VIDEO-BASED MATHEMATICS TEACHER TRAINING: A COMPARISON OF REAL CLASSROOM VIDEOS AND VIRTUAL REALITY

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ABSTRACT

Despite the promise of virtual reality (VR) videos to provide reflective opportunities analogous to those afforded by real-world classroom recordings, there has been scant research on its usage in teacher education to date. In this quasi-experimental study, we compared the effects of two distinct stimuli used for student teachers' reflections on their teaching. This mixed-methods study investigated how participants' perceptions of their own abilities to engage in reflective thinking changed over time. Twenty-three preservice instructors watched a genuine classroom film and compared it to 46 who watched a virtual reality version. Only the VR group saw a gain in self-efficacy related to reflection over time. We also discovered that, like traditional classroom videos, VR videos prompted participants to engage in self-reflection. This research is the first to show that reflecting on VR classroom footage yields similar outcomes as reflecting on actual classroom videos in mathematics. This demonstrates the viability of VR for use in teacher education and its potential value as a tool for education professionals.

Keywords: *virtual reality, learning design, educational technology, reflective thinking*

INTRODUCTION

According to Schön (1992) and Vermunt and Endedijk (2011), one of the most significant prerequisites for the professional development of teachers is the ability to reflect on their own teaching. This is why teacher education programs work hard to help their student teachers develop critical thinking skills through guided reflection on their classroom experiences. Videos are helpful in fostering instructors' capacities for reflective practice, as evidenced by evaluations of the literature on the topic (Gaudin & Chaliès, 2015; Hamel & Viau-Guay, 2019). These analyses have shown that films are a useful tool for enhancing teachers' capacities to reflect on their own teaching practices. In particular, videos of student teachers teaching might be helpful for teacher reflection (Prilop et al., 2021; Tripp & Rich, 2012). On the other hand, because of worries about the privacy of the data and the requirement for informed consent from each individual teacher (Gaudin & Chaliès, 2015), filming real classroom footage can be a difficult task. When schools were closed because of the COVID-19 pandemic and not accessible to student instructors (Kidd & Murray, 2020), this difficulty became more obvious.

The challenges associated with filming in actual classrooms can be circumvented with the help of virtual reality (VR), which gives aspiring educators the chance to hone their skills in a setting that simulates a classroom, complete with student avatars, and receive feedback on how they are doing as instructors. Furthermore, fully immersive VR classrooms make it possible for student instructors to have authentic classroom experiences even when schools are closed or when there are logistical challenges, such as protecting students' privacy or gaining access to classrooms (Huang et al., 2021).

Also, VR can easily record student teachers' classroom experiences and their perspective. The ability to produce first-person-perspective videos, in which a scene is viewed from the individual's own perspective as opposed to a third-person perspective (Blakemore & Choudhury, 2006; Mayer et al., 2020), is an essential argument for employing virtual reality tools to encourage educator introspection. Research on the effectiveness of first-person virtual reality films for introducing and refining the skill of video-based reflection in preservice teachers is sparse. (Huang et al., 2023). This is because the use of VR technology in teacher education is still in its infancy.

This research aims to contribute to the current body of literature on the reflective abilities of student teachers and the use of videos in mathematics teacher education, as well as to fill the void that had previously been identified. To begin, we explored the impact that engaging in reflective activities, either through virtual reality or actual classroom films, has on changes in the levels of self-efficacy that student instructors have regarding reflection. Second, we analyzed the similarities and differences in student teachers' written responses to their experiences in the virtual reality and authentic video discussion groups in the classroom. Our findings contribute to the expansion of existing information on the application of virtual reality classroom films to the creation of possibilities in the field of teacher training for video-based introspection. In particular, our findings extend previous results regarding the use of VR classroom videos and provide opportunities for video-based reflection on mathematics teacher education. These findings clarify the effects of VR videos on self-efficacy beliefs related to student teachers' reflection.

Teacher Practice with Regard to Reflection

According to Dewey (1933), reflection is an approach to problem-solving that systematically considers one's own opinions about the problem and potential solutions. Tripp and Rich (2012) elaborated on this concept by defining teacher training programs that encourage reflective practice as "self-reflective inquiry into how one's educational choices have shaped one's current teaching context, with the ultimate goal of enhancing that context" (p. ???). Teacher reflection, in this sense, is the process through which educators evaluate and improve their own methods of instruction (Korthagen, 2010).

It is common knowledge that engaging in reflective practice is an essential component of professional advancement for educators (Van Velzen, 2017; Ward, 2021), as it helps both preservice and in-service educators learn from their experiences in the classroom (Svojanovsky, 2017). The reflective approach helps teachers become more self-aware by having them assess, observe, and interpret their experiences.

Some theoretical frameworks define reflection as teachers describing their teaching, while others define it as a deep investigation of classroom settings. Others such as Korthagen and Kessels (1999) and Liang (2023) focus on answering a set of questions or responding to a set of prompts. Introspective training, however, is a method that entails various steps and is related to various objects (Körkkö et al., 2016). In their 2016 study, Kleinknecht and Gröschner (2016) distinguished between three stages of reflective practice: In this activity, preservice educators explain a scenario (description), interpret their own actions (interpretation), and design potential solutions to the problem at hand (alternatives). Gamoran Sherin and Van Es (2009) proposed three possible areas of focus for reflections: teacher actions, student actions, and the learning environment. Several studies, such as Santagata and Guarino (2011), have conducted empirical content analyses of written reflections by preservice and in-service educators analyzing a single lesson plan to probe several facets of the teaching process.

Positive benefits on both teachers and their students have been documented in studies on the effects of reflective teaching. According to research by Gold et al. (2017), educators can improve their confidence in their own classroom management skills by watching and reflecting on recordings of themselves and other educators at work. Kersting et al. (2012) found that student instructors' ability to identify alternative instructional tactics when analyzing classroom videos was positively related to students' proficiency in mathematics. There was a correlation between student instructors' pedagogical efficacy and with their level of reflection and their openness to trying new approaches to the classroom (Powell & Bodur, 2019). In sum, the findings of this line of inquiry suggest that

introspective methods can enhance the quality of teaching demonstrated by student teachers and even have an effect on the outcomes of their students' education.

Some studies have looked at what kinds of teachers are more likely to adopt reflective practices. Teachers' reflective practices are affected by intrinsic characteristics including reflection-related self-efficacy (Gamoran Sherin & Van Es, 2009). Self-efficacy is defined as a teacher's confidence in their own abilities to complete a certain task (Bandura, 1977). When this concept was applied to the act of reflection, Gamoran Sherin and Van Es (2009) showed that reflective teachers had higher levels of self-efficacy that differs from teacher self-efficacy in other contexts. Furthermore, they discovered an inverse correlation between teachers' sense of emotional tiredness and their ability to reflect on their own practice. We zeroed in on reflection-related self-efficacy to see if it might be cultivated through a variety of educational channels given its significance in instructors' instructional practice.

Application of Video-Reflection to Improve Student Instructors' Skills

Student instructors may benefit from video-based reflection, as suggested by numerous studies (Fuller & Manning, 1973; Gaudin & Chaliès, 2015; Weber et al., 2018). Videos can be used by both preservice and practicing instructors as pedagogical discussion and analysis launching pads (Borko et al., 2011). There is a wealth of literature supporting the use of video in teacher education to foster reflective practices (Schaepkens et al., 2022; Weber et al., 2018). Hixon and So (2009) discovered that student teachers who took a university course based on video cases reflected more deeply on their practice and considered factors such as the impact of instruction on students' conceptualizations of the material. Studies contrasting reflective video viewing with reflective viewing of other media further demonstrate video-based introspection's potential. Video-based reflection, as opposed to recall-based reflection, was shown by Rosaen et al. (2008) to help preservice teachers change their focus of reflection from surface-level classroom aspects to pedagogical challenges.

While there is some evidence that using videos can help aspiring educators become more reflective, the factors that actually prompt this behavior remain largely unknown. Motive is increased through video-based reflection on instruction (Gaudin & Chaliès, 2015). Additionally, Marsh and Mitchell (2014) demonstrated that evaluating one's own performance in the classrooms of unknown teachers using video reflection led to greater emotional-motivational engagement. While these findings are broad in scope, it is not yet known whether or not video-based reflection can increase confidence in one's ability to reflect. However, the answer to this question is significant since confidence in one's own ability to learn is linked to successful instruction (Klassen & Tze, 2014). This study set out to determine if showing movies in the classroom or using virtual reality videos could improve students' confidence in their own ability to reflect on their performance.

Processes of Reflection and Reflection Videos

Research comparing how teachers reflect on their own classrooms to how they reflect on the classrooms of other teachers yields mixed results. For instance, written responses to student instructors' own videos and those of other teachers were compared, Kücholl and Lazarides (2021) discovered no distinctions were found between the describing, interpreting, and forming alternate strategies reflection tasks. To the contrary, Seidel et al. (2011) found that teachers were less likely to offer critical feedback or suggest improvements when evaluating their own performance compared to instructors evaluating the performance of a colleague. Educators whose published responses centered on a colleague's classroom video reported on teacher in the video's activities in greater and more specific detail than those who cared just about their own lessons, and they were more likely to consider different ways of coping with adversity in the classroom. In sum, the results of the studies that were cited above do not paint a distinct image of how thoughts on one's own classroom differ from reflections on the classrooms of others.

Real classroom movies can be hard to come by, but they are often utilized in teacher training for reflection purposes (both the teacher's own and other teachers'). This is first and foremost because of moral concerns and the necessity of informed consent from the student educators involved (Derry et al., 2010). Additionally, permission from minor students' parents is needed before filming

them in the classroom. Second, due to the non-anonymous nature of video, there is a danger posed by videotaping students (Derry et al., 2010), therefore, stringent standards are required to ensure the protection of personal information. These problems may be avoided by using recordings of virtual classrooms, which still provide valuable insight into real-world instructional strategies.

Use of VR for Introspective Purposes

Virtual reality technology can be used to imitate either real or hypothetical classroom settings by creating virtual and highly interactive dimensions (Mikropoulos & Natsis, 2011). VR also offers two significant benefits for learning in the form of presence and agency (Radianti et al., 2020; Tang et al., 2022). Further, VR has found widespread use in a variety of areas for teaching both procedural and situational skills. While "being there" is one definition of presence (IJsselsteijn & Riva, 2003), "agency" refers to the experience of taking charge of one's own activities (Moore & Fletcher, 2012). Factors like enjoyment and motivation of learning (Di Natale et al., 2020) or self-efficacy (Huang et al., 2023; Wu et al., 2020) have been found to be positively connected to both presence and agency (Hamilton et al., 2021; Radianti et al., 2020). In addition to providing a setting rich in real-world learning opportunities, VR can be used to sidestep problems like field access and data security.

Virtual reality settings have been used in a variety of professional trainings (Jensen & Konradsen, 2018). However, VR classrooms have just recently been implemented in teacher preparation programs (Huang et al., 2021; McGarr, 2021; Richter et al., 2022). Virtual reality spaces for learning have been created by a number of academic institutions, such as simSchool (Theelen et al., 2019), TLE TeachLivETM (Dalinger et al., 2020), and Mursion (Nesje & Lejonberg, 2022). Teachers-in-training and professionals alike can benefit from virtual reality classrooms by doing two things: (a) engaging in real-world teaching activities in a controlled environment, and (b) honing their craft through flexible training programs that can be tailored to each participant's needs (Huang et al., 2023). Unlike in traditional classrooms, lessons in virtual reality can be easily recorded and used for reflection and review.

There is not enough data to suggest that VR videos are useful for reflective practice in teacher education, even though their features suggest they may be. Virtual reality films have been less studied than traditional classroom videos, and the few studies that did address reflection were not included in two recent survey papers that looked at virtual reality systems as a teaching tool (Huang et al., 2023; Snelson & Hsu, 2020).

The implementation of VR headsets when training educators has recently been shown to be well-received for reflective purposes (Feurstein, 2019) and enable student instructors to participate when taking a deeper look at microteaching (Walshe & Driver, 2019). This accords with the findings of Seufert et al. (2022), who discovered that teachers-in-training viewed VR favorably as a tool for introspective learning and self-evaluation. Stavroulia and Lanitis (2019) studied the differences in preservice teachers' perspectives on reflection between those who had received training in a traditional classroom setting versus an immersive virtual environment. Student educators were more likely to engage in self-reflection when exposed to a virtual reality setting. However, aside from these studies, there is a dearth of investigation into how well VR films activate reflective processes in comparison to real classroom videos, and how this relates to utilizing video analysis. It is also not obvious if the emotional-motivational processes have benefits, such as increased confidence in one's ability to reflect on their own behavior, that are associated with reflecting on virtual reality recordings.

CASE STUDY

To help fill this gap, the current study compared the impacts of student teachers' reflection on films taken in a virtual reality classroom to those filmed in a traditional classroom. In order to do this, we implemented a quasi-experimental design consisting of a pre- and posttest in conjunction with a reflective task. During the reflection task, student teachers either watched their own teaching in a virtual classroom () or watched an unknown teacher teaching in a real classroom (). Without delving deeply into the linked psychological processes, our study is a first step toward a comprehensive comparison of virtual reality and video-based reflections in the field of teacher education. We set out to investigate the following two hypotheses:

a. When comparing the and groups from the start of the required introspection (t1, Week 8) completion of the exercise in introspection (t2, Week 12), how does confidence in one's ability to learn from reflection grow among student teachers?

Previous studies have demonstrated that students can improve their reflective abilities by using video-based reflection (Gaudin & Chaliès, 2015). As a result, we anticipated that there would be an increase in the level of self-efficacy experienced by both groups of student teachers in connection with reflection. Lacking such data, we were unable to speculate on whether or not the shift would be distinct from the shift. Since the student educators in both scenarios saw videos, we hypothesized that they would gain a similar sense of competence.

b. How do the student teachers' written reflections from and compare in terms of reflection activities and reflection content?

Because this is the first study of its kind to contrast two distinct environments for introspection, we were unable to come to any conclusions regarding the differences that exist between the and the groups in terms of the behaviors related to contemplation and the content related to reflection. As a result, we focused solely on identifying potential discrepancies.

METHODS
Research Setting and Methodology

To examine how student teachers' confidence in their own ability to reflect and the quality of their written reflections evolved over time, we utilized a mixed-method, pretest-posttest, quasi-experimental design with two groups. Participants were undergraduates at a public university's teacher education program in Iran. All the participants had earned a bachelor's degree and had taken part in one of two seminars on research methods in K–12 education.

Virtual reality was employed by the group as a teaching tool (Wiepke et al., 2019). In this virtual classroom exercise, student teachers gave individual presentations on a given topic (in this case, COVID-19 vaccinations). In this simulation, future educators monitored the classroom behavior of digital representations of students and corrected them when necessary. About 15 minutes of the teaching activity were videotaped and played back as part of the subsequent reflection assignment. Thirty virtual students were placed in five rows and three columns, just like in a real upper secondary school classroom (Wiepke et al., 2021). Rehearsed activities such as writing in the notebook, conversing with neighbors, and asking questions, were done by the student avatars, who had varying physical characteristics (Huang et al., 2021). To ensure consistency among participants, we scripted the VR activity down to the last detail, including the length of time, as well as the actions of the avatar. Avatars of disobedient students might be stopped, however, by student teachers physically approaching the offending avatar. The HTC VIVE Pro Eye headset was used to transport students into a virtual reality classroom where they could freely move and use all their senses. According to earlier studies using this VR classroom, participants found it to be very lifelike and genuine (Huang et al., 2021; Wiepke et al., 2019). In contrast, the group barely used virtual reality (VR) during the semester.

There were three phases to the study for both sets of participants: (1) At Week 8 (t_i; pretest), all and group students answered a survey inquiring into their self-efficacy beliefs related to reflection after the virtual reality lesson in Week 4 of the semester. (2) A video-based reflection assignment was given to all students during Week 11 of the semester. Individually, students watched the reflection movies that were made available via Moodle, a web-based course management system. Participants in the group viewed first-person recordings they had shot of themselves instructing in a virtual classroom in Week 4. The group watched a real-life, third-person classroom film of an unnamed teacher. Learning by using video in the classroom, each participant chose one rewarding and one difficult experience. Students were instructed to apply the three-step reflection technique to both scenarios (Kleinknecht & Gröschner, 2016). Before beginning the three-step reflection activity, participants in both groups received the same input. The following was provided in the written reflection work instructions:

1. Rather than passing judgment or offering an explanation, simply describe the classroom

setting, the teacher's or individual's actions, and their interactions with students.

2. Give an account of what transpired in the classroom and how the instructor or student's actions and motivations arose from those causes. Assess the instructor's actions in light of their handling of the issue and the features of good instruction.

3. Please suggest other strategies the instructor could have used in this situation.

Following the completion of the reflection task, each participant was given a second online questionnaire to answer regarding their level of self-efficacy in relation to reflection at Week 12 (t_2; posttest).

Participants

In this study, information was gathered from a total of 57 student teachers who were enrolled at a university in Iran (Female = 53.0%). Participants in the group (N = 38, female = 54.6%, M_{age} = 25.31, SD = 5.27) and (N = 19, female = 49.8%, M_{age} = 26.11; SD = 5.83) were, on average, enrolled in the sixth semester of their four-year curriculum leading to a bachelor's degree (: M = 4.52; SD = 2.15; : M = 5.21; SD = 3.24). Participants in the group were student teachers.

The majority of the student teachers in the group were focusing their education on teaching algebra (18.2%), geometry (18.5%), and statistic (14.3%), whereas most of the student teachers in the group were focusing their education on teaching algebra (18%), geometry (17.7%), and statistic (13.3%).

MEASURES

Two methods of data collection helped us answer our research questions: online questionnaires and journal entries. The demographic factors (age, gender) and reflection-related self-efficacy views of student instructors were among the topics covered in the online questionnaire.

Quantitative study

Lohse-Bossenz et al. (2019) developed a reliable and valid instrument to assess individuals' levels of self-efficacy in relation to reflective thinking. There was a total of 13 factors used to calculate the score. One possible statement was, "I can accurately evaluate the extent to which my actions contribute to a desired outcome in the classroom."

All questions were to be rated on a Likert scale from 1 (*strongly disagree*) to 5 (*strongly agree*), with 5 being the most common response. Internal consistency tests showed good reliability (t_1 = 0.87, t_2 = 0.83, respectively).

Qualitative study

In addition, we gathered written comments from participants after they saw films taken either from the point of view of an anonymous real-world teacher (group) or the participant's own first-person perspective while teaching in a virtual classroom (group). The Research Setting and Methodology section above has instructions on how to complete the written reflections. N = 58 written reflections were gathered for this study, 38 from the $\hat{I}$_group and 19 from the group. The average length of the written responses to the videos was n = 452.7 (SD = 172.8) words.

ANALYZING THE DATA

We combined the quantitative and qualitative techniques to find answers to the two research questions.

Quantitative study

To determine whether or not there were significant differences between the group and the group in terms of the shift of confidence resulting from introspection, a two-way ANOVA with repeated measures was employed. We applied partial eta squared in the process of computing the magnitude of the shift that occurred over the course of time.

Qualitative study

To decipher the student instructors' written reflections, we resorted to a multi-step process. To begin, we created a coding system (Table 1) that drew inspiration from work by Kleinknecht and Gröschner (2016) and Kücholl and Lazarides (2021). Reflection actions and reflection content were identified as separate dimensions of reflection to be coded separately in our system. Each student's responses were recorded across two dimensions of reflection, each of which was divided into three sections. We split the reflection tasks into three categories: Description, Interpretation, and Alternatives. We used the coding system to determine whether a participant's reflection was focused on the classroom setting, the instructor, or the student.

Table 1.
Coding Scheme Adapted by Richter et al. (2022)

Reflection activities	Definition	Examples
Topics for Introspection: The Classroom		
Description	Approaches to the social and physical layout of a classroom that improve students' involvement in course material and conversational exchanges.	The kids are not actively participating in anything beyond their status as observers.
Interpretation	Explain and assess how the instruction(s) are structured, how it is taught, and how the social design of the classroom affects students' involvement in the material and their ability to interact with their peers.	Since students are not restricted to their seats, I believe this is meant to foster a more casual learning environment.
Alternatives	Create new plans for the social and physical layout of the classroom that emphasize active participation in the learning process and the exchange of ideas among students.	It would have been effective for the teacher to have a short conversation with the two pupils, as she did with the two female students who were speaking.
Topics for Introspection: The Educator		
Description	Identify the teacher's mindset and actions in relation to the classroom's organizational structure, instructional methodology, social design, and student involvement with course material and peer interaction.	K and Z began punching each other in front of the teacher while she was talking. The educator responded by walking over to stand between the students.
Interpretation	Examine the rationale and judgment behind the instructor's decisions about the structure, technique, and social design of the classroom, as well as the student's participation in the course's material and interactions.	Having to divert my attention away from teaching because of the interruption. I wanted to ensure that the two kids paid close attention to what I was saying.
Alternatives	Think of new ways to get students involved with the material and each other through a variety of organizational, pedagogical, and social design approaches to the classroom.	Instead of physically moving, the teacher may have addressed the girls more directly by speaking louder and making eye contact with them.
Topics for Introspection: The Students		
Description	Identify and explain how students behave and think in response to classroom elements such as organizational structures, instructional strategies, social design, and content and process-based interactions.	The pupils typically provide snappy, to-the-point responses.
Interpretation	Students need to be able to rationalize and analyze their own behaviors and thoughts in relation to the learning environment's organizational structures, instructional techniques, social design, and content engagement and interaction processes.	Some students may feel the task does not present enough of a challenge. It was the end for some, and they were bored.
Alternatives	Create new plans of action for educators to take in terms of the classroom's organizational framework, instructional strategy, social design, and students' involvement in and contribution to the learning process and its outcomes.	It's pointless to have students return to their desks before outlining the conditions for success, therefore I would probably respond like the teacher and offer targeted questions.

We analyzed the written reflections of student teachers using the coding method. Using MAXQDA (Kuckartz & Radiker, 2014), we performed an analysis of the content (Mayring, 2015). The smallest manageable chunk of text for analysis was determined to be a sentence. Two separate coders were used to classify the data in our investigation. Both raters independently coded 50% of the written reflections to determine inter-coder reliability. Disagreements between the two coders were ironed out through a productive conversation. Both coders independently coded 50% of the

Table 2.
Results of Repeated Measurements in Both Directions ANOVA

	Distinct Analyses						Effect of Interaction		
	t_1 t_2						Class x Period		
	$M(SD)$	$M(SD)$	$\Delta (t_2\text{-}t_1)$	SE	p	η_p^2	F	p	η_p^2
$\hat{I}$	4.15(.38)	4.23(.31)	0.15	0.06	0.03	0.07	0.17	.59	.02
$\hat{C}$	4.31(.27)	4.24(.35)	0.09	0.09	.19	0.05			

textual reflections, while the other half were coded by just one. Cohen's kappa showed that the two coders were able to agree on most categories (), indicating good inter-coder reliability. There was a total of 1,425 codes used.

Finally, we performed further analysis on the data with the help of the 1,425 codes. The frequency of reflection activities and the content of reflection were compared between the group and the group employing chi-square testing as a nonparametric alternative. To analyze the disparity between the predicted and observed frequency, a test of independence was performed independently for each case by calculating the adjusted standardized residual (z-score) and comparing it to the critical value (). More cases were observed than expected if the z-score was positive, and the opposite was true if the z-score was negative. Cramer's *V*, with a range of 0 to 1 (Evans, 1996; Privitera, 2023), was the effect size metric that was reported and interpreted. Cramer's *V* values between 0.09 and 0.23 are indicative of a modest effect, 0.23–0.39 of moderate results, and greater than 0.39 of a big effect, as suggested by Cohen (2013) for two-degree chi-square tests.

RESULTS

Initial Investigations

We began by comparing the and group pretest results on measures of reflective self-efficacy, gender, and age. There were no significant differences in gender or age at t_1 between the and groups, as measured by multivariate analysis of variance (MANOVA). Nonetheless, we did find statistically significant differences in favor of the group in terms of student instructors' self-efficacy. We used the mean absolute deviation (MAD) procedure to look for outliers in the data. Based on the strong recommendation of arithmetic mean minus 1.9 outlier detection using the MAD technique by Leys et al. (2013), due to being a significant outlier, one subject had to be excluded from the study.

Quantitative Study

Table 2 displays the results of a two-way analysis of variance (ANOVA) with repeated measures, which was used to compare the two groups' levels of self-efficacy in relation to reflection after viewing classroom films (,). We took two assessments (t1 and t2) before and after a reflection task, using and as external variables and the within-subject variable of time.

After completing the exercise with the video reflection, student teachers in both the and groups reported higher levels of reflection-related self-efficacy (0.15; = 0.09). Conducting a post hoc test of comparability, we discovered a moderate effect size rise in the group's mean score in terms of self-efficacy in relation to reflection between time points 1 and 2. Our post hoc power analysis found a 91% confidence level, indicating that our sample size was sufficient. The group did not noticeably rise with this increase. In this case, however, there was no statistically significant interaction between time and intervention.

Qualitative Study

Second, we wanted to see if and how preservice instructors reflected on the and group movies. As a result, we compared the student instructors' written reflections from the group with those from the group. The frequency distribution of the codes in the reflections is shown in Table 3.

The chi-square test was used to compare how reflective practices varied across the and groups. There were no distinctions between the group and the group in relation to introspective practices. On the one hand, the group students reflected less on the classroom setting and more on the instructor in the video compared to their counterparts in the group. On the other hand, compared to the group

Table 3.
Content Analysis of the Video Reflections Made by Student Instructors, along with the Results of the Chi-Square Test

		Reflection Activities			x^2 (df)	p	Cramer's V
		Description	Interpretation	Alternatives			
$\hat{I}$	%	37.51	39.85	19.17	0.48(2)	.71	.05
	z-score	−0.25	0.25	0.00			
$\hat{C}$	%	40.38	37.81	19.17			
	z-score	.38	−0.38	0.00			
		Reflection Content					
		Learning Environment	Students	Teacher			
$\hat{I}$	%	20.53	29.78	55.17	43.18(2)	<.001	.23
	z-score	−3.28	0.45	2.17			
$\hat{C}$	%	40.21	26.35	37.81			
	z-score	4.52	−0.41	−1.78			

participants, the group participants were more likely to reflect on the classroom setting and less likely to focus on the instructor in the video.

DISCUSSION

In this study, we analyzed the impact that reflection on videos had on student instructors' confidence in their own abilities to reflect and compared the results from a virtual reality (VR) classroom (the group) to those on videos recorded in a real classroom (the group) . Furthermore, we intended to determine whether or not virtual reality movies may serve as a helpful tool for reflection assignments in the field of teacher education by analyzing the differences between the reflective practices of the two groups. Therefore, the results of this research add to the expanding body of literature on virtual reality's usefulness as a teaching aid (Huang et al., 2023).

To answer the first research question, we found that the use of videos in teacher education has positive effects on students' ability to reflect on their own practice. The findings demonstrate that between the pretests and posttests, student instructors in the group gained confidence in their ability to reflect on their teaching practices, but their counterparts in the group did not (Schaepkens et al., 2022; Weber et al., 2018).

Our findings not only corroborate prior research but also contribute new information. Although our study did not find a statistically significant difference between the and groups, we did find that only the students who reflected using VR classroom recordings showed a statistically significant gain in self-efficacy. Therefore, the findings corroborate the work of Huang et al. (2022), who discovered that VR experiences are conducive to introspective thinking. Stavroulia and Lanitis (2019) discovered that people trained in VR were more open to introspection than those trained in a traditional classroom setting, and our findings corroborate this, as the group experienced a self-efficacy gained significantly through introspection. Because VR gives users a sense of presence and agency, it's possible that student instructors' impressions of VR instruction are similar to those of real teaching (Makransky & Petersen, 2021; Petersen et al., 2022). A recent study found that employing a virtual reality environment in teacher education helped students. They experienced virtual reality as being realistic, and it helped them improve their ability to manage the classroom (Huang et al., 2022).

For the second study's central mystery, we discovered several dissimilarities between the and groups' written reflections. Student instructors in the group had a decrease in attention to the classroom and an increased likelihood of considering the lesson plans presented in the videos, in contrast to their group counterparts. The reflections tasks (description, interpretation, and alternatives) did not differ significantly between the two groups, but other aspects of the reflections differed. Because no previous studies have examined written responses to either virtual or actual classroom experience

recordings, we place our findings in light of the existing research on the topic of educators' usage of video recordings of themselves or other educators' classroom activities. Our results are in line with those of Kücholl and Lazarides (2021), who analyzed written reflections by preservice teachers on their own or another teacher's instruction. Student instructors who reflected on the teaching experiences of another teacher were more likely to consider alternative strategies for coping with situations they first viewed as unfavorable, according to research by Kleinknecht and Schneider (2013) and Gaudin and Chaliès (2015). One possible explanation for the different results is tied to a major drawback of virtual reality: While VR could be used in the classroom in the same manner as in a traditional classroom, student instructors are always limited in how they can interact with their students, and this is true regardless of the VR software used. This restriction may force them to consider other courses of action rather than simply recounting what really transpired.

Limitations

There are important caveats to keep in mind, despite the fact that our study sheds new light on the potential of VR for application in teacher education. First, our study had some limitations, including a small sample size and a nonrandom allocation of participants into and groups. Moreover, we focused on undergraduate student teachers from a single institution.

Because of these limitations, our findings have limited applicability. The study's design also introduces a second qualification. On the one hand, the group thought on their own time spent instructing students online. In contrast, the group considered the classroom instruction of a new teacher. Despite this difference, we want to emphasize that our study has strong ecological validity because videos of this type are widely used in teacher education.

Finally, we would like to consider data quality. We use self-reports to evaluate competence in the area of reflection. Despite methodological publications debating the reliability of self-reported data (Gonyea, 2005), educational researchers frequently use self-efficacy measures (Zee & Koomen, 2016). As a result, we believe that our methodological approach to gauging reflective self-efficacy is in line with standard research procedure. Members of the two groups may have had different levels of reflection ability, according to the reflective writings used for qualitative research. Nonetheless, we made sure that all preservice teachers were given a primer on reflective writing before the actual assignment so that all reflections would be on a similar level.

Implications

Our studies show that VR may be used effectively in teacher training programs to foster critical thinking and introspection. Virtual reality can be used as a risk-free training ground for educators. As a result, student educators can focus on developing specific competencies, creating personalized learning plans, and evaluating their own growth (Lamb & Etopio, 2019).

It is still unclear how student teachers' minds, emotions, and motivations develop during the course of their training, despite our study's finding that VR use is connected with professionalization. Better understanding of how student instructors learn in VR environments is necessary for focused and sustainable usage of VR in teacher education. For example, in this setting, future studies should investigate which aspects of virtual reality are most effective in fostering the education of future teachers. The Cognitive Affective Model of Immersive Learning (CAMIL) offers a potential analysis framework (Makransky & Petersen, 2021).

CONCLUSION

Teacher education benefits greatly from the incorporation of video analysis of teaching methods (Sun & Van Es, 2015). This study adds to the current literature by demonstrating that student teachers can improve their reflective self-efficacy using virtual reality classroom videos and video-based reflection. We discovered that student instructors' reflections were qualitatively identical whether they were based on virtual reality or actual classroom films. Compared to film, virtual reality offers a potentially superior educational opportunity due to its flexibility and ability to give a standardized model that can be updated as needed to reflect shifting cultural norms and professional practices. Therefore, our research makes a substantial addition to the existing body of work on virtual reality's function in teacher preparation. This study can be the basis of many future studies. For example, investigating virtual reality on teachers' movement patterns is one of these research topics.

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