR technology is realistic and immersive, it does not provide the same consequences or experiences that would occur in the field, nor does it provide room for live feedback from observers (Golubenko, 2019). Despite its disadvantages, XR technologies are becoming more popular in education training and provide various benefits for teacher training and reflections as an immersive tool.

Current Research Using XR in Virtual Reality

Past research has indicated that using XR technological tools such as 360° cameras and virtual reality in the education preparation of PSTs resulted in higher engagement with students (Kosko et al., 2021), increased self-efficacy and confidence (Walshe & Driver, 2019), increases in interpersonal teaching behavior and style (Theelen et al., 2019), and motivation for improvement (Coffey, 2014). Furthermore, PSTs have indicated that using these tools is a beneficial way to reflect on their teaching style and view the entire classroom across different conditions (Ardisara & Fung, 2018; Coffey, 2014; Ferdig & Kosko, 2020; Feurstein, 2019; Kosko et al., 2021; Roche & Gal-Petitfaux, 2017; Seidel et al., 2011; Theelen et al., 2019; Walshe & Driver, 2019). One primary focus of current research on using XR in virtual reality regards its use on PSTs' reflections of their teaching after watching themselves teach using a 360° camera, including their increased ability to observe the classroom in entirety during their teaching experience. For example, in one qualitative study, PSTs were asked to reflect on their teaching before and after watching a video of themselves teaching using a 3D headset (Walshe & Driver, 2019). The researchers found that participants benefited from observing the entire class, such as noticing the actions and engagements of individual students. While two participants believed that using a 360° headset complicated their teaching reflection process in one study (Feurstein, 2019), most found it to be an unobtrusive and helpful way to engage in video reflection.

Compared to watching oneself teach via a basic video camera with one angle, watching one's teaching using a 360° video has been found to benefit PSTs through allowing them to better explore and observe their teaching contextually and practically, increasing their field of view of the classroom without moving the video camera, and immersing them within the classroom experience (Ardisara & Fung, 2018; Coffey, 2014; Feuerstein, 2019; Roche & Gal-Petitfaux, 2017). For example, Theelen et al. (2019) found that their participants noticed interactions more clearly between teachers and students when they watched a teaching video that was taken with a 360° camera using a 360° headset, as compared to using a 2-D video recording. Similarly, Coffey (2014) found that PST participants were able to pick up on non-verbal cues in the classroom which they otherwise would not have picked up on from watching themselves on a VR headset. Participants who reflected on watching themselves through a 360° lens felt motivated to improve their teaching and found it to be helpful for further improvement in their teaching.

The specific platforms in which virtual reality was used for education preparation has also been examined and compared in research (Ferdig & Kosko, 2020; Kosko et al., 2021). For example, Kosko et al. (2021) examined how PSTs' reflections on what they noticed within a classroom of 3rd grade students using Cuisenaire rods differed based on whether the PSTs used 360° laptops or headsets, versus a standard laptop. PSTs who were most encouraged to attend to the assigned teacher and students were those who used the 360° headsets, which the researchers noted might have been due to the higher perceptual capacity of the headset, as compared to the laptop. In a similar study (Ferdig & Kosko, 2020), although nonsignificant, researchers found that PSTs' power to notice changing conditions in a 3rd grade classroom during a math lesson was greater for those who used a 360° headset compared to a 360° laptop.

The use of VR and AR within the classroom and PST training has also been researched for its benefits outside of teacher readiness or reflection. For example, one study used reflections of PSTs on using 360° cameras to watch classroom practice as indicators of their presence

within the classroom and to validate an existing presence scale (Gandolfi et al., 2020). Another study compared pre- and post-tests of the technological readiness of PSTs before and after using VR as a training tool and found that it was linked with an increase in their technological capabilities (Lee & Hwang, 2022). Using VR simulations for PSTs was found to encourage collaboration and increased interaction in one qualitative study (Faldet et al., 2021).

XR technology, such as the use of 360° cameras and virtual reality, for reflection or simulation in PST training is becoming more common in higher education. As it is still relatively a new platform for learning in teacher education, it is important for current research to continue to examine its influence and the role it plays in teacher preparation. Accordingly, we examined how PSTs perceived the use of XR technologies in their teacher preparation, as shown through their written self-reflections.

Theoretical Stance and Perspective

Crotty (1998) stated that an epistemology "is a way of understanding and explaining how we know what we know" (p. 3). We framed our study through the epistemological realm of constructivism, which suggests that all people's way to understand the world or phenomena is valid and deserves to be respected.We used constructivism to understand how our participants made meaning of the role that using 360° cameras and virtual reality played in their reflections on their education preparation. Through the epistemological lens of constructivism, we also incorporated the theory of Bourdieu's habitus to assist in understanding our topic. Bourdieu (1977) defined habitus as "systems of durable, transposable, *dispositions*" (p. 176) in which one's habitus "produces individual and collective practices, and hence history, in accordance with the schemes engendered by history" (p. 181). It acts as an internal law that places an individual in a certain social position that they are socially qualified for and engenders one's thoughts and actions to be situated within the context of their social habitus or position. In other words, individuals are ultimately governed by their inhabited cultures and therefore behave and think within their culture's expectations, norms, and institutions. One's personal identity—one's habitus—must be compliant with one's culture. We used Bourdieu's habitus to inform our research because we believed that it would help us to understand how participants' cultures and positions within our teacher education program impacted their identities and how certain tools, or virtual reality used in reflection, could affect their habitus and perception of self as teachers.

A researcher's theoretical perspective not only guides their research, but it also allows them to claim their own stance in approaching a topic. Our theoretical perspectives ultimately represent our view of the world, the social life within it, and the assumptions in which it is grounded (Crotty, 1998). We used the theoretical perspective of interpretivism in the current study, which is based on a culture, context, and reality that are socially constructed. Specifically, interpretivism acknowledges that there are multiple truths, and the interpretivist attempts to understand the world through the eyes of the participant (Sipe & Constable, 1996). We used interpretivism to guide our study because we personally believe that reality is socially constructed. Furthermore, interpretivism guided our understanding of how our participants constructed their perceptions of the role that using 360° cameras and virtual reality played in their education preparation and reflections.

Research Questions

The following research questions guided our study:

1. How do preservice teachers perceive the use of 360° cameras and virtual reality to video record, review, and critique their own teaching?
2. How do preservice teachers use 360° cameras and virtual reality to explore immersive learning experiences?

Methods

Study Design and Data Collection

This qualitative case study examined the perceptions of PSTs on using 360° cameras and virtual reality to video record, review, and critique their own teaching; explore immersive learning experiences; and the benefits of using the technology as potential learning tools with K-6 students. Data included the written self-reflections collected from PSTs within their FOED 3800 course, in which they spent 60 contact hours in the public school setting working with mentor teachers to learn best practices for teaching. PSTs were recorded giving a 30-45 minute lesson using 360° video cameras, and the videos were then uploaded for viewing using a virtual reality headset. After viewing themselves teaching using the virtual reality headset, PSTs submitted a written self-reflection on their experiences using the XR tools as a method for education preparation, as well as their own observations of their teaching.

Sample

The sample included 35 PSTs enrolled in one teacher education course at a public 4-year university in Tennessee in Fall 2019, Fall 2020, and Spring 2021. Data were not collected in Spring 2020 due to the COVID-19 pandemic, in which all public schools turned to online instruction and PSTs completed their practicum hours virtually, therefore being unable to implement the 360° video instruction for reflection using virtual reality headsets. The course in which participants were enrolled is a field experience/practicum course that all elementary education preservice teachers are required to take as part of their program of study. PSTs take this course during their junior year in either the fall or spring semester prior to their residency. The course requires them to complete 60 contact hours in a public school K-6 classroom, in which they learn from mentor teachers, learn about behavior management, and practice teaching during their practicum experience. All participants in the current study gave consent for their data to be used.

Data Analysis

Data were analyzed using triangulation of inductive analysis, sentiment analysis, and the generation of word clouds. We first individually used inductive analysis to open code all reflections, which allowed us to further understand the meaning of using XR in teacher education, as perceived by our participants, through generating themes and categories (Thomas, 2003). We then discussed our generated categories and codes to reach conclusions, which further strengthened the trustworthiness of our results.

In addition to inductive analysis, we used sentiment analysis, which allows researchers to pinpoint and describe participants' sentiments, or emotional responses, towards some phenomenon (Becker et al., 2016). For the current study, sentiments were developed through

inputting each reflection into R Software and using syntax coding (Showrav, 2022) to algorithmically determine the sentiments of participants towards using XR technologies in teacher preparation. Lastly, we generated word clouds to further triangulate our results. Word clouds are technologically computed to represent data as images, in which the size of a certain word or phrase is representative of its frequency within the data (Mathews et al., 2015). Using all three forms of analysis increased the trustworthiness of our results and findings.

Conclusion

Thematic Analysis

Through inductive thematic analysis, 5 categories and 28 codes emerged (see Table 1). One category which emerged was *self-reflection,* which resulted in a wealth of information and numerous codes including *instructional changes, successful implementation, review classroom management, self-evaluation/critique, eye-opening, real-time feedback, nervousness,* and *review classroom presence*. The majority of students found the reflective nature of the tool to be very useful. Students shared that "Overall, I think that this experience with the 360 degree camera and the virtual reality really helped me see what I need to improve on," and "After viewing the 360 video I realized how naïve I was about all the students paying attention."

The category that highlights *The Future of Teaching* demonstrated the candidates' views on XR use in teacher training and in-service teacher classrooms moving forward. The codes that emerged were *pedagogical tool, compare/contrast,* and *Preservice Teacher (PST) programmatic improvements.* As with other categories, participants identified many positive future uses for XR. Students shared that "The Oculus 360 is a great tool in my opinion for new teachers to use to help them see where to improve or increase confidence," and "I think that this is the future of teaching and should be seriously considered as a tool for new and upcoming teachers."

The category *XR features* yielded a variety of detailed information that had a primary focus on the positive and negative attributes of the technology being used. Codes that were identified from the reflections included *easy technology, 360 view, dizziness, immersive, innovative, hearing/audio, expensive, classroom distraction,* and *comparison to standard video*. Respondents overwhelmingly identified the technology and the relevance of the 360° view when compared to standard video. An excellent summary statement that one participant pointed out was "I think that this is beneficial because it allows the lesson to be much more authentic for those that are viewing it using a VR headset."

The category *Sentiments toward XR* emerged from six codes and represented the sentiments or attitudes which participants reported regarding their experiences with using the 360° videos for reflection. Sentiment codes included *increased confidence, helpful, positive experience, difficult to watch, and surprise.* Many participants believed that watching their video increased their confidence; for example, one participant stated, "I think that seeing myself teach really gave me a boost of confidence as a future educator. This showed me that I am a strong, willing, prepared, and capable teacher that can provide students with the content they need to succeed." Participants indicated that this tool was helpful, or "beneficial for a future teacher," and an overall positive experience. Some candidates found watching

themselves teach "extremely hard to watch," and many were surprised by the things they noticed within the video. One candidate noted, "I definitely found some surprises."

Perspectives emerged as a prominent category and included the *in vivo* code *into the students' shoes, candidate awareness of student behavior,* and *candidate-student interaction/awareness.* This category represented the overall perspectives, or point of view, which participants noted they were able to experience through using XR. The *in vivo* code *into the students' shoes* represented 21 occurrences in the data in which participants noted the video allowed them to "watch themselves from a students' point of view." Participants also noted that they became more aware of student behavior, as one reflected, "I was able to go back and watch the students, see what made them engaged or even maybe when I lost them in the lesson." Candidates also noted their increased awareness of their own interactions with students, as one candidate simply stated, "By using the 360 video, I could also engage in student activity."

Category	Codes	Dimensions	Frequency
Self-Reflection tool		Positive/negative	
	Instructional changes		52
	Successful implementation		27
	Review classroom management		15
	Self-evaluation/critique		23
	Eye-opening		7
	Real-time feedback		4
	Nervousness		12
	Review classroom presence		3
The future of teaching	Pedagogical tool		18
	Compare/contrast		5
	Preservice Teacher (PST) programmatic improvements		14
XR features		Positive/negative	
	Easy technology		2
	360 view of classroom		12
	Dizziness		6
	Immersive		5
	Innovative		2
	Hearing/audio		4
	Expensive		3
	Classroom distraction		7
	Comparison to standard video		13
Sentiments toward XR		Positive/negative	
	Increased confidence		15
	Helpful		13
	Positive experience		26
	Difficult to watch		3
	Surprise		6
Perspectives	*Into the students' shoes*		21
	Candidate awareness of student behavior		15
	Candidate-student interaction/awareness		17

Table 1: Generated Categories, Codes, Dimensions, and Frequencies

Sentiment Analysis

Sentiment analysis was conducted using R Software, in which participants' reflections were manually inputted and then statistically analyzed for word frequencies in relation to various sentiments. The most prominent sentiments found included anger, trust, anticipation, and surprise, within the context of XR. The most frequently used words in reflections included those regarding students, the lesson itself, the video, and 360° video (see Figure 1).

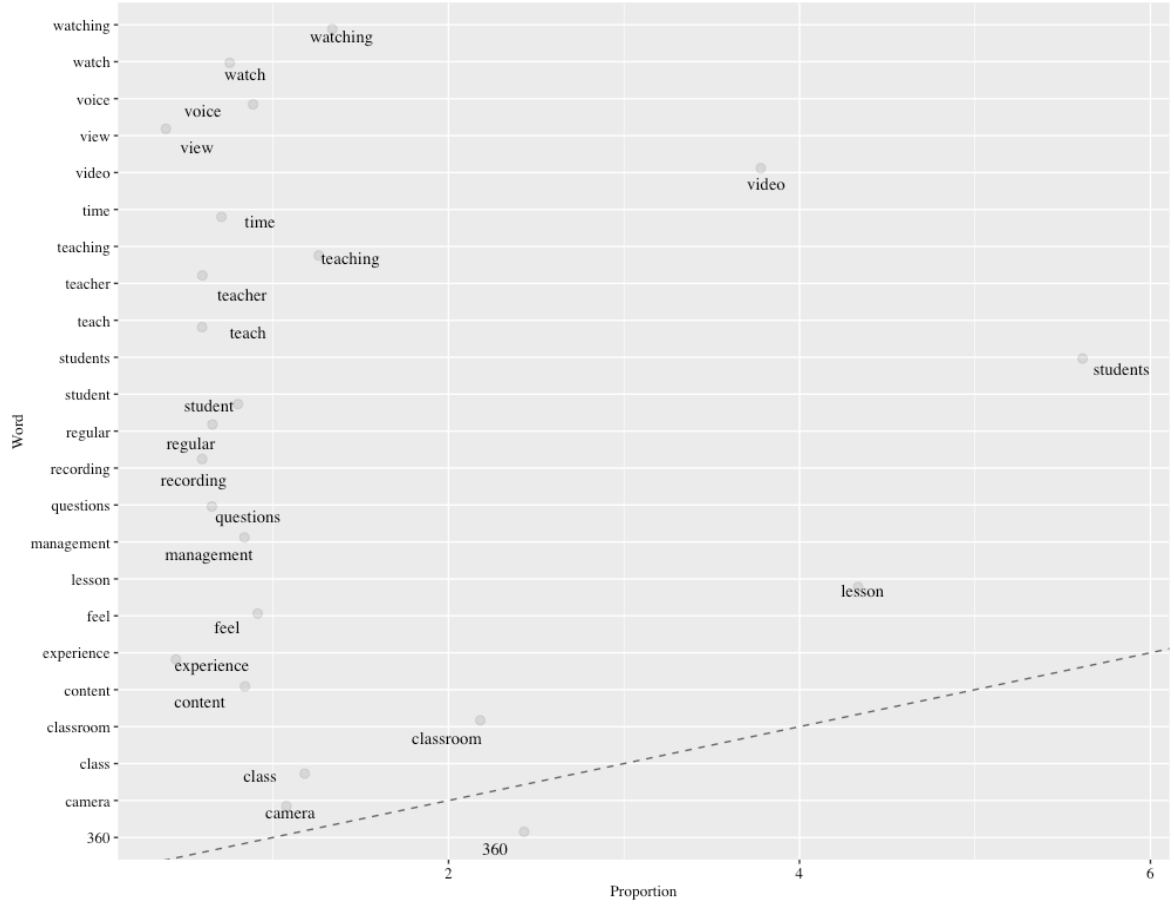

Figure 1: Frequencies of Words in Student Reflections

Two frequent sentiments which emerged were those regarding anger and trust (see Figure 2). The most frequently stated reflections which encompassed anger in participants' reflections included those surrounding features of XR, such as it being "distracting" to the classroom or difficult to use/watch. Trust was another sentiment found in reflections, in which many participants associated trust with their lesson, classroom management, confidence, and overall excitement of using XR.

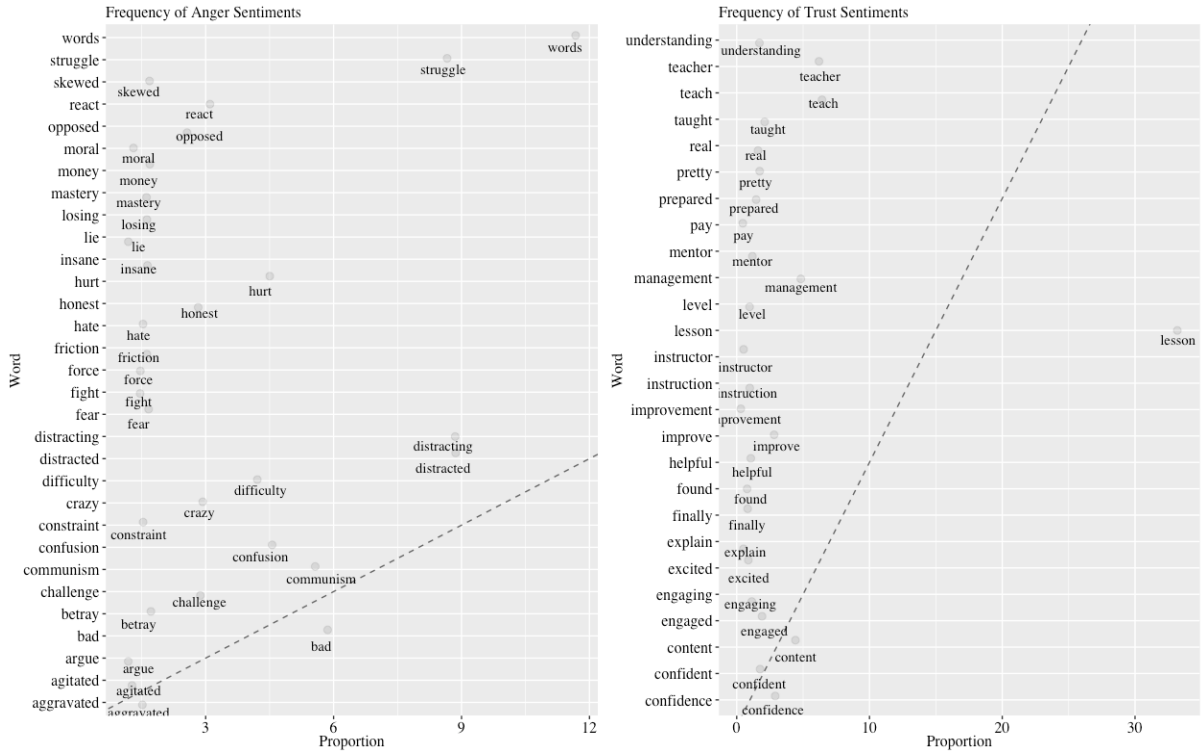

Figure 2: Proportion of Anger and Trust Sentiments Within Candidates' Reflections

Anticipation and surprise were two additional sentiments coded. While anticipation paralleled with the code *difficult to watch* from inductive analysis, surprise was a repetition of a code within the category *Sentiments towards XR*. Many participants used words such as their lesson or preparation, as well as the overall experience, in association with anticipation. Words associated with surprise in reflections included their instruction ("teach"), their success in teaching, their ability to "catch" more through the 360° video, and their overall enjoyment with the experience.

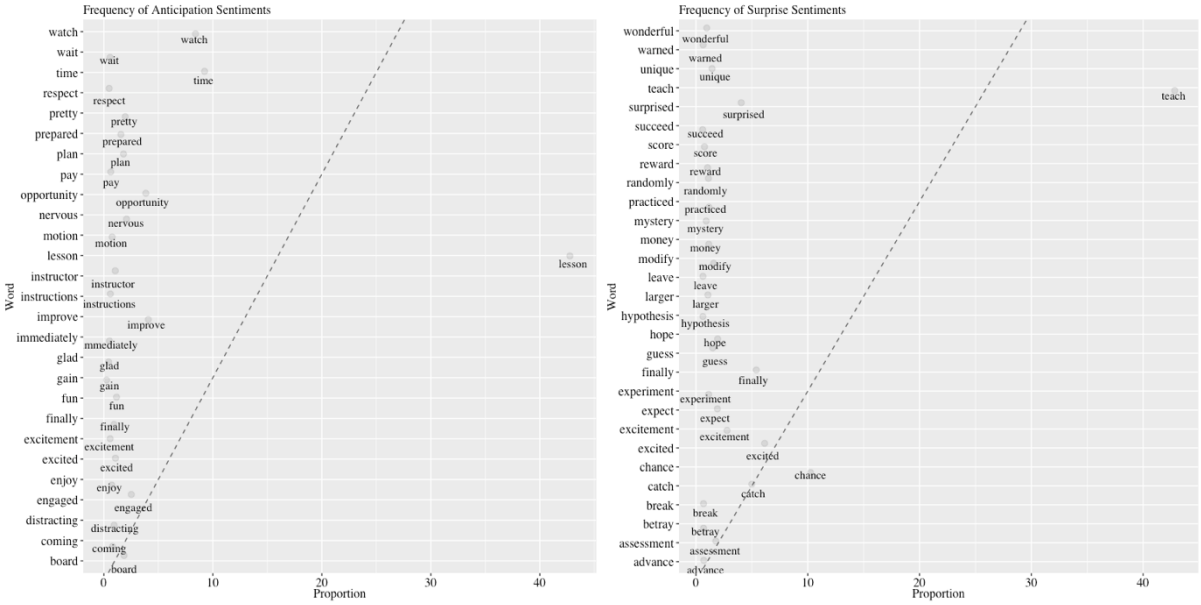

Figure 3: Proportion of Anticipation and Surprise Sentiments Within Candidates' Reflections

Word Clouds

Word clouds were generated by the researchers using EdWordle.net and reflected preservice teacher reflections through visual representations of the highest frequencies of words within each analyzed document. Across word clouds, many commonalities emerged in the visual summaries. Keywords and terms that parallel codes and categories from both inductive analysis and sentiment analysis were observed throughout the results of the visual tool and gave insight into the thoughts and reflections of the preservice teachers. Prominent themes which emerged in the word clouds included reflections on the classroom, video, students, and behavior (see Figures 4 and 5).

Figure 4: Generated Word Cloud of Teacher Candidates' Reflections

Figure 5: Generated Word Cloud of Teacher Candidates' Reflections

Discussion

The first research question aimed to understand how preservice teachers perceived the use of 360° cameras and virtual reality to video record, review, and critique their own teaching. The themes which emerged from inductive analysis indicated that most teacher candidates viewed their experience with watching their teaching through a 360° lens as a helpful self-reflection tool, which allowed them to review their classroom management, their presence, and their teaching style. While participants were anticipatory of rewatching their lesson and many felt nervous, the overall perception of the candidates towards the experience was positive and supports past findings of studies which examined candidates' perceptions of using XR (Ardisara & Fung, 2018; Coffey, 2014; Ferdig & Kosko, 2020; Feurstein, 2019; Kosko et al., 2021; Roche & Gal-Petitfaux, 2017; Seidel et al., 2011; Theelen et al., 2019; Walshe & Driver, 2019).

Many participants mentioned that the 360° video provided them with real-time feedback, which led them to brainstorm which instructional changes they could make in the future to better their teaching. The motivation to make instructional changes was also found in participants from Coffey's (2014) study, in which teacher candidates felt motivated to improve after watching themselves using a 360° video. Many participants also felt more confident after watching their video, which supports findings from Walshe and Driver (2019). The feeling of confidence as found in inductive analysis paralleled the sentiments of surprise within sentiment analysis, in which participants felt surprised by their success in teaching the lesson. Confidence gained from watching the video could also be attributed to a change in habitus, in which participants felt like their social habitus as teacher candidates increased as a result of watching their teaching abilities in action.

The second research question sought to explore how preservice teachers used 360° cameras and virtual reality to explore immersive learning experiences. Inductive analysis findings showed that teacher candidates found the experience to be immersive and innovative, making it more beneficial for their learning than a regular video would be. The comparison to regular video or other technological reflection tools, in favor of the 360° video, supports findings from other studies on the unique benefits of XR headsets for reflection (Ferdig & Kosko, 2020; Kosko et al., 2021). Additionally, teacher candidates reflected on how the video allowed them to change their perspectives, reflect from the students' shoes, and become more aware of their interactions with students in addition to students' behaviors. The immersive experience reflected by the current study's participants echoes findings of past research (Ardisara & Fung, 2018; Coffey, 2014; Feuerstein, 2019; Roche & Gal-Petitfaux, 2017; Seidel et al., 2011).

Teacher candidates did reflect on the potential disadvantages of the 360° experience, including how it could be distracting to students, expensive, and result in headaches or dizziness. These reflections were further supported within the frequencies of terms found in sentiment analysis with the sentiment *anger*. These disadvantages are supported by researchers Casono-Calle et al. (2022); however, the frequencies of positive sentiments towards XR were larger than those of a negative nature.

Limitations & Future Research

Limitations of the current study included the qualitative nature of the design, in which our main source of data were from self-written teacher candidate reflections. In other words, our findings represent the perceptions of participants, rather than any proven performance or improvement in teaching as a result of using the 360° video. Additionally, and through the lens of constructivism, we only present our interpretations of participants' reflections, rather than objective reality. While we triangulated our data analysis methods using inductive analysis, sentiment analysis, and word clouds, our main source of data were the reflections themselves, with no other data collected. Future research should additionally triangulate data sources, such as interviews, focus groups, or quantitative data like assessments. We also recommend that future research take into account improvements in teaching before and after using the 360° video for reflection, such as through pre- and post- assessments or evaluations.

References

Ardisara, A., & Fung, F. M. (2018). Integrating 360° videos in an undergraduate chemistry laboratory course. *Journal of Chemical Education*, *95*(10), 1881–1884. https://doi.org/10.1021/acs.jchemed.8b00143

Arm Blueprint Staff. (2022). *xR, AR, VR, MR: What's the difference in reality?* Arm Blueprint. https://www.arm.com/blogs/blueprint/xr-ar-vr-mr-difference

Becker, I., Parkin, S., & Sasse, M. A. (2016). Combining qualitative coding and sentiment analysis: Deconstructing perceptions of usable security in organisations. *Learning from Authoritative Security Experiment Results.* https://www.usenix.org/system/files/conference/laser2016/laser2016-paper-becker.pdf

Bourdieu, P. (1977). *Outline of a theory of practice.* Cambridge University Press.

Casano-Calle, R., Jimenez-Vivas, A., Castro, R. P., Alvarez, M. I. C., & Jenaro, C. (2022). Perceived benefits of future teachers on the usefulness of virtual and augmented reality in the teaching-learning process. *Education Sciences, 12*(855), 1-11. https://doi.org/10.3390/educsci1210855

Chen, Y., & Tsai, M. (2022). Promoting pre-service teachers' technological, pedagogical and content knowledge (TPACK) through developing virtual reality applications with the Assure Instructional Design Model. *The International Academic Forum (IAFOR).* https://papers.iafor.org/submission61803/

Coffey, A. M. (2014). Using video to develop skills in reflection in teacher education students. *Australian Journal of Teacher Education*, *39*(9). https://doi.org/10.14221/ajte.2014v39n9.7

Crotty, M. (1998). *The foundations of social research: Meaning and perspective in the research process.* SAGE.

Dick, E. (2021). *The promise of immersive learning: Augmented and virtual reality's potential in education.* Information Technology & Innovation Foundation. https://itif.org/publications/2021/08/30/promise-immersive-learning-augmented-and-virtual-reality-potential/

Faldet, A., Skrefsrud, T., & Somby, H. M. (2021). Exploring the pedagogical potential of virtual reality simulations for pre-service teachers from a Vygotskyan perspective. *Digital Culture & Education, 13*(1), 66-81. ISSN: 1836-8301.

Ferdig, R. E., & Kosko, K. W. (2020). Implementing 360 video to increase immersion, perceptual capacity, and teacher noticing. *TechTrends*, *64*(6), 849–859. https://doi.org/10.1007/s11528-020-00522-3

Feurstein, M. S., (2019). Exploring the Use of 360-degree Video for Teacher- Training Reflection in Higher Education. In: Schulz, S. (Hrsg.), Proceedings of DELFI Workshops 2019. Bonn: Gesellschaft für Informatik e.V.z. (S. 153). DOI: 10.18420/delfi2019-ws-117

Golubenko, S. (2019). *Pros and cons of using extended reality in employee training.* Training Industry. https://trainingindustry.com/articles/learning-technologies/pros-and-cons-of-using-extended-reality-in-employee-training/

Gandolfi, E., Kosko, K. W., & Ferdig, R. E. (2020). Situating presence within extended reality for teacher training: Validation of the extended Reality Presence Scale (XRPS) in preservice teacher use of immersive 360 video. *British Journal of Educational Technology*, *52*(2), 824–841. https://doi.org/10.1111/bjet.13058

Kosko, K. W, Ferdig, R. E., & Zolfaghari, M. (2021). Preservice teachers' professional noticing when viewing standard and 360 video. *Journal of Teacher Education*, 72(3), 284-297.

Lee, H., & Hwang, Y. (2022). Technology-Enhanced education through VR-making and metaverse-linking to foster teacher readiness and sustainable learning. *Sustainability, 14*(4786), 1-21. https://doi.org/10.3390/sul14084786

Loewus, L. (2017). *How virtual reality is helping train new teachers.* EducationWeek. https://www.edweek.org/education-industry/how-virtual-reality-is-helping-train-new-teachers/2017/09

Mathews, D., Franzen-Castle, L. Colby, S., Kattelmann, K., Olfert, M., & White, A. (2015). *Use of word clouds as a novel approach for analysis and presentation of qualitative data for program evaluation* [Poster Abstract]. *Journal of Nutrition Education and Behavior, 47*(4). https://doi.org/10.1016.j.jneb.2015.04.071

Roche, L., & Gal-Petitfaux, N. (2017, March 5). *Using 360° video in Physical Education Teacher Education*. Using 360° video in Physical Education Teacher Education - Learning & Technology Library (LearnTechLib). https://www.learntechlib.org/primary/p/178219/

Seidel, T., Stürmer, K., Blomberg, G., Kobarg, M., & Schwindt, K. (2011). Teacher learning from analysis of videotaped classroom situations: Does it make a difference whether teachers observe their own teaching or that of others? *Teaching and Teacher Education*, *27*(2), 259–267. https://doi.org/10.1016/j.tate.2010.08.009

Showrav, R. (2016). *Text mining and sentiment analysis in R.* MLearning.ai. https://medium.com/mlearning-ai/text-mining-and-sentiment-analysis-in-rf6cc7944d540

Sipe, L., & Constable, S. (1996). A chart of four contemporary research paradigms: Metaphors for the modes of inquiry. *Taboo: The Journal of Culture and Education, 1*(1)*,* 153–163. http://www.freireproject.org/taboo-journal-culture-and-education

Theelen, H., Beemt, A., & Brok, P. (2019). Using 360-degree videos in teacher education to improve preservice teachers' professional interpersonal vision. *Journal of Computer Assisted Learning*, *35*(5), 582–594. https://doi.org/10.1111/jcal.12361

Thomas, D. R. (2003). A general inductive approach for qualitative data analysis. *University of Auckland, New Zealand.* https://www.researchgate.net/profile/David-Thomas-57/publication/263769109_Thomas_2003_General_Inductive_Analysis_-_Original_web_version/links/0a85e53bdc04f64786000000/Thomas-2003-General-Inductive-Analysis-Original-web-version.pdf

Walshe, N., & Driver, P. (2019). Developing reflective trainee teacher practice with 360 degree video. *Teaching and Teacher Education*, *78*, 97–105. https://doi.org/10.1016/j.tate.2018.11.009

Contact email: swendt@tntech.edu