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Immersive Presence for Future Educators: Deconstructing the Concept of Presence in Extended Reality Environments for Preservice Teachers

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Immersive videos for training pre-service teachers (PST) are becoming increasingly important and, yet, inadequately investigated. This article focuses on the role of *presence* as a possible aid in 360 videos for future educators, presenting the results of a study involving 118 PSTs. A multiple factor analysis of the *eXtended Reality Presence Scale* was used to understand possible subfactors covering this construct and the potential role of one's content area and major in influencing PSTs' viewing experiences. Additionally, written noticings from 360 videos were collected for exploring correlations between themes noticed and degrees of presence. There were three main results: 1) three subfactors – i.e., Emotional Connectivity, Co-Presence, and Awareness of Self – composed

the feeling of presence, 2) the PSTs' major had an observable relationship with experiencing co-presence, and 3) presence was positively correlated to a better focus on students and negatively correlated to content knowledge in participants' noticing.

Extended reality (XR) is becoming increasingly important in preservice teacher (PST) training. XR refers to an array of technologies whose scope is to expand the sensorial involvement of their users. A popular example is virtual reality (VR), which relies on providing a digital setting that is different from reality and, as such, offers novel possibilities. A second example is augmented reality (AR), which depends on enriching our environment with digital layers and content. Finally, 360 videos can be a further, and perhaps more diffused instance, of XR, allowing viewers to look around and gather more information and insights about what they are seeing. The adoption of 360 videos may enrich the already established use of standard videos in teacher education, supporting a novel way to provide representations of practice due to the broader field of view offered. This opportunity to cover more events in an observed environment (compared to a static camera) shows promise in enriching reflection and noticing among future educators. Nevertheless, the impact of 360 videos on preservice teacher training still presents several challenges.

One of the leading gaps in the literature is the role of presence – or the feeling of being there, which is a well-established parameter of XR environments – in informing and guiding PST observation and noticing. This article aims to shed light on this construct by discussing the results of a study involving 118 future teachers watching 360 videos of elementary instruction focused on math. The key concepts driving this analysis were: a) presence in terms of the *eXtended Reality Presence Scale* (XRPS) developed by Gandolfi et al. (2021); and b) preservice teacher noticing (van Es & Sherin, 2002). For presence in the extended reality environment, a multiple factor analysis of the XRPS was directed for better understanding leading components of the construct of presence. Independent t-tests were deployed for understanding if the resulting presence factors were different across K-12 mathematics PSTs and non-K-12 mathematics PSTs and between early childhood education majors PSTs and non-early childhood education majors. Finally, correlations between themes noticed and presence were analyzed to understand if this construct was related to specific topics observed during the videos. To summarize, three research questions guided this study:

RQ1: What are the possible sub-factors composing the concept of presence in extended reality environments for preservice teachers?

RQ2: Are there any differences between PSTs from different majors in terms of presence felt during extended reality videos?

RQ3: What are the main themes noticed by PSTs while viewing 360 videos, and how do they relate to their presence scores?

EXTENDED REALITY FOR TEACHER TRAINING

Pre-service Teachers and Videos

Videos have been widely adopted for improving prospective educators' training and enriching their reflection and noticing skills in a variety of different grade levels and content areas (Blomberg et al., 2011; Ottenbreit Leftwich et al., 2018; Weber et al., 2018). For instance, video clips have proven to be productive tools for training novice and expert teachers in terms of self-reflection and event recognition in math and language (ErözTuğa, 2013; Fadde & Sullivan, 2013). Han et al. (2013) also demonstrated that using videos with PSTs can improve their perception and familiarity with educational technologies in general. Videos have also been used as assessment tools. For instance, Wiens et al. (2013) deployed videos for assessing PSTs' understanding of classroom environments and detecting malleable factors spanning academic attendance and students' major. This evaluative potential has been used to compare novice and expert teachers in recognizing meaningful events in recorded learning environments (Dessus et al., 2016; van den Bogert et al., 2014). Gaudin and Chaliès (2015) directed a meta-review of studies related to PST training and video use, highlighting the importance of this practice for strengthening self-efficacy and reflection. Moreover, these authors pointed at three areas for future development: understanding how skills and competence are transferred from viewing a video to teaching awareness practice; developing strategies for personalizing training videos according to viewers' content area and grade level; and expanding the use of videos for PST education considering related benefits and constraints.

Pre-service Teachers and XR Videos

A rising trend regarding videos for teacher training is XR. This umbrella term refers to a technology-mediated innovation that aims to expand and enrich the user's sensorial environment. VR and AR are examples of this phenomenon, developing alternative digital settings and enriching reality with digital content, respectively. The use of 360 videos is also becoming popular due to its compatibility with different hosting platforms, from desktop computers to head-mounted displays. The 360 video medium differs from standard video because it relies on a spherical recording and, therefore, the availability of what lies in the field of view is omnidirectional (Kosko et al., 2021). As such, 360 videos are promising in user involvement and understanding of what is recorded due to the broader scope covered (e.g., Ferdig et al., 2020; Joglar & Rojas-Rojas, 2019).

In the context of student teachers, there are important opportunities related to this type of XR. By using 360 videos, teachers in training have shown to be more immersed (Ferdig & Kosko, 2020; Roche & Gal-Petitfaux, 2017) and receptive to meaningful events in classroom recordings (Kosko et al., 2021) in comparison with PSTs watching standard videos. Theelen et al. (2019) deployed 360 videos of elementary lessons with 141 first-year preservice teachers, finding a significant increase in noticing and reference to theory-based terminology. Roche and Gal-Petitfaux (2017) investigated the role of 360 videos for training physical education teachers; this innovation contributed to a more involving and meaningful experience with important learning outcomes. Walshe and Driver (2019) analyzed PSTs' self-reflection with 360 videos with an interpretive case study based on think-aloud protocol and interviews; their results pointed at improved micro-teaching practice understanding and self-efficacy. Finally, Gandolfi et al. (2021) found that PSTs who feel immersed in 360 videos demonstrate more focused attention to the classroom, while the ones who are less engaged often demonstrate a discontinuous observation of students, teachers, and learning behaviors. To summarize, 360 videos are becoming important supplements and proxies for teachers, allowing them to engage with a rich and stimulating learning environment that is re-playable and safe (Walshe & Driver, 2021; Zolfaghari et al., 2020).

Despite these preliminary results, the role of 360 videos needs additional investigations to be properly anchored in PST training (Ferdig & Kosko, 2020; Zolfaghari et al., 2020). More specifically, few efforts have been made in deconstructing the experience of watching this medium in relation to comprehension and noticing outcomes. In other words, looking at

the areas of future development suggested by Gaudin and Chaliès (2015), 360 videos can expand the use and popularity of recordings for PSTs. However, more information is required to understand the impact of this innovation. Among the several metrics suggested for measuring XR dynamics, the concept of presence is particularly central for better framing strengths and limitations of 360 videos for teacher training.

The Challenge of XR Presence

XR has often been associated with the concept of presence (Ferdig et al., 2018), which is described as the sense of *being there* or naturalness (Bianchi-Berthouze et al., 2007; Lee, 2004). Indeed, technologies like virtual reality and 360 videos tend to involve the user to the extent that the technology mediation tends to disappear (Gandolfi et al., 2021; Lorenzo et al., 2013). Following these premises, presence is a desired outcome of any XR technology because it implies that the immersion it wants to provide is reached. Addressing learning and education, high presence would promote meaningful experiences where users feel engaged and involved with the virtual environments and activities offered (Lau & Lee, 2015; Lee & Wong, 2014; Webster, 2016). This potential can also be related to the relationship between presence and embodied cognition. With embodied cognition, the reference goes to interpreting thinking as "reactivation and reuse of processes and representations involved in perception and action" (Fincher-Kiefer, 2019, p. 10). Consequently, XR presence may be associated with this embodiment-related process. Rather, the sensations of *being there*, *acting like being there*, and/or *learning like being there* suggest cognitive and learning benefits for users who are sensorially immersed within XR environments.

Despite this potential, the concept of presence itself remains poorly operationalized, particularly in the context of PST training. This is partly due to the vagueness characterizing this and similar concepts like immersion and engagement (Farrow & Iacovides, 2012; Ferdig et al., 2018) and to the insufficient literature targeting the implications of presence in future educators' behaviors in XR environments (including 360 videos). Gandolfi and colleagues (2021) developed and validated the *eXtended Reality Presence Scale* (XRPS) for shedding light on this construct for this specific audience. The related analysis of the construct key map produced from Rasch analysis pointed at how this construct can be described as a continuum between mesmeric presence (high scores and the feeling of be within the XR environment) and weakened presence (low scores and the feeling of being

in a mediated and therefore artificial environment). Additionally, Gandolfi et al. (2021) highlighted how PSTs with a high degree of presence perceived emotional relatedness and sense of agency, echoing previous evidence about the role of involvement and self-empowerment in interacting with learning virtual environments (Allcoat & von Mühlenen, 2018; Freude et al., 2020; Kong et al., 2017; Marín-Morales et al., 2018).

Presence and Professional Noticing

This article aims to keep investigating the role of presence by targeting a wider scope (in comparison with Gandolfi et al., 2021), involving more participants, and looking at possible presence subfactors and implications in terms of noticing within XR outlets for PSTs. This last focus is particularly relevant for uncovering the role of presence while training future teachers. Teachers' professional noticing can be described as the ability to: a) detect and attend what is relevant in a pedagogical context and tie it to core teaching and learning guidelines and criteria (van Es & Sherin, 2002); and b) take proper action for addressing what observed (Jacobs et al., 2010). There is empirical evidence that professional noticing contributes to and is influenced by PSTs' *Specialized Content Knowledge* and *Pedagogical Content Knowledge* (Dick, 2017; Leavy & Hourigan, 2018; Lee, 2017). XR environments like 360 videos show promise for supporting future teachers' ability to notice and contextualize what is important in a learning setting (van Es & Sherin, 2002), providing a wider field of view for noticing meaningful dynamics and instances thereby setting the stage for proper teaching practices (Kosko et al., 2021; Scheiner, 2016). Additionally, there is a consensus in the literature that teacher noticing should focus more on students' actions rather than teachers' behaviors and provide detailed examples with broader implications rather than superficial statements (Barnhart & van Es, 2015; Dessus et al., 2016; Jacobs et al., 2010).

While in standard training videos prospective teachers tend to observe teachers' actions rather than students (Huang & Li, 2012; Jacobs et al., 2010), there is preliminary evidence that immersive videos may address this situation. For instance, Kosko et al. (2021) analyzed PSTs' professional noticing comparing exposure to 360 videos and standard videos of a third-grade mathematics lesson on the *Commutative Property*. They found that the former condition, 360 videos, facilitated: a) a higher focus on students rather than the teacher; and b) a more detailed overview of the math concepts and processes addressed by the students recorded. These findings

are supported by several studies (Boronat et al., 2005; Ferdig et al., 2020; Sherin & Star, 2011) that tie noticing to embodiment and movement. Following this line, Ibrahim-Didi (2015) suggested that teacher reflection is a "situated, body-dependent process" (p.239). Therefore, 360 videos show promise because they have the potential to make knowledge explicit and reinforce the embodied aspect of noticing. These highlights imply a possible role of presence in interacting with teachers' awareness and attention in immersive environments. In other words, presence may work as an ally of embodied cognition and, therefore, teacher knowledge construction.

Following these premises, the objectives of this study were to a) better understand the role of presence in supporting teacher training and noticing; and b) advance our understanding of this construct while designing XR experiences for future educators.

MATERIALS AND METHODS

Sample

Data was collected from 118 students enrolled in a public four-year institution in the Midwest (see Table 1). Participants were recruited from an undergraduate research pool to fulfill a course requirement. The participants were primarily identified as white (90.7%) and female (81.4%). Most of the participants were enrolled in their Junior (45.8%) academic year with 2 (1.7%) freshmen, 13 (15.3%) sophomores, 21 (17.8%) seniors, and 1 (0.8%) graduate student. Table 1 shows the distribution of the participants' majors for the 117 who responded. Nearly half of the participants were enrolled within the Early Childhood education program (47.9%) and had a mathematics focus or subset (54.7%).

Table 1
Distribution of Majors

Academic Major		N	%
Early Childhood/Elementary		56	47.9
Middle School	Social Studies & Language Arts	3	2.6
	Math & Science	3	2.6
Secondary	Language Arts	12	10.3
	Math	6	5.1
	Science	3	2.6
	Social Studies	10	8.5
Multi-Grade	American Sign Language	2	1.7
	Art	11	9.4
	Foreign Language	4	3.4
	Special Education	1	0.9
	Music	1	0.9
	Social Health	1	0.9
Other		4	3.4

Measures and Data

The construct used was the e*Xtended Reality Presence Scale* (XRPS) that has been validated within an initial study with the use of the Oculus Go headset (Gandolfi et al., 2021). The items were modified from the *Multimodal Presence Scale* (MPS) (Makransky et al., 2017), which focused on presence in virtual reality environments. The scale's items were tested with cognitive interviews (Gandolfi et al., 2020) and the instrument was validated with an analysis of the construct key map produced from Rasch analysis (Gandolfi et al., 2021).

The distribution of item and person scores indicated a single-factor continuous scale from low to high degree of presence. A Likert-type response format was used for each item to gain insight on how much the participants agreed with each statement (*1 = completely disagree to 5 = completely agree*). Higher scores on this construct indicate a larger sense of presence

during the 360 video. The pilot presented a final instrument of 21 items after analysis with 44 undergraduate students.

For this current study, the measure was altered after the initial investigation of the data based on the pilot (Gandolfi et al., 2021) and, thus, items i16 and i21 were eliminated prior to analysis. Item i16 (i.e., "I felt that the people in the 360 video environment were aware of my presence") was removed due to the similarity to item i14 ("I felt that people in the video were aware of my presence") with the same difficulty determined by the pilot study. Item i21 was removed due to the same level of difficulty, determined by a Rasch model in the pilot, with two other items (i23 and i8). Thus, the final XRPS examined for the study focused on 19 items, which are reported later in Table 3.

Procedures

Participants were recruited through the authors' university to fulfill a research credit course requirement. All participants completed a demographics form and then were presented with the task of the study via Qualtrics. All participants were asked to watch an introduction video (approximately 3 minutes long) that illustrated the importance of looking all around to get the entire immersive experience of the classroom. The tutorial was embedded to be an initial instruction of how to view a 360 video to eliminate potential confusion of the software and to lessen a participants' lack of *movement* in the environment.

Once the tutorial was completed the participants were asked to watch a 360 video classroom recording of an upper elementary mathematics classroom (approximately 5 minutes long) through their web browser. 54 (45.8%) participants watched a 360 video of a third-grade classroom recording of the commutative property of multiplication. 29 (24.6%) viewed a 360 video recording of students learning equivalent fractions with pattern blocks (fourth grade) and adding fractions (fifth grade), and 35 (29.7%) viewed a video on reviewing fraction comparisons. These videos were selected for the study because similar in terms of length, setting, main focus, and phases sequence (i.e., teacher instruction, group work, discussion). The overall procedure was approved and monitored by the authors' university Institutional Review Board committee.

Quantitative Analysis

Classical Test Theory was the primary analysis to assess the reliability of the XRPS. Reliability is the reproducibility of the construct if the same group of participants were to be tested again (Crocker & Algina, 1986). Assessment of reliability was computed by calculating the Coefficient Alpha (Cronbach Alpha) which measures the *internal consistency* of the construct (Crocker & Algina, 1986). Additionally, analysis focused on two of the four forms of validity that are described in the *Standards for Educational and Psychological Testing* (AERA, APA, & NCME, 2014). Validity refers to the "process by which a test developer or test user collects evidence to support types of inferences that are to be drawn from test scores" (Crocker & Algina, 1986, p. 217). Following the initial validation of XRPS (Gandolfi et al., 2021) further validation evidence of *test content* and *internal structure* were examined. Table 2 provides the claims of each validity type and the supporting evidence.

Table 2
Summary of Validity Type, Claims, and Evidence

Validity Type	Claim(s)	Primary Evidence
Test Content	• The measure assesses Presence of preservice teachers. • Differences between presence scores of PST early childhood and non-early childhood majors • Differences between presence score of PSTs mathematics focus and non-mathematics focus	• Purpose and the intended use of the measure • Independent Sample T-test
Internal Structure	• Analysis of the relationships between the items and how they align with the intended purpose of the construct	• Factor Analysis

Validity evidence for *test content* comes from the findings from the independent sample t-test. Findings would indicate whether XRPS can denote a difference between the scores of early childhood PSTs and all other majors as well as denoting the difference between mathematics education and non-mathematics. The intended purpose of this construct is to measure a PSTs level of presence within an XR environment. It is believed that early childhood PSTs and mathematics focused education would have a higher

presence in these XR environments due to their *Specialized Content Knowledge* and *Pedagogical Content Knowledge* (Dick, 2017; Leavy & Hourigan, 2018; Lee, 2017), which would be more aligned with the learning environment recorded (i.e., an upper elementary mathematics classroom). Thus, it is believed that this analysis provided some evidence towards *test content* due to the topic of the video. Validity of *internal structure* "addresses the degree to which the relationships among test items and test components conform to the construct" (AERA et al., 2014, p. 16). Validity evidence for *internal structure* comes from the findings of an exploratory factor analysis (EFA) that identifies if the factors align with the intended purpose of the test (Crocker & Algina, 1986; Pett et al., 2003).

Exploratory factor analysis (EFA) was used to measure validity of the *internal structure*. An EFA aids in examining the interrelationships amongst the items within a construct (Pett et al., 2003). Conducting an EFA can further serve as an additional instrument validation in that it can "identify items that do not empirically belong to the intended construct and that should be removed from the survey" (Knekta et al., 2019, p. 6). Factor analysis aides in determining "whether item responses 'cluster' together in patterns … reasonable in light of the theoretical structure of the construct" (Crocker & Algina, 1986, p. 232). In general, an EFA is an important beginning step for the validation of a construct (Pett et al., 2003). However, it should be cautioned that EFA helps to identify a goodness of fit of the items and not the construct as a whole (Pett et al., 2003).

An independent t-test was used to determine a difference in construct scores on the identified factors. The two sets of groups compared were K12 mathematics PSTs and non-K12 mathematics PSTs as well as early childhood education majors and all non-early childhood educations (i.e., all other majors). The purpose of an independent sample t-test was to compare the means of two groups and the probability of difference occurring (Kim, 2015).

Qualitative Analysis

For the qualitative analysis, two subsets of 89 participants' written responses were analyzed (the rest of the sample did not leave any comment). One subset of 44 participants watched a classroom video about commutative property. The other subset of 45 participants watched a video about adding equivalent fractions. The viewing sessions were recorded, and participants answered two questions about pivotal moments in the video. The first

question asked about all pivotal moments participants noticed; the second question asked participants to select and explain one pivotal moment that was the most important.

Participants' written responses were analyzed using a systemic functional linguistics (SFL) approach (Eggins, 2004; Halliday & Matthiessen, 2014). This approach looks at how the grammar in language is used to convey meaning. By using systemic functional linguistics as an analytic framework, we were able to decipher the participants' meaning from their written narratives. First, we used rich text features (Saldaña, 2018) to categorize the writings into nominal, transitive, and hedging groups. Nominal words or phrases identifying the actor or goal in a clause (Halliday, 2014) were underlined. The process of transitivity (Halliday, 2014), or transferring the action to an object, were put into bold font. Clauses or phrases were separated by //. Hedging words that are a sign of cautious language (Gillet et al., 2009) were italicized. This rich text feature is illustrated in the example below (i.e., a participant's answer in response to what was the most important pivotal moment in the videos).

When the students **shared** what answers they got //

and [students] **worked** together,

[students] **talking** through the problem.

Sometimes it is helpful for students **to discuss** their thought process //

and [students] **work** with their peers to come to a conclusion.

In the above example, the *students* are the nominal element with different transitive words such as *shared*, *worked*, and *talking* being utilized. These rich text features allowed us to analyze what the participants were referring to and how repeated referencing identified referential chains (Eggins, 2004). It was crucial to look at how all these aspects were interconnected as references cannot be semantically interpreted on their own and must refer to other aspects of the text (Halliday & Hasan, 1976).

After written noticings were analyzed and themes were identified, the reliability of whether the theme was observed or not was examined. Cohen's Kappa was used to measure the inter-rater reliability (Cohen, 1960). The kappa statistic strength of agreement can be interpreted on a scale with < 0.00 Poor Agreement, 0.00-0.20 Slight Agreement, 0.21-0.40 Fair Agree-

ment, 0.41-0.60 Moderate Agreement, 0.61-0.80 Substantial Agreement, and 0.81-1.00 Almost Perfect Agreement (Landis & Koch, 1977). Inter-rater reliability with both subsets were shown to have substantial agreement on the identified themes with the equivalent fractions video having a Cohen's κ of (0.69) and the commutative property video having a Cohen's κ of (0.732). Both Kappa coefficients suggest authors reached substantial agreement in identifying themes.

Merging Quantitative & Qualitative Data

The relationship between presence scores and theme occurrence was analyzed by calculating the related Pearson Correlation Coefficient. In addition, high and low presence subsets were selected for detecting trends in terms of themes noticed. High and low presence groups were gathered by calculating the presence z score with standard deviation and their cumulative density function (CDF). Z scores which were considered one standard deviation above the mean were considered as high presence, and Z scores which were one standard deviation below the mean, were associated with low presence. This part of the analysis was mainly exploratory due to the absence of evidence tying presence and noticing skills in PSTs.

RESULTS AND FINDINGS

Quantitative Results

Factor Analyses

Multiple factor analyses were performed. Each analysis was extracted using *Principal Axis Factoring* (PAF) and was rotated orthogonally using the *Oblimin with Kaiser Normalization*. The final three components can be seen in Table 3. Through this process an additional 2 items were removed: 1) i5 ("I was able to see everything in the classroom"); and 2) i21 ("During the experience there were times where the technology seemed to disappear, and I felt like I was immersed in the 360 video environment"). These items were justified to be removed due to the similarities to other items in the construct and the factor values.

Table 3
Final Selection of Items on the Presence Scale through Factor Analysis

Label	Item	
Emotional Connectivity	i27	I felt emotionally attached to people in the 360 video.
(Sense of Being)	i28	I felt emotionally influenced by what was happening in the 360 video.
	i29	Observing the 360 video was an emotional experience.
	i9	I felt part of the lesson as if I had been there in the classroom.
	i8	In some cases, I wanted to interact with the students/teacher directly.
	i12	I felt immersed in the lesson.
	i19	I had a sense that I was dealing with other people in the 360 video rather than just observing a recorded video.
	i11	I felt that my actions could affect what was happening in the classroom.
Co-Presence	i13	I felt like I was with actual students in the classroom.
(Awareness of Others)	i15	I had a sense that I was in the classroom with the students, rather than watching a video of the students.
	i17	I felt I was in a realistic educational setting.
	i18	I felt that people in the 360 video were behaving normally.
	i26	I felt like what my eyes were seeing in the 360 video was the same as what my eyes would see if I were physically in the classroom.
Awareness of Self	i24	During the 360 video, I felt like my real body was there.
	i23	When something happened around my viewpoint, it felt like it was happening to my real body.
	i7	While I was watching the video, I has a sense of "being there".
	i14	I felt the people in the video were aware of my presence.

Following the results in Table 3, the first factor was named *Emotional Connectivity* (EC) since all the items referred to the participant feeling connected to the students, teacher, or the classroom setting. The items in this factor all have the commonality of being there and having the same emotional connection as if they were there in person, echoing the previously mentioned importance of emotional attachment in experiencing presence (Gandolfi et al., 2021). The second factor was named *Co-Presence* (CP), the

items within this factor all referred to the participants' sense of being in the actual classroom and being with the students. This component may be associated with the concept of agency and the feeling of being an active actor within the recording, which is connected to presence (Gandolfi et al., 2021). The last factor was named *Awareness of Self* (AS), where the items were directed at the participants being *physically* in the environment and removing themselves from the technology component. Even this finding can be tied to the first validation of XRPS, which pointed at how low presence is associated with perceiving the technological mediation (Gandolfi et al., 2021). To summarize, findings from the EFA illustrate that the items within the construct fit together well. Analysis also aided in two items within the construct that did not group well within the three factors and ended up being removed from the construct.

A reliability analysis was conducted on each of the individual factors. Table 4 provides the coefficient alpha of each of the factors as well as the overall mean, standard deviation, and variation. Further, classical test theory investigated the correlations between the items within the factors. Factors 2 and Factors 3 indicated some items that had a high correlation with each other; however, this was not much of a surprise given the nature of some of the items. For example, i24 ("During the 360 video, I felt like my real body was there") and i23 ("When something happened around my viewpoint, it felt like it was happening to my real body") are extremely similar in the wording with nuanced differences.

Table 4
Factor Reliability Results

	Mean	Std. Deviation	Variation	Coefficient Alpha
Emotional Connectivity	16.13	6.362	40.469	0.857
Co-Presence	15.35	3.859	14.895	0.836
Awareness of Self	7.60	3.969	15.756	0.858

After checking on potentially problematic high correlations, further Classical Test Theory examination was done. Table 5 shows the items-total correlations and coefficient alpha if the item was deleted from the construct. The item total correlation is the correlation of the item and the overall construct score. Thus, if they scored high on an item (i.e., they agreed with the statement) participants should have a higher presence score on the construct than those who scored lower on the item (i.e., they disagreed with the statement). Overall, all items were above 0.30, which is the suggested general

rule for internal consistency reliability (Nunnally & Bernstein, 1994).

Further, examining the coefficient alpha if an item was removed did not warrant an item being deleted, despite some high correlations between items discussed prior Only one item (i18) of the second factor could slightly increase the alpha (see Table 4). However, this item was not an issue of high correlation with other items and, therefore, was left in. The same reasoning corresponds to the rationale of keeping an item (i18) in the third factor.

Table 5
Item-total Correlations and Alpha if Item Deleted for XRPS

Construct	Item	M if Item deleted	Var. if Item Deleted	Item-Total Correlation	α if Item Deleted
Emotional Connectivity	i27	14.68	32.696	0.551	0.845
(Sense of Being)	i28	14.37	29.828	0.726	0.824
	i29	14.76	30.660	0.675	0.831
	i9	13.41	30.722	0.674	0.831
	i8	13.64	33.595	0.474	0.853
	i12	13.52	32.801	0.596	0.841
	i19	13.76	31.474	0.576	0.843
	i11	14.77	31.169	0.542	0.848
Co-Presence	i13	12.51	8.094	0.786	0.758
(Awareness of Others)	i15	12.47	8.830	0.749	0.769
	i17	12.04	10.323	0.717	0.787
	i18	11.89	12.171	0.431	0.851
	i26	12.48	10.199	0.552	0.828
Awareness of Self	i24	5.82	8.969	0.765	0.792
	i23	5.69	8.405	0.810	0.771
	i7	5.03	9.934	0.686	0.827
	i14	6.27	9.824	0.567	0.876

Independent t-test

Results suggested that there was a statistically significant difference in the scores only for CP for early childhood education majors (M=15.7, SD=3.2) and non-early childhood education majors (M=15.0, SD=4.4). This implied that the construct could detect differences of presence scores

for early childhood PSTs and non-early childhood PSTs regarding *Co-Presence* but not the other subfactors. However, the CP construct did not have the ability to detect differences in presence scores of mathematics education focused majors and non-mathematics after the viewing of an elementary mathematics lesson. In general, these findings partially matched our expectations, suggesting that XRPS can detect differences in early childhood versus non-early childhood PSTs CP scores after watching an upper level elementary 360 video. Additionally, they can be related to how XR presence may be influenced by PSTs' background, which has been already suggested in the literature about standard videos (e.g., Wiens et al., 2013). Indeed, *Co-Presence* has been defined as the feeling to be in the actual classroom with the students and to make a difference (i.e., agency). It can be argued that the early childhood education students found the recordings more aligned with their future learning environment and audience. Therefore, they experienced more a) proximity with the students observed and related actions and b) confidence in detecting and reading the classroom (i.e., the *Co-Presence* factor in the presence construct).

Qualitative Findings

In examining how references are conveyed through meaning, five common themes emerged including *group work*, *problem/math specific*, *hands-on*, *value video format,* and *teacher focus*. *Group work* was one of the themes that emerged across PSTs' written noticings with 35. 5% of participants (n = 16 out of 45) for the fraction video and 15.9% (n = 7 out of 44) for the commutative video. This theme was conveyed through PST's references to students' collaboration on the task. Considering the example below; the PST used *students* as a nominal group which acted upon a problem to *solve* through collaboration. Then, the PST continued in the second sentence using the same nominal element *another student* to convey the act of offering an idea to the whole class, which *allowed* students to *continue* to solve a problem that they were *getting stuck* on.

I thought//

the collaboration between the students **to solve** the examples they[students] were given//

allowed them to **problem solve** any obstacles they [students] **encountered**.//

Instead of **getting stuck and stopping** [while students working on problems], another student was **able t**o offer a suggestion that **allowed** them [students] to continue.

The second theme was *problem/math specific,* which was observed at 40% of participants for the fraction video (n = 18 out of 45), and 38.6% (n = 17 out of 44) of participants for the commutative property video. The participants referenced the mathematical problems and used math language in their written noticing. For instance, in PST's excerpt shown below the referent was introduced using "equivalent fractions for 5/6 and 3/8" and then continued with another referent "fraction sticks". In the third sentence, the referent chain is built using the reference "divide fractions" but with a different nominal element "one group".

Students **were able to** effectively **find** equivalent fractions for 5/6 and 3/8.//

They [students] **used** fraction sticks to **create** fractions or multiplied on their whiteboards.//

There was one group that **tried to divide** fractions smaller//

but [one group] **couldn't** [divide fractions].

Hands-on was another theme that we observed from the participants. In the fraction video 24.4% of participants wrote about hands on (n = 11 out of 45), and 29.5 % in the commutative property video (n = 13 out of 44). In the *hands-on* theme, participants may have directly stated the value of students doing a hands-on activity, or they may have used language that referred to the usage of hands-on activities such as *concrete manipulatives* or *using the strips*. One example of this theme can be seen below.

Some of the pivotal moments is//

students **being able to be** hands on when figuring out the problem,//

This [hands on] is especially pivotal in math.

In this example, the participant specifically stated the importance of hands-on learning in mathematics. An additional theme observed was that of *valuing video format*. In this theme, participants' grammar was coded for

the use of language that referred to the use and value for 360 video. PSTs wrote about what the 360 video allowed them to do during the viewing experience. This can be seen in the excerpt below.

> The use of the 360 video **makes** the viewer **feel** like
>
> they [viewer] are **able to listen** in on conversations of the classmates//
>
> and **to work** with them [students/classmates].

Use of 360 video was the first nominal phrase utilized with transitive words creating a connection to the viewer throughout the clause. For valuing video format, 8% of participants in the fraction video were identified (n = 4 out of 45), while 13% in the commutative property video (n = 6 out of 44) wrote about valuing video format. The final theme we will discuss in this paper is that of teacher focus. In this theme, participants were focused on driven teacher actions such as asking questions or the teachers' movement around the classroom. 46.6% of participants in the fraction video (n = 21 out of 45) had teacher focused themes in their writing while 43.1% of participants in the commutative property video (n = 19 out of 44) were identified with this theme.

> I **noticed//**
>
> > that the teacher was continuously **walking** around from table to table and back and forth between students//
> >
> > > which allows her [teacher] **to get and give** immediate feedback from the kids on their understanding of the material.

The example above shows that the participant is focused on what the teacher is doing in the video and how they are conducting the lesson.

Merged Findings and Results

After the qualitative and quantitative analyses, written noticings and degrees of presence were compared for detecting possible trends and correlations. Table 6 indicates the themes reported by low (N = 12) and high (N = 16) presence subsets. High presence subjects tended to report more about

group work between students and teacher-related behavior, while the other themes were reported with almost the same frequency.

Table 6
Themes by Low and High Presence Subsets

	Math	Group work	Hands on	360 video	Teacher
Low presence group	7	2	2	0	3
High presence group	6	7	2	1	8

Looking at the whole sample, Pearson correlations between presence score and themes noticed were calculated. There were a) a positive moderate correlation between presence and group work ($r=0.312$, $p < .001$) and b) a moderate negative correlation between presence and math problem/content ($r=-0.291$, $p < .001$).

DISCUSSION

Addressing RQ1, the current study provides evidence that a) XRPS is a validated and reliable instrument and b) presence in extended reality for perspective teachers is a multidimensional construct composed of three factors. *Emotional Connectivity* reiterates the importance of emotional attachment to what and who is observed in extended reality environments for PSTs, echoing the importance of empathy and feelings in making a technology-mediated experience immersive and involvement (see Allcoat & von Mühlenen, 2018; Marín-Morales et al., 2018). *Co-Presence* highlights the importance of other human actors in 360 videos and the role of agency - feeling able to play an active role despite the lack of interaction characterizing the recording (see Nardi, 2015; Guadagno et al., 2007; Freude et al., 2020). *Awareness of Self*, which describes how technology mediation is a key component to address for making the experience itself more transparent and engaging (Aydin et al., 2019). These parameters were already introduced in the first XRPS validation study (Gandolfi et al., 2021), and now they are properly defined providing insights and directions for improving XR videos for PSTs.

Focusing on RQ2, there were no differences between the student groupings in terms of *Emotional Connectivity* and *Awareness of Self.* This finding can be explained by the fact that these two factors may be considered content/grade neutral. *Emotional Connectivity* is associated with emotions and empathy experienced toward the individuals recorded. As all the par-

ticipants were PSTs, it can be argued that they were equally sympathetic toward the students in the 360 videos. *Awareness of Self* is related to the technology itself and how the interface supports or weakens the sense of being there aside from the topic of the lesson viewed; as such, it is related to how the immersive environment is displayed and made accessible. By contrast, *Co-Presence* was higher among early childhood majors in comparison with the other groups. This finding may be explained by the fact that this subset (i.e., early childhood majors) was observing videos of its ideal teaching environment (i.e., an elementary class) and were familiar with the grade taught and the related learning environment. As such, it can be argued that these participants felt to be well suited for monitoring and understanding what was watched, thereby experiencing *Co-Presence* with the students and, therefore, agency (even if hypothetical). Nevertheless, the variable of content area (i.e., math) did not point at any difference in these terms, suggesting that *Co-Presence* seems to be more related to the grade taught than the subject area addressed.

Addressing RQ3, group work, problem/math specific, hands on, value video format, and teacher focus emerged as leading themes noticed by the participants. Group work can be related to students' dynamics and related problem-solving activities, which are tied to the *Co-Presence* subfactor. Problem/math specific and hands-on are related to the specific task/content addressed. Value video format is at the core of the *Awareness of Self* subfactor and refers to perceiving the technology itself. Finally, teacher focus regards paying attention to the instructor as a main guide throughout the video. The *Emotional Connectivity* subfactor did not emerge in the written noticings, probably because participants were asked to report pivotal math moments during the lesson rather than emotionally important events.

Among the findings, Pearson Correlation Coefficients indicated a positive moderate correlation between presence and group work and a negative moderate correlation between presence and math problem/content. The former result indicates that a higher sense of presence is associated with a focus on students and their dynamics in noticing. This is a desired outcome according to the literature (Dessus et al., 2016; van den Bogert et al., 2014) because it allows PSTs to observe the class and how learners interact with each other and learn together. This finding is aligned with previous evidence regarding 360 videos and PSTs (Kosko et al., 2021). At the same time, the latter result highlights how content may conflict with presence, adding a *subject area* component that may weaken the sense of *being there*, especially considering that only some participants were from a STEM-related background. Looking at high and low presence subsets, this emphasis on

group work and presence was present again, showing how this construct goes along with noticing students' dynamics. However, high presence subjects seemed to be more receptive toward teacher behaviors. This element may suggest that the instructor/teacher can, in some cases, work as a guide for some viewers and increase their sense of presence.

Implications

There are numerous implications for teacher education and teacher educators. First, practitioners can use the XRPS and its subfactors for better assessing how PSTs perceive and are immersed in XR videos on an iterative basis. This process can facilitate content revision, personalization, and scaffolding (e.g., refining content selection and focus). Second, to foster *Co-Presence* in PSTs, 360 videos should target the ideal learning environment of the student teachers in terms of grade level. This implication means that innovations do not work by themselves and that XR video selection is an important step for teacher educators and trainers. A third implication for practitioners is for them to refer to the themes emerged from participants' written noticings (and the related method of analysis) for exploring their own students' reports and observations. These categories can be easily revised for serving different content areas and grades taught.

A fourth implication for practice is the strong need for 360 video repositories for PSTs to satisfy their specific learning and professional needs. Although there are exceptions (i.e., https://xr.kent.edu/), considering the scarcity of available 360 videos, teacher instructors should consider recording their own immersive videos for maximizing the outcomes of this innovation. Consequently, XR video production may become the focus of additional lines of inquiry. Finally, when developing 360 videos for teachers, it is important to focus on: a) the actors involved for fostering emotional attachment, and b) making the technological interface as transparent as possible for empowering the overall feeling of presence, echoing what is suggested in the literature about XR learning environments (Allcoat & von Mühlenen, 2018; Freude et al., 2020; Kong et al., 2017; Marín-Morales et al., 2018).

There are several implications for research that teacher education scholars should consider. First, the feeling of presence in 360 videos should be promoted and facilitated because it is correlated to student-focused noticing, which is a desirable observation behavior for PSTs (Barnhart & van Es, 2015; Huang & Li, 2012). It also better explains the impact of 360 videos on teachers' ability to detect meaningful events (Kosko et al., 2021).

Future studies could uncover new strategies for promoting this construct, from technology features to content-based components. Second, the role of emotions and interface mediation (Freude et al., 2018) demands more attention (e.g., composition of the class recorded, emotion-related events in the video) and technological/sensorial criteria (e.g., use of haptic media, interface structure, audio). There is also a need of theory and model building for better framing presence, embodied cognition, XR environments, and their reciprocal interactions and relationships. Considering that embodied cognition relies on reactivating schemes and representations based on movement and perception (Fincher-Kiefer, 2019; Ibrahim-Didi, 2015), it can be argued that this study's results indicate that this construct and presence are related for two reasons: 1) presence (being there) supports a desired embodied cognition toward students (noticing like being there); 2) variables like major and subject area impacted presence because they supposedly played a role in students' perception and reuse of representations of practice. Regardless, these preliminary insights require additional efforts for being properly developed.

The specific content addressed in 360 videos for PSTs should also be carefully examined. According to the noticing-related data, it may work as a distraction for students who are not familiar with it, decreasing their feeling of presence. The role of *Specialized Content Knowledge* and *Pedagogical Content Knowledge* (Dick, 2017; Leavy & Hourigan, 2018; Lee, 2017) is therefore ambiguous and needs to be considered for hosting a well-balanced experience. Further studies with different XR videos and participants are required for better understanding the impact of these variables on PSTs' noticing in XR environments. 360 videos can work as productive instruments to evaluate PSTs' presence and noticing. Researchers should investigate how the use of XR videos can improve these two factors through time, from continuous exposure to immersive content to supporting activities before and/or after watching.

Limitations

The present study presents four main limitations. First, the study's findings may be affected by the current sample size of the participants, the distribution within academic ranks, the way in which the video was watched (via a web browser), and the content of the videos. Therefore, these findings cannot be generalizable to the general population of PSTs and other types of 360 videos for training educators. Second, additional variables could

have been considered, from PSTs' attitudes toward technology to previous experience with XR devices. Additional studies are currently underway for shedding light on the possible relationship between presence and perception of XR in teacher training. Third and despite some evaluation criteria (e.g., students oriented versus teachers focus), the qualitative analysis of the written noticings focused on the content rather than on their overall quality. As such, additional investigations may be staged for better comprehending the level of noticing and its nuances, also in relationship with the three presence subfactors. Fourth, the concept of presence itself can be associated with other potential constructs like fidelity, engagement, or realism, which were not investigated in the present study. The authors wish that these limitations will provide insights for expanding the scope of this article, contributing to the increasing literature about 360 videos for PSTs with further methodologies and research foci.

CONCLUSIONS

This article has shown that XRPS is a validated and reliable instrument composed of three sub factors that shed light on its own meaning and potential. The role of PSTs major emerged as an important variable for designing and selecting 360 videos that can engage with in-training educators, while the concept of presence itself is associated with a higher focus on students' interaction between each other. Moreover, specific factors (major, subject area) have been found associated with presence and noticing skills among PSTs. This highlight is important because it allows scholars and practitioners to *deconstruct* the impact of XR videos in teacher training and detect the core variables at stake. This opportunity shows promise in terms of research (broadening scholars' understanding about this innovation) and practice, emphasizing the importance of content selection and production.

Nevertheless, these are still questions about how we can realize the full potential of this innovation for student teachers. The hope of this study is to have provided useful insights for staging additional scholar and practical initiatives aimed at understanding XR experiences for future educators and related malleable factors. The next steps would be to: a) refer to these preliminary findings for designing and developing 360 videos that are tailored for the specific PST audience served; and b) keep investigating strategies and factors associated with presence and its improvement.

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