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Comparing video and virtual reality as tools for fostering interest and self-efficacy in classroom management: Results of a pre-registered experiment

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Abstract

Video is a widely used medium in teacher training for situating student teachers in classroom scenarios. Although the emerging technology of virtual reality (VR) provides similar, and arguably more powerful, capabilities for immersing teachers in lifelike situations, its benefits and risks relative to video formats have received little attention in the research to date. The current study used a randomized pretest–posttest experimental design to examine the influence of a video- versus VR-based task on changing situational interest and self-efficacy in classroom management. Results from 49 student teachers revealed that the VR simulation led to higher increments in self-reported triggered interest and self-efficacy in classroom management, but also invoked higher extraneous cognitive load than a video viewing task. We discussed the implications of these results for pre-service teacher education and the design of VR environments for professional training purposes.

KEYWORDS
cognitive load, immersive media, pre-service teacher, professional training, simulations, student teacher, teacher education

Practitioner notes

What is already known about this topic

- Video is a popular teacher training medium given its ability to display classroom situations.
- Virtual reality (VR) also immerses users in lifelike situations and has gained popularity in recent years.
- Situational interest and self-efficacy in classroom management is vital for student teachers' professional development.

What this paper adds

- VR outperforms video in promoting student teachers' triggered interest in classroom management.
- Student teachers felt more efficacious in classroom management after participating in VR.
- VR also invoked higher extraneous cognitive load than the video.

Implications for practice and/or policy

- VR provides an authentic teacher training environment for classroom management.
- The design of the VR training environment needs to ensure a low extraneous cognitive load.

INTRODUCTION

A practicing teacher constantly makes rapid-fire decisions in stressful situations, such as responding to disruptive student behaviours. To learn these skills, student teachers need to experience and practice in dynamic and realistic classroom situations (Grossman, 2018). Practicing in lifelike situations, as opposed to passively learning about principles in lectures, has been shown to increase interest and self-efficacy (Banas, 2014; Herrington et al., 2014), both of which are powerful motivators that sustain continuous learning according to the expectancy-value theory (Eccles & Wigfield, 2002).

Video is a reliable and widely used medium for presenting such realistic situations in teacher education (Santagata et al., 2021). Recordings of classrooms have been utilized to develop teachers' noticing of key classroom events (van Es & Sherin, 2021), reflection (Gibbons & Farley, 2021), and analytical skills (Keller et al., 2022), among many other competencies (Sablić et al., 2021).

The popularity of video in teacher training has been partly attributed to its "unique capacity to capture the richness and complexity of classroom activity" (Gaudin & Chaliès, 2015, p. 43), which provides an indirect but vivid experience that elicits a sense of presence: Teachers feel as if they are inside the classroom they are watching (Goldman, 2007; Seidel et al., 2011). According to the theoretical cognitive affective model of immersive learning (CAMIL), presence leads to a high level of interest and self-efficacy which in turn contributes to learning (Makransky & Petersen, 2021). Indeed, video viewing has been found to positively affect teachers' interest (Santagata et al., 2021) and promote their self-efficacy beliefs (Chen, 2020).

Despite its ubiquitousness in teacher education, video is not unique in its capacity to elicit a feeling of "being there". Yet compared to the traditional method of showing classroom recordings on desktop monitors, the emerging technology of virtual reality (VR) affords similar, if not more powerful, capacities to immerse teachers in classroom situations. A simulated classroom in VR allows teachers to experience and interact with classroom events firsthand instead of watching videos that provide at best a "secondhand experience" (Miller & Zhou, 2007, p. 322). As fully immersive VR headsets have become more widely available in recent years (Lamb & Etopio, 2020), researchers and teacher educators are increasingly utilizing this technology for training purposes (for a review, see Huang, Richter, Kleickmann, & Richter, 2021).

In spite of VR's high potential and growing popularity in teacher education (eg, Seufert et al., 2022), no study to date has directly compared the impact of video viewing versus VR simulation in developing student teachers' situational interest and self-efficacy in classroom management—a skill that is both important and challenging for student teachers to learn (Wolff et al., 2021). The present study therefore examined both the potential benefits and risks of using VR versus video to present a comparable classroom management task to student teachers. We focused in particular on the change in situational interest and self-efficacy in classroom management using a pretest–posttest experimental design.

Video as a popular training medium for classroom management

Classroom video has long been incorporated into different stages of teacher education (Santagata et al., 2021; van der Linden et al., 2022). In the pre-service stage, video is considered an advantageous medium (Ramos et al., 2021) that helps student teachers "to activate, acquire, and apply knowledge in a meaningful way" (Blomberg et al., 2013, p. 93). Classroom management, a highly situated professional competency (Dicke et al., 2015), has been a particular learning focus of video-based teacher training (Harford et al., 2010). Classroom management is a professional practice aiming to "create an environment that supports and facilitates both academic and social-emotional learning" (Evertson & Weinstein, 2006, p. 5). Despite its significance in promoting various educational outcomes such as academic achievement (van Dijk et al., 2019) and positive learning attitudes (Gage et al., 2018), classroom management is often considered by student teachers to be one of the greatest challenges they face in their studies (Wolff et al., 2021). Much research has therefore addressed the use of videos in developing classroom management expertise. For instance, Gold et al. (2021) used classroom recordings from different perspectives to promote student teachers' strategic classroom management knowledge, and Weber et al. (2018) used video viewing with peer and/or expert feedback to foster student teachers' professional vision in classroom management.

Many argue that the benefits of videos, as compared to a medium with no dynamic contextual information such as text or photos, lies in its ability to present classroom situations in an authentic and nuanced manner (eg, Blomberg et al., 2011; Kramer et al., 2020). Video's capacity to portray the perspective of someone who is in the classroom and experiencing an event as it unfolds in real time creates a sense of "presence"—a feeling of physically "being there" (Ijsselsteijn & Riva, 2003). For example, Seidel et al. (2011, p. 260) stated that video viewing was "activating" for teachers, both emotionally and cognitively, due to the feeling of actually being in the classroom.

The sense of presence in a learning environment would increase motivational variables such as interest and self-efficacy that in turn affect learning outcomes according to the cognitive-affective theory of learning with media (CATLM) (Moreno & Valdez, 2007) and its recent descendants, the cognitive-affective theory of learning with media in virtual reality (CATLM-VR) (Huang, Roscoe, et al., 2022) and CAMIL (Makransky & Petersen, 2021). Video can be seen as a prime example of a medium that provides the affordance of presence for teachers, yet it is not the only one that does so. Increasingly, virtual reality (VR), as the new player in the field of immersive media, has gained popularity in professional education in various fields (Jensen & Konradsen, 2018).

VR simulation for teacher training

VR is any media system that provides "synthetic, highly interactive three-dimensional spatial environments" (Mikropoulos & Natsis, 2011, p. 769) that could depict real or non-real situations. The current state-of-the-art––(fully) immersive VR systems––almost completely replace sensory input from actual reality with computer-generated sensory information, including visual images, auditory sounds, touch, smell, and even proprioception (Villena-Taranilla et al., 2022), resulting in a believable experience of actual presence in the virtual environment (Coban et al., 2022).

Due to its capacity to depict an authentic and interactive environment that closely resembles actual scenarios, VR has been widely employed in the training of professionals who must operate in dynamic and complex situations (Howard et al., 2021), such as pilots (Abich et al., 2021) and surgeons (Mao et al., 2021). According to a recent review covering 2010 to 2020 (Huang, Richter, Kleickmann, & Richter, 2021), VR technology has also been used for teacher training in areas including noticing and reacting to misbehaviours (eg, Chen, 2022), subject-specific pedagogy (Ely et al., 2018) and communicative skills (eg, Spencer et al., 2019) among other competencies (eg, Artun et al., 2020; Stavroulia & Lanitis, 2020). These studies consistently reported positive results regarding the intended outcomes, demonstrating the potential merits of VR in teacher education.

Benefits of VR over traditional media formats such as videos have been reported in several recent investigations in teacher education, including studies comparing traditional videos versus 360-degree videos presented in VR (Kosko et al., 2021), real-life versus VR teaching simulations (Ke et al., 2021), and video-facilitated versus VR-facilitated courses (Seufert et al., 2022). Yet, some researchers have found VR to be more distracting than useful for learning (Gulikers et al., 2005), given that it often elicits a higher extraneous cognitive load than traditional formats such as videos (eg, Moreno & Mayer, 2002; Parong & Mayer, 2021). Cognitive load is the degree of mental effort needed to accomplish a certain cognitive task (Plass et al., 2010). Among different types of cognitive load (Sweller et al., 2011, p. 57), the extraneous cognitive load––the unnecessary load imposed by "the manner in which the information is presented"—has been shown to be unhelpful or even detrimental to learning (Anmarkrud et al., 2019). Parong and Mayer (2020) asserted that the strong sense of presence in VR did not improve retention and transfer of knowledge due to the higher level of extraneous cognitive load created by cognitive processing of information inessential to learning.

Despite the conflicting evidence on the relative benefits and costs of the technology, the VR medium has rarely been juxtaposed with video––one of the most widely used media format for teacher education. The merits and drawbacks of VR simulation for student teachers' learning have yet to be studied in comparison to video-based training.

Relevance of interest and self-efficacy for student teachers' professional development

Among the many potential outcomes of video and VR-based training, we focused on student teachers' interest and self-efficacy in classroom management as the main variables of interest in the present study, given their theoretical significance and attested value for teachers' professional development (for a review, see Morris et al., 2017). According to expectancy-value theory, self-efficacy is an indicator of the expectancy component (expectation of future success), and interest is an indicator of the value component (evaluation of task value) (Klassen & Tze, 2014; Wigfield & Eccles, 2000). Similarly, according to the theoretical framework for learning with immersive media (eg, video and VR), CAMIL and CATLM-VR alike focus on the important role of interest and self-efficacy in bridging the relationship between the affordances of learning media and learning outcomes. CAMIL states that interest and self-efficacy along with other affective and cognitive factors intermediate the positive associations between media affordances (presence and agency) and learning outcomes such as knowledge acquisition and transfer (see Figure 1). The following sections briefly introduce these two constructs and discuss their relevance for student teachers' professional development.

Being interested in something is the starting point and also the driving force of learning (Palmer, 2004). Interest is a motivational variable describing the psychological state of (re-)engaging with particular topics (Hidi & Renninger, 2006). According to Hidi and Renninger (2006), interest begins as triggered interest and if sustained, evolves into a maintained interest. Triggered and maintained interest combined are referred to as situational interest––a momentary focused attention and affective reaction triggered by environmental stimuli. Situational interest has repeatedly been found to positively influence levels of attention (Krapp, 2002) and learning (Köller et al., 2001). Teachers' interest in a topic has been found to affect attitudes toward that subject (Palmer, 2004), occupational well-being (Schiefele et al., 2013), and to indirectly influence their students' interests (Keller et al., 2014).

In addition to situational interest in a topic, individuals' beliefs about their competence, that is, self-efficacy, form another key motivational construct in learning (Bardach & Klassen, 2021; Eccles & Wigfield, 2002). Teachers' self-efficacy can be defined as beliefs about their ability to "organize and execute the courses of actions" (Bandura, 1997, p. 3) necessary to be effective in instructional situations. Feeling self-efficacious in a particular topic area is crucial to continuing engagement with that topic (Bandura & Locke, 2003), whether it is mathematics (Williams & Williams, 2010) or classroom management (Aloe et al., 2014). Specifically, classroom management self-efficacy contributes significantly to the quality of teaching (Lazarides et al., 2020), long-term well-being (Dicke et al., 2014), and ultimately also student outcomes (for a review, see Bardach & Klassen, 2021).

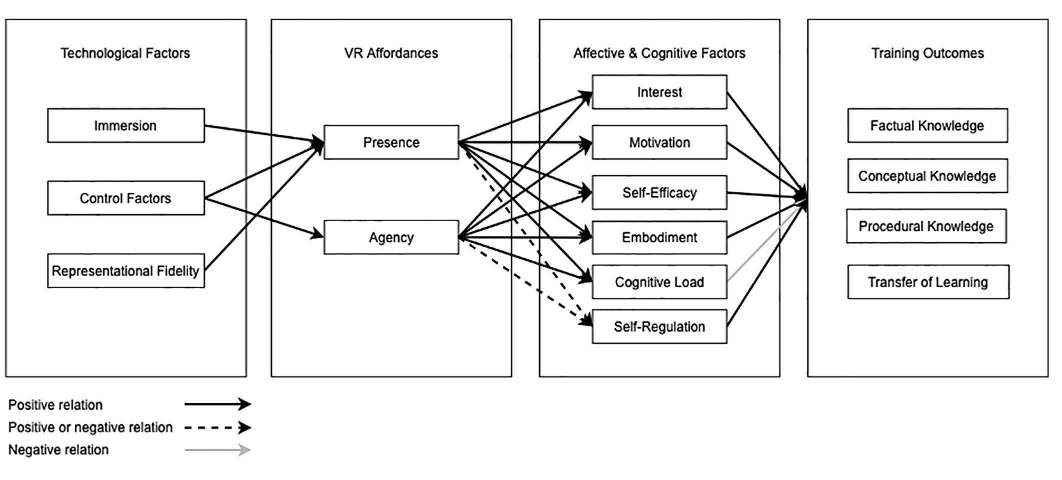

FIGURE 1 Graphical representation of the cognitive affective model of immersive learning (CAMIL). Adapted from "Figure 2 Overview of the CAMIL" (Makransky & Petersen, 2021).

Do video and VR affect interest and self-efficacy?

Given the importance of interest and self-efficacy, research has looked at how their development might be fostered in student teachers through the use of various media in teacher education (eg, Chen, 2020). The benefit of the video format in terms of interest and self-efficacy is obvious when compared to static text and pictures (eg, Gold et al., 2021; Kramer et al., 2020). According to Moreno and Valdez (2007), student teachers who were presented with an exemplary classroom situation in either video or text format rated the demonstrated idea to be more interesting and were more motivated to learn about it when a video was used. In a review of sources of teachers' self-efficacy, Morris et al. (2017) summarized that indirectly experiencing classroom situations through watching videos was helpful in improving student teachers' self-efficacy. Blomberg et al. (2013, p. 93) concluded that watching classroom videos is overall "motivating and compelling" for student teachers (also see Seidel et al., 2011).

A similar positive effect on interest and self-efficacy has also been indicated in training environments that utilized VR. For instance, Makransky, Andreasen, et al. (2020) found that the high level of presence embedded in immersive VR was associated with increased motivation, interest, and enjoyment in learning among both university and middle school students. In another semi-immersive training environment, student teachers reported increased efficacy beliefs in science teaching following the use of VR in their training (Bautista & Boone, 2015; Gundel et al., 2019). In a systematic review focusing on classroom simulations more generally, Theelen et al. (2019) summarized that computer-based classroom simulations positively affect student teachers' self-efficacy in instruction.

As reviewed so far, video is the primary medium used in teacher education to promote teachers' interest and self-efficacy, while VR is also considered highly promising in this area. Yet up to now, there has been no experimental investigation examining the effect of VR versus video in developing student teachers' interest and self-efficacy, specifically in the area of classroom management, while at the same time accounting for the potential risk of VR––the extraneous cognitive load.

Present study

Our study aimed to examine how changes in situational interest and self-efficacy in classroom management differ when student teachers undertake an identical classroom management task in a video versus VR environment. We were also interested in the perceived extraneous cognitive strain associated with the medium. With the random assignment of participants into VR and video groups and comparison of pre/posttest outcomes, we expected that

1. the VR group would report larger increments in situational interest in the topic of classroom management than the video group;
2. the VR group would report larger increments in self-efficacy in classroom management than the video group;
3. The VR group would report higher extraneous cognitive load related to the medium than the video group.

This randomized controlled study and its hypotheses were pre-registered with OSF https://osf.io/9256h.

MATERIALS AND METHODS

Participants and design

Forty-nine student teachers (24 women, 23 men, 2 missing) aged 18–43 years ($M = 22.4$, SD = 4.2) were recruited from the teacher preparation program at a public German university. All participants were German speakers and were pursuing a bachelor's degree. Among them, 23% had former experience using VR but not with this VR classroom (see Table A1 in the Supporting Information for detailed sociodemographic characteristics).

The sample size was determined by a priori power analysis conducted in G*Power 3.1 (Faul et al., 2007). With an effect size of $f = 0.5$, alpha level of 0.05, and power of 0.8, each group would require at least thirteen participants to detect an effect. In this experiment, participants were randomly assigned to either the video (23 participants) or the VR (26 participants) condition. Due to scheduling difficulties, two individuals did not attend the session, leaving 22 in the video condition and 25 in the VR condition.

Materials and procedure

Both the procedure and the classroom management task were identical across groups. The general procedure for both groups took three steps. Participants first completed a 20-minute pretest questionnaire about their demographics, situational interest, and self-efficacy in classroom management. Second, participants performed a 10-minute classroom management task during which they needed to respond to typical classroom disruptions. These disruptions were presented either with video snippets or in a VR classroom,[1] which will be introduced in more detail later. Finally, after the classroom management task, all participants completed a posttest questionnaire that included the pretest questions and also cognitive load ratings of the medium. The duration of the entire experiment was approximately 60 minutes.

In the classroom management task for the video condition, participants watched and responded to typical classroom situations presented through short video snippets. Five video snippets ranging from 37 to 83 seconds were selected from an open video repository at the Free University of Berlin.[2] These videos contained staged classroom situations in which both on- and off-task behaviours (eg, answering the teacher's question, completing worksheets, using a cellphone, chatting with neighbours) were taking place. After each short video, the participant was required to respond to three questions: (a) Did you perceive any classroom disruptions during this video? (b) If so, what did the misbehaviour look like? (c) If so, how would you respond as a teacher? Participants watched and responded to these videos on a desktop computer. The entire task took around 10 minutes.

In the VR condition, participants managed student avatars in a virtual classroom that was modelled closely after the upper secondary classrooms in Germany (Wiepke et al., 2021). The virtual classroom contained five rows and three columns of desks with 30 student avatars. Student avatars possessed a variety of physical features (see Figure 2 top). These avatars' actions were predetermined and standardized (see Table A2 in the Supporting Information for the script). The environment also featured typical classroom items such as wall clocks, posters, chalk and a blackboard. Participants were immersed in the VR classroom through the HTC VIVE Pro Eye system. With this system, participants could move freely in physical reality while receiving multisensory information from the VR classroom. To recreate the experience of teaching in physical reality, participants could also pick up

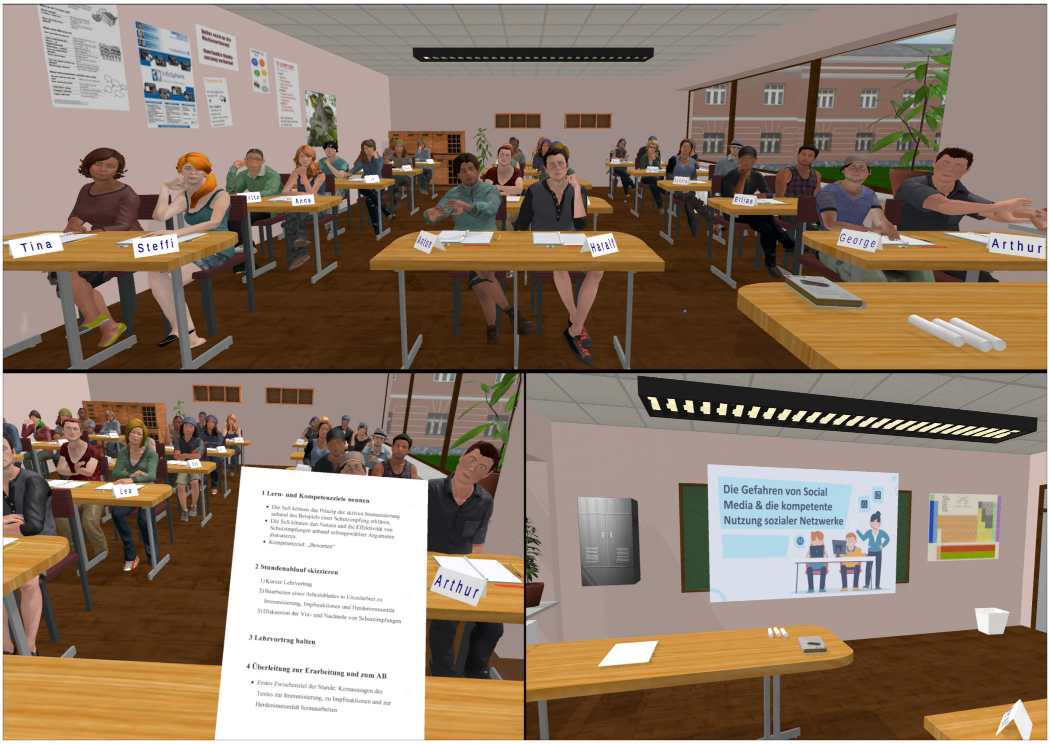

FIGURE 2 Appearances of the VR classroom. Top: a participant's view from the teacher's desk; bottom left: a participant picking up the handout (lesson plan); bottom right: a participant looking at the projected slides on the blackboard.

and read a handout from teacher's desk and operate slide presentations projected on the blackboard as they speak (see Figure 2 bottom). Participants in previous studies using the prototypes of this VR classroom reported it to be realistic and authentic (Huang, Richter, Kleickmann, Wiepke, et al., 2021; Richter et al., 2019).

Ahead of the classroom management task, participants in the VR condition first listened to five minutes of instructions on how to interact with the environment. Then they were instructed to give a short lecture on a given topic (COVID-19 vaccinations). During their lecture, student avatars would perform both on- and off-task behaviours (see Figure 3) that typically occur in classrooms (Borko, 2016; Wolff et al., 2016). The misbehaviours were similar to the ones presented in the video snippets described earlier, such as sleeping on the desk and chatting with neighbours (see Table A2 in the Supporting Information for all the possible behaviours). The location, time, length and kind of student behaviours were programmed in order to standardize the entire situation. As with the video condition, participants were instructed to respond to these misbehaviours as they saw fit. Participants may respond to misbehaviours by explicitly addressing the avatar by name, physically approaching the avatar without speaking or employing any other strategy possible given their ability to freely speak and move as they would in real-world classrooms (see also, Huang, Richter, Kleickmann, Wiepke, et al., 2021; Huang, Richter, et al., 2022). The VR session concluded after the classroom management task, and the entire session took around 15 minutes.

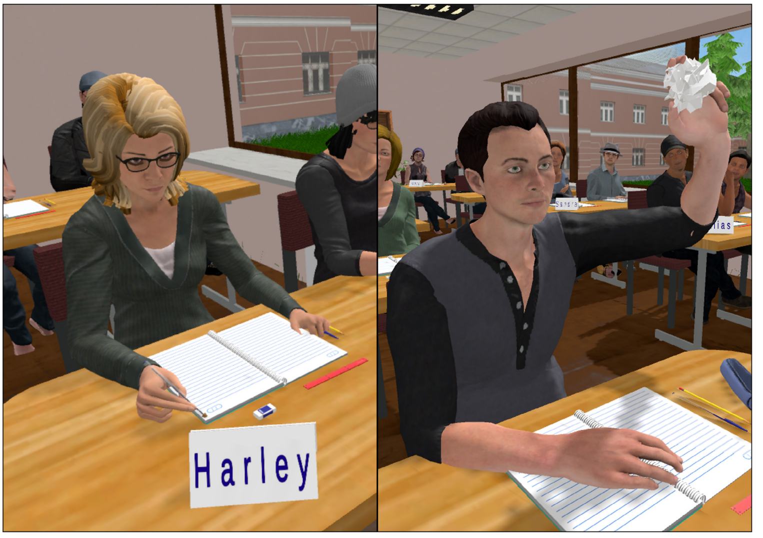

FIGURE 3 Student avatar behaviours. Left: On-task behaviour (write on the notebook); right: Off-task behaviour (throw paper balls).

Measures and instrumentation[3]

In terms of demographics, we asked participants to state their age, semester, prior teaching experience ("How many lessons have you planned and taught yourself so far, for instance, in the context of internships?"), and prior VR experience ("How much experience do you have with virtual reality?", from "1 = none" to "3 = a lot") in the pretest questionnaire.

We then measured triggered and maintained interest in classroom management—the two components of situational interest. The immediate reaction triggered by the environment is referred to as triggered interest, and maintained interest supersedes this triggered state to involve longer engagement with the topic (Hidi & Renninger, 2006). We assessed triggered interest in classroom management with a 5-item measure from Rakoczy et al. (2020) but with the topic replaced with "classroom management". An example item was "The topic of classroom management is exciting." with responses from "1 = I don't agree" to 4 = "I fully agree". The measure had good reliability with $\alpha = 0.93$.

Maintained interest in classroom management was evaluated with a three-item measure from Knogler et al. (2015) with the topic replaced with "classroom management". An example item was "I would like to learn more on the topic of classroom management." with responses from "1 = I don't agree" to "4 = I fully agree". The measure also had good reliability of $\alpha = 0.83$.

Classroom management efficacy was assessed with a five-item measure from Pfitzner-Eden et al. (2014). An example item was "I am confident that I can control disruptive behavior in class." with responses from "1 = I don't agree" to "4 = I fully agree". The measure had good reliability with $\alpha = 0.86$.

Extraneous cognitive load was evaluated with the extraneous subscale (7-item) of the multidimensional cognitive load scale for virtual environments (Andersen & Makransky, 2021). An example item was "The technology used to complete the task was difficult to use." with responses from "1 = I don't agree" to "4 = I fully agree". The measure had good reliability with $\alpha = 0.75$.

Statistical analyses

Linear mixed (effects) modelling (LMM, see the Supporting Information for details) was used to evaluate the main effect of condition (VR vs. video) and time (pretest vs. posttest) on triggered interest, maintained interest and self-efficacy. We treated participant and semester as random effects so that the findings could be generalized to other samples of participants and semesters (Baayen et al., 2008). We also used the analysis of covariance (ANCOVA) for the main effects of condition on the extraneous cognitive load at posttest as there is only one measure time for this variable.

The LMM models were fitted with restricted maximum likelihood (REML) using the lme4 package (Bates et al., 2015), and the ANCOVA was conducted with jmv package (Selker et al., 2020) in R 4.0.4 (R Core Team, 2021). In terms of goodness of fit for LMM, we included indices commonly used in the field (eg, Goldhammer et al., 2014; Kliegl et al., 2011): the Akaike information criterion (AIC; decreases with goodness of fit) and the Bayesian information criterion (BIC; decreases with goodness of fit). Estimated marginal means (EMM) such as EMM_{VR} (estimated marginal means of VR group) and effect sizes (standardized $\hat{\beta}$, d, and η^2) were also reported (see the Supporting Information for details).

RESULTS

Preliminary analysis

To see if there were any pre-existing differences between groups notwithstanding random assignment, we first compared the demographics of the participants. The percentages of female and male participants did not differ significantly according to the chi-squared test. One-way analysis of variance (ANOVA) revealed that the two groups did not differ significantly in terms of age, semester, prior teaching experience, or prior VR experience.

Triggered and maintained interest in classroom management

Our first hypothesis was on the group difference in situational interest. As shown in the model summary in Table 1 (see Table A4 in the Supporting Information for the full model

TABLE 1 Model summary of situational interest

	Triggered interest[a]				Maintained interest[b]			
Terms	$\hat{\beta}$	SE	Standardized $\hat{\beta}$	t	$\hat{\beta}$	SE	Standardized $\hat{\beta}$	t
Group (Video–VR)	−0.25	0.12	0.44	−2.16*	0.13	0.11	0.13	1.15
Time (Post–Pre)	0.44	0.09	1.02	4.97***	−0.04	0.05	−0.06	−0.64
Group * Time	−0.51	0.18	−0.93	−2.90**	0.01	0.11	0.02	0.09
Teaching experience	0.00	0.00	0.07	0.74	0.00	0.00	0.15	1.16
VR experience	−0.15	0.14	−0.11	−1.09	−0.22	0.13	−0.21	−1.67

Note: $n = 94$ observations from 47 participants.

[a]AIC = 144.29; BIC = 188.55.

[b]AIC = 95.60; BIC = 142.38.

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

summary), both group ($\hat{\beta}$ = −0.25, $t(40)$ = −2.16, p = 0.037, d = 0.97) and time ($\hat{\beta}$ = 0.44, $t(45)$ = 4.97, $p<0.001$, d = 0.99) significantly predicted the triggered interest but not the maintained interest in classroom management.

A significant interaction ($\hat{\beta}$ = −0.51, $t(45)$ = −2.90, p = 0.006, d = −0,97) between group and time for the triggered interest demonstrated that the increment in triggered interest in the VR group was significantly larger than the video group despite that both groups increased on triggered interest in classroom management from pretest to posttest (EMM_{VR} from 2.96 to 3.66, EMM_{video} from 2.97 to 3.15). Specifically, the VR group (EMM = 3.66, SE = 0.14) had higher triggered interest than the video group (EMM = 3.15, SE = 0.14) at posttest, $t(77)$ = −3.48, $p<0.001$ (see Figure 4). Maintained interest, however, remained stable from pretest to posttest for both VR and video groups (EMM_{VR} from 3.22 to 3.19, EMM_{video} from 3.37 to 3.34). These findings partially supported our predictions in Hypothesis 1: The VR group reported larger increments in triggered interest in the topic of classroom management than the video group, but there were no significant group or time differences in maintained interest in classroom management.

Self-efficacy in classroom management

Similarly, in the second hypothesis about the VR versus video group's self-efficacy in classroom management, we first examined the LMM model shown in Table 2 (see Table A5 in Supporting Information for the full model summary). Similar to triggered interest, both group ($\hat{\beta}$ = −0.24, $t(38)$ = −2.16, p = 0.041, d = 0.63) and time ($\hat{\beta}$ = 0.27, $t(45)$ = 3.86, $p<0.001$, d = 1.69) predicted participants' self-reported self-efficacy in classroom management.

The interaction between group and time was significant for self-efficacy ($\hat{\beta}$ = −0.36, $t(45)$ = −2.56, p = 0.014, d = −0.0.75). Therefore, both groups reported higher self-efficacy in the posttest (EMM_{VR} from 2.51 to 2.95, EMM_{video} from 2.45 to 2.54), but the VR group (EMM = 2.95, SE = 0.13) had higher self-efficacy scores than the video group (EMM = 2.54, SE = 0.13) in the posttest, $t(65)$ = −3.15, p = 0.002 (see Figure 5). In sum, our findings supported predictions in Hypothesis 2: The VR group reported larger increments in self-efficacy in classroom management than the video group.

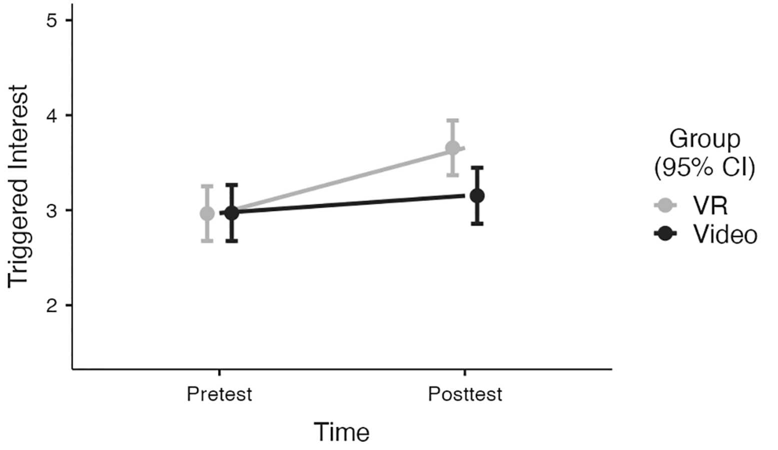

FIGURE 4 Time and group effect on triggered interest in classroom management.

TABLE 2 Model summary of self-efficacy

Terms	$\hat{\beta}$	SE	Standardized $\hat{\beta}$	*t*
Group (Video–VR)	−0.24	0.11	0.30	−2.12*
Time (Post–Pre)	0.27	0.07	0.82	3.86***
Group * Time	−0.36	0.14	−0.79	−2.56**
Teaching experience	0.00	0.00	0.02	0.19
VR experience	0.00	0.13	0.00	0.02

Note: $n = 94$ observations from 47 participants. AIC = 119.739; BIC = 165.257.
*$p<0.05$; **$p<0.01$; ***$p<0.001$.

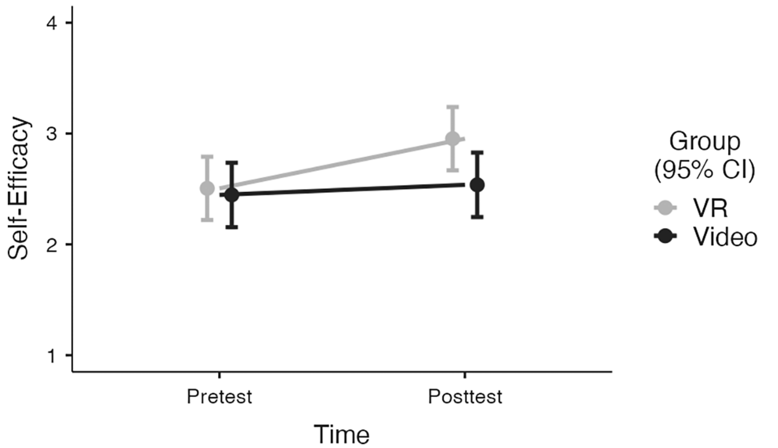

FIGURE 5 Time and group effect on self-efficacy in classroom management.

Extraneous cognitive load

We expected that VR, as a novel medium, would induce higher extraneous cognitive load than videos. We conducted ANCOVA on self-reported extraneous cognitive load with teaching experience and VR experience as covariates. The VR group (EMM = 1.74, SE = 0.07) reported higher extraneous cognitive load than the video group (EMM = 1.47, SE = 0.07), $F(1, 87) = 8.28$, $p = 0.005$, $\eta^2 = 0.08$ (medium to large effect size) (see Figure 6). None of the covariate effects were statistically significant. Additionally, we examined the correlations between extraneous cognitive load, situational interest, and self-efficacy at posttest. We found that extraneous cognitive load was negatively associated with all three outcomes of interest, and significantly associated with self-efficacy ($r = -0.33$, $p = 0.023$). Our prediction for Hypothesis 3 was supported by this result: The VR group reported higher extraneous cognitive load related to the medium than the video group.

DISCUSSION

The effect of VR versus video on situational interest in classroom management

Triggered interest is the entry point to prolonged engagement in a topic area (Hidi & Renninger, 2006), and the present study found that VR simulation fostered student teachers' triggered interest in classroom management more than the video task, despite the fact

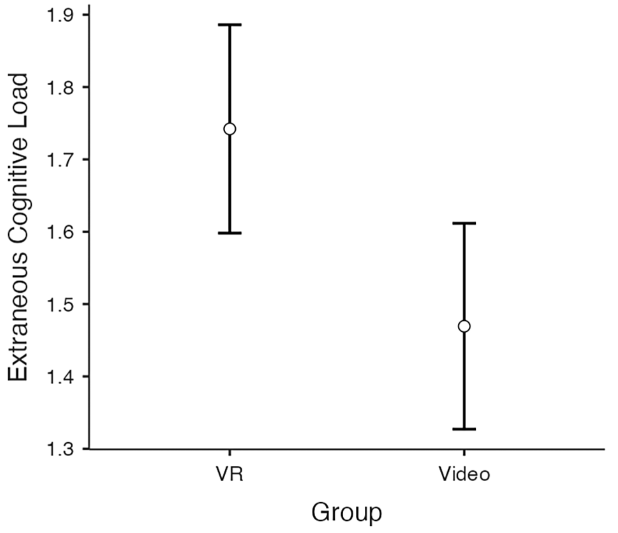

FIGURE 6 Group effect on extraneous cognitive load.

that both groups had significant increments from pretest to posttest. This finding is in line with studies on the benefits of VR simulation on learning outcomes (eg, Gandolfi et al., 2021; Howard et al., 2021). For instance, Makransky, Petersen, et al. (2020) found that a VR simulation sparked middle and high school students' interest in science more than a video did. Our findings extended this line of research by highlighting that VR simulation also enhanced teachers' situational interest in the context of pre-service teacher education.

At the same time, our findings did not support the benefits of VR or video in significantly increasing student teachers' maintained interest in classroom management. Instead, maintained interest in classroom management remained high from pretest to posttest for both groups. The different development patterns in triggered and maintained interest might be attributed to the short duration of the training intervention, as maintained interest involves "focused attention and persistence over an extended episode in time" (Hidi & Renninger, 2006, p. 114). This result was also similar to Makransky, Petersen, et al. (2020) finding that a short-duration learning session was able to trigger learners' interest but not enough to cultivate the later phase of interest development.

Research on interest development has proposed that situational interest could be promoted through learning tasks that are novel (Stipek, 1993), meaningful (Hidi & Harackiewicz, 2000), and personally involving (Hoffmann, 2002). The vivid, visceral and first-hand experience that immersive VR could provide would afford learners a novel and personally involving environment that might explain the increments in our sample's triggered interest. It is worth noting that the novelty effect could be attributable to our participants' lack of VR experience, as 77% of them had never experienced VR before. It remains unclear whether the triggered interest initiated by the VR environment would be sustained if participants are more experienced with VR technology in general. Finally, the VR simulation also provides a more meaningful and authentic training environment than responding to video recordings, another potential source of situational interest for student teachers (Palmer, 2004).

The effect of VR versus video on classroom management self-efficacy

Teachers' self-efficacy in classroom management is a component of their professional competence (Lazarides et al., 2020) and is positively related to classroom management quality, especially in the early stage of a teaching career (Klassen et al., 2011). Our results revealed that VR simulation better supported the development of student teachers' self-efficacy in classroom management than the video task. This finding confirms previous studies on the communicative affordances of VR and learners' self-efficacy beliefs (eg, Buttussi & Chittaro, 2018; Seufert et al., 2022). In Gegenfurtner and colleagues' meta-analysis (Gegenfurtner et al., 2014), for example, the feeling of control (agency) in and over the virtual environment correlated positively with learners' self-efficacy.

According to social cognition theory (Bandura, 1997), one of the most important sources of efficacy is mastery experience (Tschannen-Moran & Hoy, 2001). Teachers' perceptions of their own successful performance enhance their self-efficacy beliefs about their future performance in similar situations (Cantrell et al., 2003). Given that mastery experience can only be gained in an authentic training scenario (Ross & Bruce, 2007), we would argue that the realism of VR simulation provides student teachers an essential context for mastery experience and is therefore beneficial for the development of their self-efficacy beliefs.

There is a nuance to our findings regarding self-efficacy in classroom management, in that the particular VR simulation we used targeted the situated expertise in classroom management and may not be readily generalized to other areas of teacher learning, especially when it concerns factual learning. Past studies have shown that learners' self-efficacy in factual knowledge may not be strongly influenced by the use of VR simulation (Moreno & Mayer, 2002). For instance, Petersen et al. (2022) found no significant effect of VR simulation on self-efficacy or knowledge transfer about biological facts (virus and vaccination). It is probable that the learning mechanism of factual and procedural knowledge might differ in immersive VR (Parong & Mayer, 2021) and require further investigation.

Potential risk of VR and its remedies

We also addressed a common concern in the literature about VR-based training and learning: the evolution in extraneous cognitive load in VR experience. Similar to previous studies (eg, Gold & Windscheid, 2020; Parong & Mayer, 2020), we found that VR induced higher extraneous cognitive load than the video condition, which was negatively associated with self-efficacy but not with situational interest in classroom management.

As extraneous cognitive load is not inherently related to learning but consumes the valuable yet limited cognitive processing capacity a learner has, it was considered detrimental to learning (Sweller, 2011). Theories stemming from cognitive load theory (Sweller, 2010), such as the cognitive-affective theory of learning with media (CATLM) (Moreno & Mayer, 2007) and the cognitive affective model of immersive learning (CAMIL) (Makransky & Petersen, 2021), all posit that the design of a learning environment should reduce extraneous cognitive load that is not essential for learning. Yet, many studies have found that immersive VR environments bear the risk of imposing higher extraneous cognitive load on learners (eg, Albus et al., 2021; Frederiksen et al., 2020). This could be attributed to the entirely different control device and interaction method in VR as compared to the traditional human-machine interaction with mouse and keyboard (Makransky et al., 2019) as well as the high-fidelity 3D virtual environment which can be emotionally arousing to the point of distraction (Parong & Mayer, 2020). Familiarity with the VR environment and its interaction method as well as more in-VR aids (eg, virtual assistants) would been useful for reducing extraneous cognitive load (Albus et al., 2021).

It can be argued that the benefits and risks of immersive VR technology for training and learning stem from the same source, and it depends on the fit between design and instructional goal whether the benefits predominate. The merits of immersive VR appear to exceed the disadvantages in the context of classroom management training for student teachers

(McGarr, 2021). For instance, Seufert et al. (2022) found significant gains in classroom management competency after student teachers participated in immersive VR simulations. Similarly, we found that despite the negative associations between extraneous cognitive load and classroom management self-efficacy, the VR group still showed a significant increase in triggered interest and self-efficacy in classroom management compared to the video group. Therefore, we concluded that the VR simulation, which is authentic in terms of both the environment and the task, is beneficial for developing student teachers' classroom management competencies.

Last but not least, the finding that the video group also improved in triggered interest and self-efficacy in classroom management, although to a lesser extent, speaks to the long-acknowledged benefits of classroom recordings (eg, Tripp & Rich, 2012; van der Linden et al., 2022). Our findings also confirmed that the video task imposed less extraneous cognitive load than VR. As stated by Sherin (2007), videos are windows that student teachers can use to safely observe a classroom situation without experiencing the extra pressure to respond instantly (Blomberg et al., 2013).

Limitations and future directions

The present study could be extended in the following directions. First, despite the previous evidence that the VR classroom is highly authentic and immersive (Richter et al., 2019), we recognized the artificiality of avatars' behaviours, which were scripted and unadaptable. Future VR classroom iterations should address the issue of natural dialogue between users and agents/avatars in order to further strengthen the benefits of VR simulation.

Second, while VR simulations have shown considerable promise in terms of increasing student teachers' interest and self-efficacy in classroom management, their effectiveness in enhancing actual classroom management performance when compared to traditional training formats has received little attention. To examine how different training formats affect the development of classroom management performance, student teachers' classroom management behaviours should be investigated using a similar experimental design in the future.

Third, the study focused specifically on student teachers' classroom management expertise, which plays a major role in situational skills such as professional vision (Gold & Windscheid, 2020). Yet, as we mentioned above, the mechanism of factual and procedural learning in VR simulations might differ from each other. In order to generalize the identified benefits of VR for teacher training, it is necessary to replicate the current study design in other areas of expertise, such as pedagogical content knowledge in specific subjects (Walshe & Driver, 2019). Investigating effectiveness of different media at various phases of teachers' professional career would further advance this line of research.

Finally, as VR-based teacher training is still in its early stages, it is vital to develop suitable materials and tasks to be used in VR classrooms that made good use of its multisensory immersion and interactivity. As Moreno and Mayer eloquently noted (Moreno & Mayer, 2002, p. 602), "media enables method," and media alone would not be enough for meaningful learning. CAMIL also claims that if VR is beneficial for learning, it is not the medium itself that is effective but the instructional method that it enables.

CONCLUSION

This randomized controlled experiment revealed that immersive VR simulation led to higher increments in self-reported triggered interest and self-efficacy regarding classroom management compared to a video viewing task. Our findings demonstrated that immersive VR could be an authentic teacher training environment that reflects the way professional competencies are applied in a real-life classroom and could hold great potential to bridge the long-drawn-out gap between theory and practice in teacher education (eg, Grossman & Pupik Dean, 2019; Korthagen & Kessels, 1999). Concurrently, we also found that the VR simulation invoked higher extraneous cognitive load than video, indicating that the feeling of "being there" may be a double-edged sword for learning. To ensure that VR serves as a catalyst for teacher learning and not a "distractor" (Parong & Mayer, 2021, p. 228), the training method in VR simulation needs to be carefully investigated in the future. In sum, we would advise the use of VR simulation alongside and not instead of traditional training media such as video in teacher education.

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CONFLICT OF INTEREST
We declare that there are no known conflicts of interest associated with this research.

DATA AVAILABILITY STATEMENT
The pre-registration, anonymized dataset, and analysis script is openly available on OSF: https://osf.io/9256h. The source code of our virtual reality classroom (https://gitup.uni-potsdam.de/mm_vr/vr-klassenzimmer) is shared under GNU Affero General Public License.

ETHICS APPROVAL STATEMENT
This study adhered to all national and international regulations for protecting human subjects.

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ENDNOTES
[1] Source code available at https://gitup.uni-potsdam.de/mm_vr/vr-klassenzimmer

[2] https://tetfolio.fu-berlin.de.

[3] See Table A3 in the Supporting Information for all the items.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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