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Enhancing Students' Self-Reflection with 360° VR Video Across Digital Literacy Levels

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ABSTRACT

Microteaching is central to the development of pre-service teachers' instructional skills, yet conventional two-dimensional video often fails to capture the spatial and interactive complexity of classroom teaching, resulting in relatively superficial reflection. This study aimed to examine whether 360° Virtual Reality (VR) video was associated with higher self-reflection outcomes than PPT-based video and whether these differences varied across digital literacy levels. A quasi-experimental 2 × 2 factorial design was employed with 67 fourth-semester undergraduates from the Agricultural Technology Education program at Universitas Negeri Makassar. Participants were assigned to an experimental group (n = 32) using 360° VR video and a control group (n = 35) using PPT-based video, while digital literacy was classified as high (n = 38) or low (n = 29). Post-test self-reflection scores were analysed using two-way ANOVA, with pre-test data used for baseline comparison. The results showed significant main effects of learning media and digital literacy. Students using 360° VR video achieved higher self-reflection scores (M = 77.23) than those using PPT-based video (M = 74.73; F = 74.776, p < .001), and students with high digital literacy outperformed those with low digital literacy (F = 8.950, p = .004). A significant interaction effect was also found (F = 13.457, p = .001), indicating that the advantage of 360° VR video was greater among students with higher digital literacy. These findings suggest that 360° VR video, particularly when paired with stronger digital literacy, may better support self-reflection in microteaching and strengthen reflective practice in teacher education.

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1. INTRODUCTION

Microteaching has long been recognised as a central component of teacher education because it provides pre-service teachers with opportunities to rehearse instructional skills, receive feedback, and reflect on their teaching performance in a controlled setting. Within this process, self-reflection plays an important role in helping pre-service teachers identify strengths and weaknesses, evaluate pedagogical decisions, and improve subsequent teaching practice. In recent years, developments in educational technology have expanded the range of tools available to support this reflective process. Among them, virtual reality (VR), especially 360° VR video, has attracted increasing scholarly attention because it can simulate authentic teaching situations and allow users to revisit them from multiple visual perspectives (Atal et al., 2023; Rosendahl & Wagner, 2023; Atal et al., 2024; Stefanski & Ibrahim, 2024). The growing use of immersive media in education also reflects broader developments in digital pedagogy, where VR has been linked to experiential learning and to stronger connections between theoretical knowledge and practical application (Van der Want & Visscher, 2024; Lee & Wu, 2024; Conrad et al., 2024; Lampropoulos et al., 2024; Radianti et al., 2020).

Even with these technological advances, important limitations remain in how microteaching reflection is commonly conducted. Reflection often depends on two-dimensional PPT-based or standard video recordings, yet such formats do not always capture the full complexity of classroom interaction. They may restrict learners' ability to notice non-verbal behaviour, classroom positioning, and student responses, thereby limiting the depth of pedagogical reflection (Menon & Ngugi, 2022; Kosko et al., 2022; Arefian, 2022; Baysan et al., 2023). For that reason, the issue is not merely technological; it is fundamentally pedagogical. The quality of reflective insight

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depends in part on the quality of the representation through which teaching is revisited. In response to these shortcomings, 360° VR video has increasingly been considered a promising alternative because it enables panoramic review of teaching performances and broader observation of classroom events (Cross, 2022). Recent work has suggested that this immersive format may support reflective thinking and professional awareness more effectively than conventional flat video formats (Kosko et al., 2022).

A growing body of empirical work has reported encouraging findings in this area. VR-supported self-reflection has been associated with stronger classroom management awareness, more accurate self-assessment, and deeper evaluation of teaching strategies, alongside increases in pedagogical confidence (Qian et al., 2023; Taggart, 2023; Roche & Gal-Petitfaux, 2017). Reviews in teacher education also point to positive outcomes in motivation and reflective practice (Kosko et al., 2022). In addition, immersive media may enrich interpersonal vision and instructional noticing by allowing users to analyse classroom interactions from several angles with greater observational breadth (Arefian, 2022). At the same time, these benefits should not be assumed to operate uniformly across contexts. Much of the literature emphasises positive outcomes, but fewer studies have examined the conditions under which immersive reflection is more or less effective. This issue is particularly relevant in teacher education, where the quality of reflection may depend not only on the medium itself but also on the learner's ability to use digital tools meaningfully (Dhimolea et al., 2022).

Digital literacy appears especially relevant in this regard. Engaging with immersive reflection media requires more than basic technical access; it also involves navigating digital environments, interpreting information, and using technological affordances in a purposeful way. Learners with stronger digital literacy may therefore be better positioned to benefit from immersive media, whereas those with lower digital literacy may engage with the same tools less effectively (Chang et al., 2023). Although interest in VR has expanded across educational fields, studies focusing specifically on microteaching in teacher training remain relatively limited, and even fewer have examined whether the effectiveness of 360° VR video differs across levels of digital literacy (Dhimolea et al., 2022; Chang et al., 2023). This leaves an important unanswered question: it is still unclear not only whether 360° VR video is more effective than PPT-based video for reflection, but also whether its value depends on the digital readiness of the learners who use it.

These issues matter because effective self-reflection is closely connected to professional growth in teacher education. When pre-service teachers are able to revisit teaching episodes with greater detail and broader observational scope, they may be better able to analyse their instructional strategies, identify missed opportunities, and refine future practice. Previous work has also suggested that immersive media may support confidence and reflective engagement in dealing with classroom dynamics, although those adjacent outcomes are not the central focus of the present study (Qian et al., 2023; Taggart, 2023; Roche & Gal-Petitfaux, 2017). What remains underexplored is how reflective benefit varies when immersive media are used by learners with different levels of digital literacy within a microteaching context. Viewed from this perspective, the contribution of the present study lies in examining 360° VR video, self-reflection in microteaching, and digital literacy within a single analytical framework. Rather than treating immersive technology as uniformly beneficial, the study investigates whether the use of 360° VR video is associated with stronger self-reflection than PPT-based video and whether this pattern differs across digital literacy levels. This approach offers a more differentiated understanding of VR-supported reflection in teacher education than studies that report only general treatment effects.

This study investigates the impact of 360° VR video on pre-service teachers' self-reflection abilities in microteaching, while also examining the contribution of digital literacy and the potential interaction between learning media and digital literacy level. The use of 360° VR video is expected to provide a more immersive and contextual learning experience, enabling pre-service teachers to observe their teaching performance from a broader and more authentic perspective. Through this medium, students may be able to identify strengths, weaknesses, classroom interactions, teaching strategies, and areas for pedagogical improvement more deeply than through conventional PPT-based video materials. The inquiry is guided by three research questions: (1) What differences exist in self-reflection abilities between students who use 360° VR videos and those who use PPT-based videos? (2) How do different levels of digital literacy, categorized as high and low, influence students' self-reflection abilities? (3) Is there an interaction between learning media type and digital literacy level in influencing self-reflection abilities? These questions are directly aligned with the quasi-experimental factorial design of the study, which allows the researcher to examine not only the separate effects of learning media and

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digital literacy but also their combined influence on students' reflective development. The findings are expected to provide a more precise understanding of how immersive reflective media can be used effectively in teacher education, particularly in supporting pre-service teachers' ability to evaluate, interpret, and improve their microteaching performance.

2. MATERIAL AND METHOD

Research Design

This study employed a quasi-experimental nonequivalent control group design with a 2 × 2 factorial structure to examine whether the use of 360° Virtual Reality (VR) video was associated with differences in students' self-reflection abilities in microteaching across digital literacy levels. This design was selected because random assignment was not feasible in the educational context and intact classes had to be maintained. In educational research, such a design is appropriate for examining intervention effects under authentic instructional conditions where strict experimental control is difficult to achieve (Gopalan et al., 2023; Kosko et al., 2022). The two factors examined in the study were learning media (360° VR video vs. PPT-based video) and digital literacy level (high vs. low) (Andrade, 2024).

The intervention consisted of two reflection modules. Students in the experimental group engaged in microteaching reflection using 360° VR recordings of their own teaching performances. These recordings were captured with 360° cameras and reviewed through VR headsets, allowing students to navigate different perspectives of the classroom environment. The design of this module was intended to support richer observation of verbal and non-verbal teaching behaviour. In contrast, students in the control group reflected on their microteaching sessions using conventional two-dimensional recordings integrated with PowerPoint slides, which guided reflection through selected frames and annotations, reflecting commonly used practice in teacher education (Arefian, 2022; Snelson & Hsu, 2019). Both reflection modules were aligned with the learning objectives of the microteaching course. To maintain comparability across conditions, both groups reflected on their own teaching performances, used the same reflection focus, completed the activities within the same overall time frame, and received instructor facilitation during the reflection sessions. The procedure followed a structured four-week sequence. In Week 1, all participants completed the Digital Literacy Scale (DLS) and the self-reflection pre-test. In Weeks 2 and 3, students conducted their microteaching sessions, which were then recorded and reviewed using the assigned reflection medium. Reflection sessions lasted approximately 60–90 minutes and were facilitated by the same instructor to maintain consistency across groups. In Week 4, all participants completed the post-test self-reflection questionnaire.

Participants

The participants were 67 fourth-semester undergraduate students enrolled in the Microteaching course in the Agricultural Technology Education program, Faculty of Engineering, Universitas Negeri Makassar, during the 2024–2025 academic year. Because the study used a quasi-experimental design with intact classes, participants were drawn from two existing classes, resulting in an experimental group (n = 32) that used 360° VR video and a control group (n = 35) that used PPT-based video. Eligibility criteria required that students: (a) were officially registered in the Microteaching course, (b) had completed prerequisite coursework in pedagogy and teaching methodology, and (c) attended both the pre-test and post-test sessions. Students who were absent at any stage of the intervention were excluded from the analysis. At the time of the study, all participants had completed core theoretical modules in lesson planning, classroom management, and instructional reflection. This ensured that the participants entered the study with a common pedagogical background, although group equivalence was still examined empirically through pre-test data rather than assumed from coursework alone.

Instrument

Two instruments were used in this study: a Digital Literacy Scale (DLS) and a self-reflection questionnaire. As shown in Table 1, the DLS was designed to represent six dimensions of digital literacy that cover both technical and higher-order aspects of digital competence. The instrument was developed with reference to several established frameworks, including UNESCO's Digital Literacy Global Framework (Vuorikari et al., 2022), the European Commission's Digital Competence Framework for Citizens (Vuorikari et al., 2016; Vuorikari et al., 2022), the Digital Competence Framework for Teachers (INTEF, 2022), the South Pacific Digital Literacy

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Framework (Atal et al, 2023), and perspectives on digital accessibility literacy in educational settings (Fisseler, 2024). These frameworks informed the content coverage of the instrument and helped ensure that digital literacy was treated not only as technical skill, but also as involving critical evaluation, ethical engagement, and inclusive digital practice. For the purposes of factorial analysis, participants were classified into high and low digital literacy groups using a median-split procedure based on their total DLS scores. Although categorising a continuous variable may reduce variability, this procedure was adopted to match the 2 × 2 factorial design and to facilitate interpretation of interaction patterns between media type and digital literacy level.

Table 1. Main Characteristics of the Research Instruments

Instrument	Dimensions / Indicators	Number of Items	Response Format	Scoring / Classification
Digital Literacy Scale (DLS)	(1) Access and navigation of digital technologies; (2) Evaluation and analysis of digital information; (3) Digital communication and collaboration; (4) Digital safety and privacy; (5) Digital ethics and responsibility; (6) Digital creativity and innovation	30	5-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree)	Total score used to classify students into high and low digital literacy groups
Self-Reflection Questionnaire	Awareness of teaching strengths and weaknesses; responses to peer teaching observations; intentions to improve pedagogical practice; development of professional teacher identity	20	Multiple-choice items with five progressive response levels	Each item scored from 0 to 4, ranging from highly unreflective (0) to highly reflective (4)

Also shown in Table 1, the second instrument was a structured self-reflection questionnaire administered as both a pre-test and a post-test to assess students' reflective thinking in the context of microteaching. The questionnaire was constructed to capture progressive levels of reflective awareness, critical analysis, and pedagogical insight. Its conceptual design drew on several established perspectives in reflective practice, including Kember et al.'s Reflective Thinking Questionnaire (van der Linden et al., 2022), Hatton and Smith's levels of reflection (Hatton & Smith, 1995), Larrivee's model of critical reflection in teaching (van der Linden et al., 2022), Experiential Learning Theory (Gordon, 2022), the social dimension of reflection (Wetcho & Na-Songkhla, 2021), and the Iceberg Model of Reflection (Maguire, 2023). These perspectives informed the item structure by representing reflection as a progression from descriptive awareness to deeper critical and transformative reflection. Because the instrument used multiple-choice response options to represent reflective levels, it should be interpreted as a structured measure of reflective judgment rather than as a direct qualitative capture of reflective discourse. With regard to psychometric properties, the DLS demonstrated excellent internal consistency (Cronbach's $\alpha = 0.937$), while the self-reflection questionnaire showed acceptable internal consistency (Cronbach's $\alpha = 0.712$). In addition, the self-reflection instrument was reviewed by experts in teacher education and reflective practice. Taken together, these findings suggest that both instruments provided acceptable reliability and preliminary content-based validity support for use in this study, rather than definitive construct validation in a strong psychometric sense.

Data Collection and Analysis

Data collection followed four main steps: (1) administering the digital literacy scale (DLS), (2) conducting the self-reflection pre-test, (3) implementing the learning intervention (experiment) using either 360° VR video or PPT-based video, and (4) administering the post-test to assess changes in self-reflection ability. In Week 1, all 67 participants completed the Digital Literacy Scale (DLS) and the self-reflection pre-test questionnaire in a supervised classroom setting. During Weeks 2 and 3, students conducted their microteaching sessions, which were recorded using either 360° cameras (experimental group) or standard video recording (control group). Reflection sessions (60–90 minutes each) were then held, during which participants reviewed their own teaching

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performances using the assigned medium: 360° VR video for the experimental group or PPT-based video for the control group. In Week 4, all participants completed the self-reflection post-test questionnaire under the same controlled conditions.

Data analysis employed a quantitative approach to examine differences in post-test self-reflection scores across learning media and digital literacy level. Descriptive statistics were first used to summarise participant distribution and pre-test–post-test means. Because the study used a pretest–posttest quasi-experimental design, pre-test scores were used to describe baseline conditions and support interpretation of post-test differences, whereas the main inferential analysis focused on post-test self-reflection scores. Before the main analysis, assumption testing was conducted using Shapiro–Wilk for normality and Levene's test for homogeneity of variance. Only one normality-testing procedure is reported here to maintain consistency. These tests were used to determine whether the data met the assumptions for parametric analysis. Because the dependent variable was analysed as a post-test score and the independent variables were categorical, a 2 × 2 factorial ANOVA was used as the main inferential procedure to test the effects of learning media, digital literacy level, and their interaction on students' self-reflection scores. The null hypotheses were tested at a significance level of $\alpha = 0.05$. All analyses were conducted using SPSS version 24.00 for Windows.

3. RESULTS

Digital Literacy Descriptions

The distribution of participants across learning media and digital literacy categories is presented in Table 2. As shown in the table, the experimental group consisted of 32 students, of whom 13 were classified as having low digital literacy and 19 as having high digital literacy. Meanwhile, the control group consisted of 35 students, including 16 students with low digital literacy and 19 students with high digital literacy. When viewed across the whole sample, 29 students were classified as having low digital literacy and 38 students as having high digital literacy, producing a total sample of 67 participants. These table show that the distribution of digital literacy levels was not perfectly equal across the sample, as students classified in the high digital literacy category outnumbered those in the low category (Andrade, 2024). However, the table also indicates that both digital literacy categories were represented in each learning-media condition, meaning that neither the 360° VR group nor the PPT-based group was limited to only one digital literacy profile (Luthfia et al., 2021). This is important because it preserves the internal logic of the 2 × 2 factorial design, in which each level of the first factor (learning media) must coexist with each level of the second factor (digital literacy) in order to allow comparison of both main effects and interaction patterns.

Table 2. Description of Students' Digital Literacy

	Video VR 360°	Video-PPT	Total
Low Digital Literacy	13	16	29
High Digital Literacy	19	19	38
Total	**32**	**35**	**67**

From an analytical perspective, the data in Table 2 suggest that the study had a sufficiently distributed structure to examine whether self-reflection outcomes differed not only by type of reflection media but also by digital literacy level, and whether the relationship between these two variables varied across groups. The near balance in the high digital literacy subgroup across both media conditions (19 students in the 360° VR group and 19 students in the PPT-based group) is particularly useful because it reduces the likelihood that the comparison at this level was distorted by highly unequal subgroup size. Although the low digital literacy subgroup was slightly smaller in the experimental group (13 students) than in the control group (16 students), the difference was still moderate rather than extreme, and both cells remained adequately populated for factorial comparison. In substantive terms, these data indicate that the sample included students with differing levels of digital readiness within both treatment conditions, which strengthens the study's ability to explore whether the effectiveness of 360° VR video may vary according to students' digital literacy. Therefore, the distribution shown in Table 2 does not by itself provide evidence of outcome differences, but it establishes an important descriptive foundation for

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the subsequent inferential analysis by showing that the factorial grouping structure was present and analytically workable.

Descriptive Statistics of Self-Reflection Scores

Descriptive statistics for students' self-reflection scores before and after the intervention are presented in Table 3. Overall, the table shows a consistent increase in self-reflection scores from pre-test to post-test across all groups, indicating that students in both learning-media conditions demonstrated improvement after participating in the reflection activities. However, the magnitude of improvement was not uniform across media type and digital literacy level. In the 360° VR video condition, students with low digital literacy improved from a pre-test mean of 68.54 to a post-test mean of 78.77, while those with high digital literacy improved from 70.26 to 78.68. This means that both subgroups in the 360° VR condition achieved post-test scores at a similarly high level, despite beginning from slightly different pre-test positions. In the PPT-based video condition, students with low digital literacy improved from 65.75 to 73.19, whereas students with high digital literacy improved from 66.53 to 76.26. These values indicate that improvement also occurred in the conventional reflection condition, but the post-test scores remained lower overall than those observed in the 360° VR condition. When viewed at the group-total level, the mean self-reflection score in the 360° VR group increased from 69.40 at pre-test to 77.23 at post-test, while the mean score in the PPT-based group increased from 66.14 to 74.73. Descriptively, these patterns suggest that both media supported reflective growth, but the 360° VR condition was associated with the higher final outcome.

Table 3. Mean Scores of Self-Reflection Ability Before and After the Treatment

Learning Media	*Literasi Digital*	*Pretest Mean* (M)	*Posttest Mean* (M)	N
Video VR 360°	*Low Digital Literacy*	68.54	78,77	13
	High Digital Literacy	70.26	78,68	19
	Total	**69.40**	**77.23**	**32**
Video-PPT	*Low Digital Literacy*	65.75	73.19	16
	High Digital Literacy	66.53	76.26	19
	Total	**66.14**	**74.73**	**35**

A closer reading of Table 3 also reveals a more nuanced pattern that is relevant to the study's factorial design. First, the 360° VR group not only started with a somewhat higher overall pre-test mean than the PPT-based group (69.40 versus 66.14), but also maintained a higher post-test mean (77.23 versus 74.73). Second, within both media conditions, students with high digital literacy generally achieved stronger post-test performance than those with low digital literacy, especially in the PPT-based condition, where the post-test difference between the two digital literacy groups was more visible (76.26 versus 73.19). Interestingly, in the 360° VR condition, the post-test scores of low- and high-digital-literacy students were very close (78.77 and 78.68), suggesting that the 360° VR format may have supported strong reflective outcomes across both literacy groups at the descriptive level. At the same time, these descriptive statistics should be interpreted cautiously because they do not by themselves establish statistical significance (Atal et al., 2024; Schroeder et al., 2023). Rather, they provide an initial picture of the score distribution and indicate three important tendencies: (1) self-reflection scores improved in all groups from pre-test to post-test, (2) the 360° VR group achieved higher post-test means than the PPT-based group, and (3) digital literacy appears to be related to outcome differences, although the exact pattern requires confirmation through inferential analysis. Thus, the data in Table 3 serve as an important descriptive foundation for the subsequent factorial ANOVA by showing how self-reflection scores varied across media conditions and digital literacy levels before formal hypothesis testing was conducted (Richter et al., 2022; Andrade, 2024).

Hypothesis Testing

To test the research hypotheses, a 2 × 2 factorial ANOVA was conducted on post-test self-reflection scores, with learning media (360° VR vs. PPT-based video) and digital literacy level (high vs. low) as the independent variables. This analysis was intended to determine whether post-intervention self-reflection

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differed according to the type of reflection media used, the level of students' digital literacy, and the combination of both factors. As shown in Table 4, the overall ANOVA model was statistically significant, with a Corrected Model F-value of 31.172 and an R^2 of .597 (Adjusted R^2 = .578), indicating that the set of predictors included in the model accounted for a substantial proportion of variance in students' post-test self-reflection scores. In substantive terms, this suggests that the combination of learning media, digital literacy, and their interaction explained a considerable part of the observed differences in post-test reflective outcomes among participants. The model therefore provided adequate inferential support for examining the three research hypotheses, rather than relying only on descriptive comparisons of mean scores.

Table 4. Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	332.221[a]	3	110.740	31.172	.000
Intercept	392203.066	1	392203.066	110401.145	.000
Learning Media VR 360°	265.645	1	265.645	74.776	.000
Digital_Literacy	31.795	1	31.795	8.950	.004
Learning Media VR360° Digital_Literacy	47.806	1	47.806	13.457	.001
Error	223.809	63	3.553		
Total	394725.000	67			
Corrected Total	556.030	66			
a. R Squared = .597 (Adjusted R Squared = .578)					

Table 4 shows that all three focal effects were statistically significant. A significant main effect of learning media was found, F(1, 63) = 74.776, p < .001, indicating that students in the 360° VR video group achieved significantly higher post-test self-reflection scores than those in the PPT-based video group. This result suggests that the type of reflection medium was strongly associated with differences in reflective outcomes after the intervention. A significant main effect of digital literacy was also found, F(1, 63) = 8.950, p = .004, indicating that students classified as having high digital literacy obtained significantly higher post-test self-reflection scores than those classified as having low digital literacy. This finding implies that learner readiness in the form of digital literacy was also related to reflective performance. In addition, a significant interaction effect emerged between learning media and digital literacy level, F(1, 63) = 13.457, p = .001. This indicates that the effect of learning media on self-reflection was not uniform across all students, but varied depending on digital literacy level. In other words, the difference between 360° VR video and PPT-based video was conditioned by whether students belonged to the high or low digital literacy group (Richter et al., 2022; Daltoè et al., 2024). Taken together, these results indicate that post-test self-reflection scores were significantly associated with both the reflection medium and students' digital literacy level, and that the relative advantage of 360° VR video differed across digital literacy categories. On this basis, all three null hypotheses were rejected.

4. DISCUSSION

The Contribution of 360° VR Video to Self-Reflection in Microteaching

The findings reported in Table 4 show a significant main effect of learning media, F(1, 63) = 74.776, p < .001, indicating that students who used 360° VR video achieved significantly higher post-test self-reflection scores than those who used PPT-based video. This inferential result is consistent with the descriptive pattern shown in Table 3, where the overall post-test mean in the 360° VR group reached 77.23, compared with 74.73 in the PPT-based group. The pre-test means were also somewhat higher in the 360° VR group (69.40) than in the PPT-based group (66.14), but the post-test pattern still indicates that the 360° VR condition ended with the stronger reflective outcome (Walshe & Driven, 2019). Taken descriptively, these data suggest that both groups improved from pre-test to post-test, yet the group using 360° VR video reached the higher final level of self-

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reflection. Thus, the statistical and descriptive evidence points in the same direction: the immersive reflection medium was associated with stronger post-intervention reflective performance (Van der Want & Visscher, 2024).

A plausible explanation for this pattern is that 360° VR video offered broader observational access to classroom events than PPT-based video. In microteaching, self-reflection depends not only on remembering what was taught, but also on revisiting how teaching unfolded in space, including body positioning, non-verbal cues, and student responses (Rosendahl & Wagner, 2023). The 360° VR format may therefore have enabled students to re-examine their teaching performance more comprehensively than a two-dimensional format that presents only selected frames or guided slides (Zohrabi & Xodabande, 2024; Nduagbo & Casale, 2023). This interpretation is consistent with prior work suggesting that immersive video can strengthen reflective thinking and professional awareness by expanding the learner's visual and situational perspective (Van der Want & Visscher, 2024; Kosko et al., 2022; Atal et al., 2024). At the same time, the present study did not directly measure noticing processes, attentional focus, or reflective depth as separate constructs. For that reason, the data support the conclusion that the 360° VR condition was associated with higher self-reflection scores, but they do not by themselves prove the exact mechanism through which this advantage emerged.

The Role of Digital Literacy in Shaping Reflective Outcomes

The results in Table 4 also indicate a significant main effect of digital literacy, $F(1, 63) = 8.950$, $p = .004$, showing that students classified as having high digital literacy achieved significantly higher post-test self-reflection scores than those classified as having low digital literacy. This result suggests that learner readiness in the form of digital literacy was meaningfully related to reflective performance in a technology-supported microteaching environment. Although the ANOVA result establishes the inferential significance of this factor, the descriptive values in Table 3 help clarify how the pattern appeared across groups. In the PPT-based condition, students with high digital literacy obtained a post-test mean of 76.26, while those with low digital literacy obtained 73.19. In the 360° VR condition, the corresponding post-test means were 78.68 for high digital literacy and 78.77 for low digital literacy. These values indicate that digital literacy was associated with post-test differences overall, but that the pattern varied by media condition (Andrade, 2024).

Conceptually, this main effect can be interpreted as evidence that digital literacy may shape how effectively students engage with reflection media. Digital literacy is relevant not only because it enables technical access to digital tools, but also because it may support more effective navigation, interpretation, and critical use of mediated learning artefacts (Richter et al., 2022). Students with stronger digital literacy may be better able to interact with video-based reflection tools, revisit teaching events, identify relevant pedagogical moments, and translate those observations into reflective judgments (Walshe & Driver, 2019). This interpretation is broadly consistent with literature emphasising the role of digital literacy in supporting critical engagement with digital environments and mediated learning processes (Getenet, 2024; McGarr, 2024). Even so, the present finding should be interpreted cautiously. Digital literacy in this study was not experimentally manipulated, but classified into high and low categories. Therefore, the data support an association between digital literacy level and self-reflection outcomes, rather than a claim that digital literacy itself was causally altered or directly produced higher reflection (Richter et al., 2022).

The Interaction Effect Between Learning Video Media and Digital Literacy on Self-Reflection Ability

The most conceptually important result appears in the significant interaction reported in Table 4, $F(1, 63) = 13.457$, $p = .001$. This indicates that the effect of learning media on self-reflection was not identical across students, but differed according to digital literacy level. However, this interaction must be interpreted with care and in direct relation to the subgroup means in Table 3 and the pattern illustrated in Figure 1. The descriptive means do not show that 360° VR was dramatically stronger only among students with high digital literacy. Instead, the 360° VR condition appears highly stable across both literacy groups: students with low digital literacy reached a post-test mean of 78.77, while those with high digital literacy reached 78.68. By contrast, the PPT-based condition shows a clearer digital-literacy gap, with students in the high digital literacy group scoring 76.26 and those in the low digital literacy group scoring 73.19 (Andrade, 2024; Walshe & Driver, 2019; Atal et al., 2024).

This pattern suggests a more nuanced interpretation of the interaction. Rather than showing that the benefits of 360° VR were amplified only when digital literacy was high, the results more plausibly suggest that 360° VR may have reduced the gap associated with digital literacy. In other words, under the 360° VR condition,

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students with lower digital literacy performed at almost the same level as those with higher digital literacy, whereas under the PPT-based condition, differences according to digital literacy remained more visible (Richter et al., 2022; Walshe & Driver, 2019). This interpretation is also more consistent with Figure 1, which visually represents the interaction between media type and digital literacy. Although the figure indicates that the two factors jointly shaped self-reflection outcomes, the observed subgroup means imply that the interaction is better understood as a pattern of stabilisation across literacy levels in the VR condition rather than a simple "high literacy amplifies VR" effect (Richter et al., 2022; Schroeder et al., 2023). This distinction is important because it changes the practical meaning of the finding. The data suggest that immersive reflection media may provide a more supportive environment for reflective practice across different levels of digital readiness, rather than benefiting only students who are already digitally strong (Richter et al., 2022).

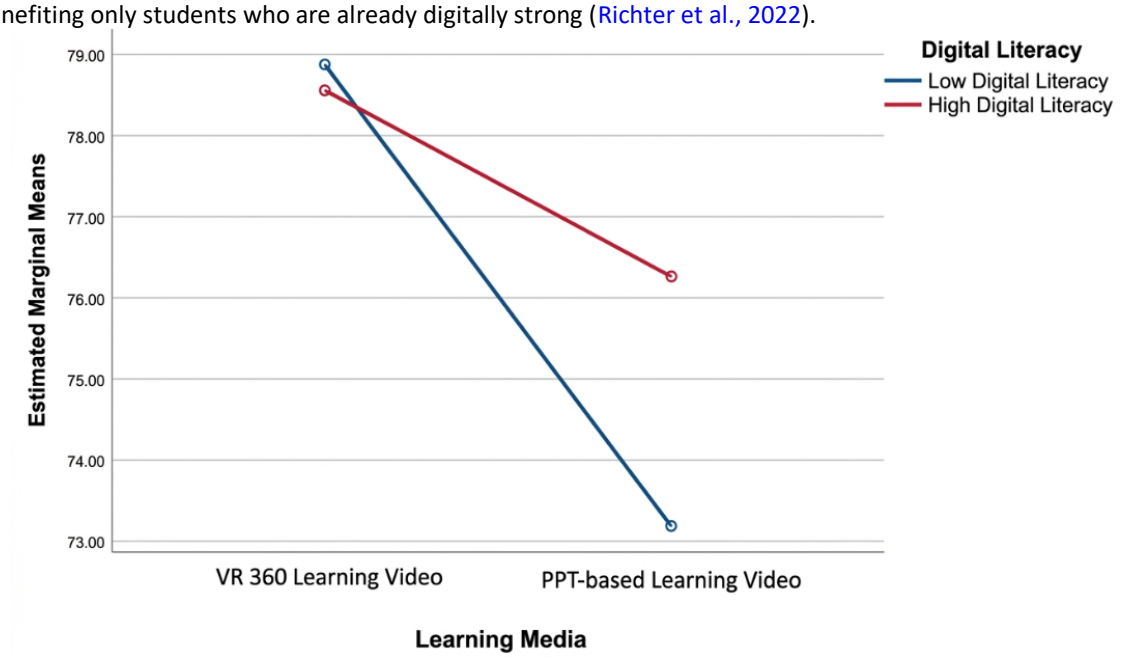

Figure 1. Mean Posttest Plot Showing the Interaction Between Variables.

The Pedagogical Meaning of The Interaction Pattern

When the subgroup means in Table 3, the inferential results in Table 4, and the visual pattern in Figure 1 are read together, a more balanced pedagogical interpretation becomes possible. The 360° VR format appears to have supported strong post-test self-reflection outcomes in both the low and high digital literacy groups, with means of 78.77 and 78.68, respectively. This near-identical pattern suggests that the immersive medium may have provided sufficient observational support for students regardless of whether they entered the study with relatively lower or higher digital literacy. In contrast, the PPT-based condition yielded lower post-test outcomes overall and showed greater divergence by digital literacy level, with a gap of more than 3 points between the low and high literacy groups (73.19 vs 76.26). From a pedagogical standpoint, this may imply that the more conventional medium required stronger digital readiness in order to be used optimally as a reflective tool, whereas the 360° VR medium may have been more robust across learner profiles (Schroeder et al., 2023; Richter et al., 2022).

This interpretation should still be treated cautiously. The interaction result identifies a statistically significant dependency between media type and digital literacy, but it does not prove why that dependency occurred (Walshe & Driver, 2019). The study did not directly measure how students navigated the VR environment, how much they used specific media features, or whether students in different digital literacy groups focused on different aspects of their teaching performance. Accordingly, the discussion should not claim that VR directly developed digital literacy, nor that digital literacy definitively mediated the treatment effect. What the data do show is that the combination of learning media and digital literacy mattered, and that this combination was reflected in different post-test patterns across the subgroups shown in Table 3 and Figure 1.

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This makes the interaction effect one of the study's strongest contributions, but also one that requires disciplined interpretation (Daltoè et al., 2024; Richter et al., 2022).

Implications, Limitations and Directions for Future Research

The results carry several implications for teacher education. First, the consistently higher post-test mean of the 360° VR group in Table 3 (77.23) relative to the PPT-based group (74.73), together with the significant media effect in Table 4, suggests that immersive reflection media may offer practical advantages for microteaching reflection. For teacher education programmes, this means that reflection activities may benefit from moving beyond conventional two-dimensional replay formats toward media that provide broader visual access to the classroom environment. Second, the significant digital literacy effect suggests that technology-based reflection should not be treated as purely a matter of hardware or platform availability. Students' ability to engage with reflective technology meaningfully remains important, and digital literacy support may therefore strengthen the overall effectiveness of reflection activities (Daltoè et al., 2024; Richter et al., 2022). At the same time, the interaction pattern indicates that the relationship between digital literacy and reflective outcomes is not straightforward. Because students with low digital literacy performed very strongly in the 360° VR condition (78.77), the results imply that immersive media may help reduce some of the disadvantage associated with lower digital readiness. This is an important practical point: the use of advanced media in teacher education should not automatically be assumed to privilege only already digitally capable learners. Instead, when designed and facilitated appropriately, immersive tools may provide reflective support across heterogeneous learner profiles. For this reason, a sensible curricular implication is not simply to "add VR," but to integrate immersive reflection activities with structured digital literacy support, so that both media affordances and learner readiness are addressed in a complementary way (Daltoè et al., 2024; Schroeder et al., 2023).

Several limitations should be acknowledged when interpreting these findings. First, the study used a quasi-experimental design with intact classes, which means that the differences reported in Table 4 should be interpreted as statistically significant associations within this design rather than as definitive proof of causal superiority. Second, although Table 3 provides valuable descriptive pre-test information, the main inferential model focused on post-test scores, so the baseline was not incorporated as directly as it would be in an ANCOVA or repeated-measures framework. Third, the sample was limited to 67 pre-service teachers from a single institution, which restricts generalisability. Fourth, the outcome measure was a structured self-reflection questionnaire, which captures reflective judgment in a useful but still bounded form and does not fully represent the richness of reflective discourse (Andrade, 2024). The study also remains open to several internal-validity concerns already identified in the manuscript. Novelty effects associated with VR, technical differences in recording and replay conditions, and possible variation in students' comfort with headset use may all have influenced performance independently of the pedagogical value of the medium itself. Future research would benefit from larger samples, longer intervention periods, pretest-adjusted models, and multiple measures of reflection, including journals, stimulated recall, interviews, or observation-based coding. It would also be valuable to analyse in greater detail how students with different digital literacy profiles actually interact with immersive reflection media (Walshe & Driver, 2019; Atal et al., 2024; Schroeder et al., 2023). Such work would help clarify whether the pattern seen in Figure 1 and the subgroup means in Table 3 reflects differences in navigation behaviour, attentional focus, interpretive strategy, or other mechanisms not directly measured in the present study.

5. CONCLUSION

This study suggests that 360° VR video may provide a stronger reflective medium than conventional PPT-based video for pre-service teachers during microteaching. As shown in Table 3, students in the 360° VR group obtained a higher overall post-test mean (77.23) than those in the PPT-based group (74.73), and this difference was supported by the significant main effect of learning media reported in Table 4, $F(1, 63) = 74.776$, $p < .001$. The findings also indicate that digital literacy was significantly associated with self-reflection outcomes, as students classified as having high digital literacy achieved higher post-test scores than those classified as having low digital literacy, $F(1, 63) = 8.950$, $p = .004$. In addition, the significant interaction effect shown in Table 4, $F(1, 63) = 13.457$, $p = .001$, and illustrated in Figure 1, suggests that the relationship between learning media and self-

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reflection differed across digital literacy levels. However, when interpreted together with the subgroup means in Table 3, this interaction is better understood as indicating that the advantage of 360° VR video was relatively stable across digital literacy levels, while the PPT-based condition showed greater variation by digital literacy, rather than as evidence that VR benefited only students with higher digital literacy.

These findings can be interpreted through reflective and experiential learning perspectives, particularly in relation to how immersive media may support richer observation of teaching practice during microteaching. At a practical level, the study suggests that teacher education programmes may benefit from integrating 360° VR-based reflection activities with support for digital literacy, so that students can engage more effectively with reflective technologies. At the same time, the conclusions of this study should be interpreted within the limits of the research design. The sample was drawn from a single institution, the study used a quasi-experimental design with intact classes, and the outcome variable was measured through a structured self-reflection instrument rather than more open qualitative evidence. Future research should therefore use larger and more diverse samples, apply stronger pretest-adjusted or longitudinal designs, and combine quantitative and qualitative measures to examine how immersive media and digital literacy jointly shape reflective practice and its transfer to actual classroom teaching.

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7. REFERENCES

Andrade, C. (2024). Understanding factorial designs, main effects, and interaction effects: Simply explained with a worked example. *Indian Journal of Psychological Medicine*, *46*(2), 175–177. https://doi.org/10.1177/0253717624123706

Arefian, M. H. (2022). Collaborative action research as a reflective tool for pre-service EFL teachers' inclusion. *Reflective Practice*, 23(6), 651–662. https://doi.org/10.1080/14623943.2022.2103107

Atal, D., Admiraal, W., & Saab, N. (2023). 360° video in teacher education: A systematic review of why and how it is used in teacher education. *Teaching and Teacher Education*, 135, Article 104349. https://doi.org/10.1016/j.tate.2023.104349

Atal, D., Admiraal, W., & Saab, N. (2024). Effects of 360 video virtual reality-supported reflection on student teachers' classroom management self-efficacy and their stress levels. *Teaching and Teacher Education*, 144, Article 104573. https://doi.org/10.1016/j.tate.2024.104573

Baysan, A., Çonoğlu, G., Özkütük, N., & Orgun, F. (2023). Come and see through my eyes: A systematic review of 360-degree video technology in nursing education. *Nurse Education Today*, 128, Article 105880. https://doi.org/10.1016/j.nedt.2023.105886

Chang, C. Y., Kuo, H. C., & Du, Z. (2023). The role of digital literacy in augmented, virtual, and mixed reality in popular science education: A review study and an educational framework ., APA 7th editiondevelopment. Virtual Reality, 27(3), 2461–2479. https://doi.org/10.1007/s10055-023-00817-9

Conrad, M., Kablitz, D., & Schumann, S. (2024). Learning effectiveness of immersive virtual reality in education and training: A systematic review of findings. Computers & Education: X Reality, 4, Article 100053. https://doi.org/10.1016/j.cexr.2024.100053

Cross, S., Wolfenden, F., & Adinolfi, L. (2022). Taking in the complete picture: Framing the use of 360-degree video for teacher education practice and research. Teaching and Teacher Education, 111, Article 103597. https://doi.org/10.1016/j.tate.2021.103597

Daltoè, T., Ruth-Herbein, E., Brucker, B., Jaekel, A.-K., Trautwein, U., Fauth, B., Göllner, R., & Praetorius, A.-K. (2024). Immersive insights: Unveiling the impact of 360-degree videos on preservice teachers' classroom

p-ISSN: 2597-7792 / e-ISSN: 2549-8525
DOI: https://doi.org/10.20961/ijpte.v10i1.111818

observation experiences and teaching-quality ratings. Computers & Education, 213, 104976. https://doi.org/10.1016/j.compedu.2023.104976

Dhimolea, T. K., Kaplan-Rakowski, R., & Lin, L. (2022). A systematic review of research on high-immersion virtual reality for language learning. *TechTrends*, 66(5), 810–824. https://doi.org/10.1007/s11528-022-00717-w

Fisseler, B. (2024). Digital accessibility literacy: A conceptual framework for training on digital accessibility (arXiv:2410.11931). arXiv. https://doi.org/10.48550/arXiv.2410.11931

Getenet, S. (2024). First-year preservice teachers' understanding of digital technologies: Implications for teacher education programs. Technology, Knowledge and Learning. Advance online publication. https://doi.org/10.1007/s10758-023-09724-z

Gopalan, M., Rosinger, K., & Ahn, J. B. (2023). Use of quasi-experimental research designs in education research: Growth, promise, and challenges. *Education Finance and Policy*, 18(2), 277–301. https://doi.org/10.3102/0091732X20903302.

Gordon, S. P. (2022). Integrating the Experiential Learning Cycle with Clinical Supervision. Journal of Educational Supervision, 5(1), 1–13. https://doi.org/10.31045/jes.5.1.1

Hatton, N., & Smith, D. (1995). Reflection in teacher education: Towards definition and implementation. *Teaching and Teacher Education*, 11(1), 23–32. https://doi.org/10.1016/0742-051X(94)00012-U

INTEF. (2022). *Spanish framework for the digital competence of teachers*. Ministry of Education and Vocational Training. https://intef.es/wp-content/uploads/2023/04/English-SFDCT_2022.pdf.

Kosko, K. W., Heisler, J., & Gandolfi, E. (2022). Using 360-degree video to explore teachers' professional noticing. *Computers & Education*, 180, Article 104443. https://doi.org/10.1016/j.compedu.2022.104443

Lee, S.-M., & Wu, J. (2024). Preparing teachers for the future: Microteaching in the immersive VR environment. *ReCALL*, 36, 252–267. https://doi.org/10.1017/S0958344024000089

Lampropoulos, G., & Kinshuk. (2024). Virtual reality and gamification in education: A systematic review. Educational Technology Research and Development, 72, 1691–1785. https://doi.org/10.1007/s11423-024-10351-3

Luthfia, A., Wibowo, D., Anggia, M., & Angeline, M. (2021). The role of digital literacy on online opportunity and online risk in Indonesian youth. *Asian Journal for Public Opinion Research, 9*(2), 142–160. https://doi.org/10.15206/ajpor.2021.9.2.142

Maguire, K. R. (2023). Pre-service teachers' reflections on content knowledge through microteaching. *Reflective Practice*, *24*(2), 153–167. https://doi.org/10.1080/14623943.2022.2146082

McGarr, O. (2024). Exploring and reflecting on the influences that shape pre-service teachers' digital competence. Journal of Education for Teaching, 50(2), 1–17. https://doi.org/10.1080/13540602.2024.2313641

Menon, D., & Ngugi, R. (2022). Preservice secondary STEM teachers' reflective practice in microteaching: An analysis of journal writing and video-mediated reflections. Teacher Education Quarterly, 49(1), 29–52. https://www.jstor.org/stable/27118191

Nduagbo, K., & Casale, C. (2023). Preservice teachers' reflective practices, self-efficacy, and professional growth. ELTHE: Educational Leadership and Teaching in Higher Education, 6(1), 56–72. https://doi.org/10.46787/elthe.v6i1.3555

Qian, J., Shang, J., & Qin, L. (2023). A systematic scoping review of 360-degree videos in teacher education. *Journal of Research in Innovative Teaching & Learning*, 16(1), 20–38. https://doi.org/10.1108/JRIT-03-2023-0029

p-ISSN: 2597-7792 / e-ISSN: 2549-8525
DOI: https://doi.org/10.20961/ijpte.v10i1.111818

Radianti, J., Majchrzak, T. A., Fromm, J., & Wohlgenannt, I. (2020). A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda. Computers & Education, 147, Article 103778. https://doi.org/10.1016/j.compedu.2019.103778

Richter, E., Hußner, I., Huang, Y., Richter, D., & Lazarides, R. (2022). Video-based reflection in teacher education: Comparing virtual reality and real classroom videos. Computers & Education, 190, 104601. https://doi.org/10.1016/j.compedu.2022.104601

Roche, L., & Gal-Petitfaux, N. (2017). Using 360° video in physical education teacher education. In *Proceedings of the Society for Information Technology & Teacher Education International Conference* (pp. 2012–2016). https://www.learntechlib.org/primary/p/178219/

Rosendahl, P., & Wagner, I. (2023). 360° videos in education – a systematic literature review on application areas and future potentials. *Education and Information Technologies*, 29, 1319–1355. https://doi.org/10.1007/s10639-022-11549-9

Schroeder, N. L., Siegle, R. F., & Craig, S. D. (2023). A meta-analysis on learning from 360° video. Computers & Education, 206, 104901. https://doi.org/10.1016/j.compedu.2023.104901

Snelson, C., & Hsu, Y.-C. (2019). Educational 360-degree videos in virtual reality: A scoping review of the emerging research. *TechTrends*, 63(4), 404–412. https://doi.org/10.1007/s11528-019-00474-3

Stefanski, H., & Ibrahim, M. (2024). Enhancing critical reflection in preservice teacher internships: Examining the impact of 360-degree video and VR technology. *International Journal of Modern Education Studies*, 8(2), 319–340. https://doi.org/10.51383/ijonmes.2024.379

Taggart, S., Roulston, S., Brown, M., Donlon, E., Cowan, P., Farrell, R., & Campbell, A. (2023). Virtual and augmented reality and pre-service teachers: Makers from muggles?. *Australasian Journal of Educational Technology*, *39*(3), 1–16. https://doi.org/10.14742/ajet.8610

van der Linden, S., Voerman, D., & McKenney, S. (2022). ReDesign of a teacher reflection formative assessment tool. In *Proceedings of the 18th International Conference of the Learning Sciences (ICLS)* (pp. 2029–2032). https://doi.org/10.22318/icls2024.605286

Van der Want, A. C., & Visscher, A. J. (2024). Virtual reality in preservice teacher education: Core features, advantages and effects. *Education Sciences*, 14(6), Article 635. https://doi.org/10.3390/educsci14060635

Vuorikari, R., Kluzer, S., & Punie, Y. (2022). *DigComp 2.2: The digital competence framework for citizens—With new examples of knowledge, skills and attitudes*. Publications Office of the European Union. https://doi.org/10.2760/115376

Vuorikari, R., Punie, Y., Gomez, S. C., & Van Den Brande, G. (2016). *DigComp 2.0: The digital competence framework for citizens. Update phase 1: The conceptual reference model* (EUR 27948 EN). Publications Office of the European Union. https://doi.org/10.2791/11517

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

Wetcho, S., & Na-Songkhla, J. (2021). Fostering pre-service teachers' reflection in self-regulatory process through socio-emotional collaborative note-taking in the mCSCL environment. Contemporary Educational Technology, 13(4), Article ep319. https://doi.org/10.30935/cedtech/11074

Zohrabi, M., & Xodabande, I. (2024). Reflective practice as a tool for teacher education: A comparison between individual and peer reflection of Iranian EFL teachers. *Discover Education*, 3, Article 225. https://doi.org/10.1007/s44217-024-00338-w

p-ISSN: 2597-7792 / e-ISSN: 2549-8525
DOI: https://doi.org/10.20961/ijpte.v10i1.111818