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Past lives, present learners: Future directions for history education in virtual reality

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ABSTRACT

This study investigates the relationship between presence and learning outcomes in Virtual Reality (VR) environments, with a focus on both cognitive and affective learning. Using the *Anne Frank VR House*, a virtual replica of a hiding place for a group of Jewish people during World War II, 74 university students explored how the feeling of presence affects knowledge acquisition and perspective-taking. The results showed a significant positive correlation between presence and perspective-taking, but no effect on knowledge acquisition, meaning that a higher sense of presence predicted higher perspective-taking, while knowledge scores did not. These findings highlight VR's potential to create a sense of presence and thus foster emotional engagement in history education, suggesting that empathy-driven learning may be an effective way to engage students with complex socio-political issues beyond factual knowledge.

1. Introduction

In recent years, Virtual Reality (VR) has emerged as a powerful tool in education, offering immersive environments that facilitate a unique kind of learning experience. Central to this experience is the concept of *presence* often defined as the subjective feeling of being in the virtual environment rather than merely observing it (Huang et al., 2020; Slater & Wilbur, 1997). Presence is believed to enhance engagement and motivation, making it a focal point in various theoretical models of VR-based learning. Notably, VR-specific models such as the Cognitive Affective Model of Immersive Learning (CAMIL) by Makransky and Petersen (2021) and the Educational Framework for Immersive Learning (EFiL) by Dengel and Mägdefrau (2020) have incorporated presence as a key factor influencing learning outcomes. These frameworks emphasize that presence is not merely an ancillary experience but a critical component of how learners interact with virtual environments.

Despite the theoretical importance assigned to presence, empirical evidence on its effects remains mixed (Loureiro Krassmann et al., 2020). Some studies suggest that heightened presence correlates with increased flow, a state of deep immersion and engagement (Csikszentmihalyi, 1990) that can enhance learning performance (Makransky & Lilleholt, 2018; Makransky & Mayer, 2022). Others, however, indicate that excessive presence may lead to cognitive overload, thereby distracting learners and impairing learning efficiency (Makransky et al., 2019; Rus-Calafell et al., 2013). The complex and sometimes contradictory nature of these findings highlights the need for further research. Our study seeks to contribute to this growing body of knowledge by exploring both the positive and negative consequences of presence in VR learning environments.

Moreover, while much of the existing research focuses on cognitive learning outcomes such as knowledge acquisition and problem-solving skills there is a noticeable gap in studies examining affective learning, particularly in terms of emotional and empathetic engagement (Herrera et al., 2018; Schutte & Stilinović, 2017). Empathy, a key component of affective learning, is an essential skill for interpersonal understanding and social learning. Yet, it has been relatively underexplored in the context of VR. In this study, we aim to address this gap by examining empathy as an indicator of affective learning, thereby providing a more holistic understanding of how VR can support both cognitive and emotional development.

By integrating these two lines of inquiry, namely presence as a potentially ambivalent factor in cognitive learning and empathy as an indicator of affective learning, this study offers a nuanced perspective on the role of VR in education. The investigation is deliberately situated

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within the field of history education, which is particularly well suited to immersive learning environments. History education aims not only to convey factual knowledge but also to promote historical understanding and empathetic engagement with past human experiences. Emotional engagement is widely regarded as important for enabling learners to connect with historical narratives and reflect on their ethical dimensions (Endacott & Brooks, 2013; McCully, 2012; Zachrich et al., 2020). Nevertheless, the affective potential of VR remains underexplored. This study addresses this gap by focusing on a historically and morally significant VR application, the *Anne Frank VR House*. By examining how the feeling of presence influences emotional variables such as perspective-taking, we aim to contribute to a better understanding of the pedagogical potential and limitations of VR in emotionally and ethically sensitive historical contexts.

2. Theoretical background

This theoretical section begins by exploring learning in VR environments, focusing on how the feeling of presence influences learning outcomes. We then discuss VR applications in history education, particularly its role in enhancing empathy. Finally, we lead on to our hypothesis that affective learning variables, such as perspective-taking, have a stronger link to presence than cognitive learning variables like knowledge acquisition.

2.1. Learning in virtual reality

VR is a technology that simulates three-dimensional and interactive environments (Sherman & Craig, 2018), often portrayed via desktops or head-mounted displays (HMD). Equipped with high levels of immersion, meaning vividness in their simulations and the ability to shut out the outside world (Cummings & Bailenson, 2016), VR technologies offer meaningful and engaging learning opportunities through the mechanisms of *agency* and *presence*. According to the VR-specific and well-known CAMIL model (Makransky & Petersen, 2021), agency is to be understood as a sense of control over one's own actions, while presence describes a feeling of being there.

While agency is mainly facilitated by the degree of interactivity of the virtual environment, the perception of presence can be sourced to different reasons, depending on the kind of presence felt (Makransky & Petersen, 2021). For example, the CAMIL model makes a distinction between three different types of presence: (1) *Physical presence* is the sense in which the virtual environment feels real. (2) *Social presence* can be understood as the feeling that other social actors within the virtual environment feel like actual social beings. (3) *Self-presence* is the sense in of the virtual representation or self of the user feeling like their actual self (Makransky & Petersen, 2021).

Whereas presence is one of many variables within CAMIL, it is a central part of the EFiL, wherein the perception and interpretation of presence is influenced by the negative and positive emotions of learners, and in turn affects learning outcomes (Dengel & Mägdefrau, 2020). The EFiL assumes that, apart from prior knowledge, emotions and presence are key factors that influence learning performance in educational virtual environments (Dengel & Mägdefrau, 2020).

Next to CAMIL and EFiL, various immersive learning frameworks originating from different disciplines (e.g., pedagogy, psychology, technology) exist. A review by Fernandes et al. (2023) provides a comprehensive overview of the existing frameworks. The authors detected that in most frameworks, the concepts of immersion and sense of presence were approached, but with divergent views, which underlines the scientific importance of these constructs.

There is some empirical research to support the claim that presence experienced in VR environments can be beneficial for learners: For example, presence in conjunction with a narrative is positively correlated with knowledge transfer and positive emotions in high school students (Calvert & Hume, 2023). In another study, learners in a HMD-based virtual environment perceived a higher degree of special presence compared to a 360°-video (Breves & Stein, 2022). Further researchers report a stronger feeling of presence might also be related to more intense perspective-taking, which may lead to change in behavior (Herrera et al., 2018; Spangenberger et al., 2024). In a study with high-school students, higher sense of presence positively predicted learning satisfaction (Huang et al., 2020). Especially high-immersion environments seem be better suited to evoke empathy than low-immersion environments, depending on whether a first-person or third-person perspective is taken (I. Han et al., 2022). Likewise, higher levels of empathy and engagement were found when viewing a documentary about refugees in VR compared to a 2D-video format (Schutte & Stilinović, 2017).

It should be noted that perspective-taking is sometimes viewed as a subset of empathy. Empathy, however, is a complex and multifaceted construct that has been defined and operationalized in various ways in literature (Davis, 1980; Paulus, 2009). According to Davis (1980), empathy is the ability to understand and share the feelings of another person. This involves not only the ability to recognize and understand the emotions of others, but also the ability to imagine oneself in another person's situation and to feel what they feel. A central issue in the discussion of empathy is whether it is a cognitive or affective concept. Cognitive empathy refers to the ability to understand and recognize the thoughts, feelings, and intentions of others. This involves the ability to take another person's perspective and to understand their point of view. Affective empathy, on the other hand, refers to the ability to feel and share the emotions of others. This involves the ability to imagine oneself in another person's situation and to feel what they feel (Cuff et al., 2016). Research has shown that empathy is related to personality traits such as agreeableness, conscientiousness, and openness to experience. Individuals who are high in empathy tend to be more agreeable, conscientious, and open to experience, and are more likely to engage in prosocial behaviors such as helping and volunteering (Melchers et al., 2016). Empathy is also related to social learning theory, which suggests that individuals learn by observing and imitating the behaviors of others (Bandura, 1977). Moreover, empathy is linked to emotion recognition, which is the ability to recognize and understand the emotions of others (Ekman, 1984). Research has shown that individuals who are high in empathy tend to be better at recognizing and understanding the emotions of others.

One of the most common methods of measuring empathy is the Interpersonal Reactivity Scale, a questionnaire to measure empathy, contains perspective-taking, fantasy, personal distress and empathic concern as subscales of empathy: (1) Perspective-taking refers to the ability to imagine oneself in another person's situation and to feel what they feel, (2) fantasy refers to the ability to imagine oneself in a fictional situation and to feel what the characters feel, (3) empathic concern refers to the ability to feel concern for the well-being of others and (4) personal distress refers to the ability to feel anxious or upset when observing the distress of others (Davis, 1980, 1983). In a previous study we conducted, we found that presence had a positive moderating effect on self-assessed knowledge and on attitudes towards the sustainable development of our environment (Mulders & Träg, 2023). Overall, it is likely that VR environments are capable of inducing a perception of presence within learners, and that this perception of presence may amplify affective learning variables.

However, other research suggests that highly immersive media does not inherently improve learning and might in fact induce higher cognitive load (Leahy & Sweller, 2011; Skulmowski & Xu, 2022; Sweller, 2011). A systematic review of 46 articles showed higher cognitive load and reduced cognitive engagement for VR in 14 of those studies (J. Han et al., 2021). This was especially the case when users had to read text within the virtual environment. The same systematic review observed partially lower test scores and task performance for immersive VR users (J. Han et al., 2021). When comparing HMD-based VR to 360°-video, Breves and Stein (2022) found that learners in the HMD

condition reported higher cognitive load and symptoms of cybersickness. Another study that compared 360°-video on HMD to a desktop version also registered higher presence in the HMD group, but no difference between groups for the emotional dependent variables fear and joy (Filter et al., 2020). One study comparing interactive VR, non-interactive VR, and video formats found no effect of presence on learning gain (Loureiro Krassmann et al., 2020). Another comparison between desktop and HMD reported that learners in the HMD condition felt overloaded and distracted (Makransky et al., 2019). Overall, it seems that VR environments can easily induce an increase in cognitive load, overwhelming the learners and leading to poorer learning performance. It is however notable that the outcome variables concerned by this seem to mainly fall in the category of cognitive variables, whereas affective variables seem to be not as prone to influence through cognitive load. In this regard, some authors argue that emotions should be considered as a moderator in cognitive load theory (Beege et al., 2018; Plass & Kalyuga, 2019). The present paper wants to dive deeper into the relation of presence and those affective variables, specifically empathy and perspective-taking.

2.2. History education in VR

With a sense of presence able to facilitate highly emotionally engaging experiences (Marougkas et al., 2024), VR lends itself to learning about historical topics (Serrano-Ausejo & Mozelius, 2024). VR learning environments can also help make otherwise difficult to experience topics, like the lives of historical personalities, easier to grasp (Frentzel-Beyme & Krämer, 2023; Janssen et al., 2016; Mulders, 2023). For instance, Frentzel-Beyme and Krämer (2023) used VR technology to enhance media enjoyment and salience of moral foundations in adults who witnessed a 360°-video version of Hohenschönhausen prison through the VR-eyes of an inmate. Hohenschönhausen prison was a detention center where dissidents critical of the East German regime were held between 1945 and 1989. In another study, Patterson et al. (2022) found that VR can foster historical empathy when learning about the Children's Immigration Project, a network that allowed children of targeted groups to flee persecution under Nazi rule. They argue that understanding people from the past and their thoughts, decisions, and actions helps instill the values of a pluralistic democracy (Patterson et al., 2022). Further studies reported that utilizing VR in history education may, apart from empathy, also increase presence, academic performance, and engagement in university and high school students (Calvert & Abadia, 2020; Zhang, 2019). A recently published study by I. Han et al. (2024) investigated the complex relationships between presence, empathy and immersive tendency. In this study, immersive tendency is understood as the inclination of individuals to immerse themselves in a virtual environment. In contrast, presence refers to the experience of being in a virtual environment and feeling as if one is part of it. I. Han et al. (2024) found that immersive tendency was a significant predictor of presence and empathy, and that VR experiences with high immersive tendency were associated with higher levels of presence and empathy.

However, with reference to teaching history it should be noted that clearly showing students which parts of their learning experience are real and which are not is important to ensure an ethical use of VR technology (Bunnenberg, 2020; Lewers, 2022), especially when learning about a sensitive historical topics (Knoch, 2021; Mulders et al., 2025; Träg & Mulders, 2025).

2.3. Hypotheses

We aim to investigate whether the relationship between the affective variable of perspective-taking and the sense of presence will be stronger than the relationship between the cognitive variable of knowledge acquisition and presence. Research so far has shown that immersive VR experiences are capable of facilitating a sense of presence in users (Breves & Stein, 2022; Calvert & Abadia, 2020; Filter et al., 2020; Zhang, 2019), which in turn leads to an increase in empathy or its facet perspective-taking (I. Han et al., 2022; Patterson et al., 2022; Spangenberger et al., 2024). Therefore, we state the following hypothesis:

1. There is a positive effect of presence on perspective-taking.

The current research literature on the effect of presence on cognitive variables when using VR is more mixed. Some researchers found positive effects on learning outcomes (Frentzel-Beyme & Krämer, 2023; Mulders & Träg, 2023), some emphasize negative effects (Breves & Stein, 2022; Makransky et al., 2019), others do not find beneficial effects beyond existing media at all (Filter et al., 2020; Loureiro Krassmann et al., 2020). What researchers do however consistently seem to find is a higher level of cognitive load in learners using VR environments (J. Han et al., 2021). Because of the generally negative effects of extraneous cognitive load on learning (Leahy & Sweller, 2011; Skulmowski & Xu, 2022; Sweller, 2011), we state the following hypothesis:

2. There is a negative effect of presence on knowledge.

3. Methods

For this study, we opted for a mixed-methods design in a laboratory setting. The study included online questionnaires, the exploration of the VR application *Anne Frank VR House* and generative learning strategies. The investigation of the additional effectiveness of these generative learning activities is reported in a separate paper (Mulders et al., 2025).

3.1. Sample size and design

Our study started in April 2023 and was completed in January 2024. The study involved 74 bachelor's students from the Department of Education at the University of Duisburg-Essen in Germany. Participants were recruited through posters displayed around the university and social media advertisements. Participation was entirely voluntary and unpaid. The study was conducted at a laboratory facility at the University of Duisburg-Essen, where each student was scheduled for an individual appointment. The overall sample was randomly divided into three groups, with two groups engaging in additional generative learning activities based on the principles of Fiorella and Mayer (2016) (1. drawing, 2. self-explanation), while the other group did not. The focus of this study was not on investigating these activities. Instead, we aimed at a more detailed examination of the factor of presence. Therefore, we consider the entire sample and do not further differentiate between groups.

The study was designed as follows: Upon arrival, students were greeted by a research assistant, who informed them that they could terminate the experiment at any time if they felt unwell. Symptoms of discomfort were not considered further in this study. Before commencing the experiment, students were required to read and sign a consent form, which provided additional information about the study. Before and after the VR exploration, the participants were asked to complete online questionnaires which were linked to each other via test codes while guaranteeing anonymity. In addition to demographic variables, declarative knowledge (i.e., cognitive learning) and perspective-taking (i.e., affective learning) were measured. The experimental groups performed the generative activity after the VR exploration, while the control group immediately started completing the post-questionnaire.

3.2. The VR application

For this study we utilized the *Anne Frank VR House*, a free application co-produced by the *Anne Frank Foundation Amsterdam* and the game development studio *Force Field VR*. With this application, users can

explore Anne Frank's hiding place virtually by using HMDs and controllers. The *Anne Frank VR House* is a virtual and faithful replica of Anne Frank's hiding place, which became part of a Dutch museum after World War II. During World War II, the Germans invaded the Netherlands and forced Anne Frank, her family, and four other people, all of whom were Jewish, into hiding. In their hiding place, Anne Frank documented all her experiences and thoughts about this time in her world-famous diary. After her hiding place was found out, Anne Frank and her family were deported. In 1945, Anne Frank died at the age of 15 in the Bergen-Belsen concentration camp.

In our study, only Anne Frank's room was relevant. To virtually explore Anne Frank's room, all participants had to use an HMD (in this case: *Meta Quest 2*) and two corresponding controllers. In VR, the participants' bodies were not visualized with an avatar, only white hands such as gloves were represented (Fig. 1). In Anne Frank's room, the participants were able to interact with four elements: Anne Frank's diary, a postcard, a book lying on the bed, and binoculars. Whenever the participants picked up one of the elements, they heard the voice of a young woman that gave them the impression Anne Frank herself was speaking. For example, when the postcard is picked up, the off-screen voice says the following: *My hopes are fixed on the time that will come after the war. I would love to go to Paris for a year and London for a year to learn the language and study art history.* (Vertigo Games & Knucklehead Studios, 2019). On average, participants spent approximately 20 min exploring the virtual environment of Anne Frank's room.

3.2.1. Instruments

The students' data was collected using an online pre- and post-questionnaire. The students employed a conventional laptop to answer the questions. We used *SosciSurvey* as the standard tool for online academic surveys. All the questionnaire materials are available in the appendix.

To measure cognitive learning outcomes, we asked the students to answer four open-ended knowledge questions (e.g., *What does Anne's diary look like?)*. These were rated independently by two raters according to a previously developed coding key. A maximum of 2 points for the first three questions and 3 points for the fourth question could be obtained, resulting in a maximum knowledge score of 9.

Fig. 1. Screenshots from the application *Anne Frank VR House*.

As an affective learning objective, perspective-taking was determined. Perspective-taking is interpreted as the ability to empathize with another person's feelings. It is a prerequisite for the emergence of empathy or compassion (Roberts et al., 2014; Wolgast et al., 2020). To measure perspective-taking, we utilized the four items of the Perspective Taking subscale of the *Saarbrücker Persönlichkeitsfragebogen - Interpersonal Reactivity Index* (SPF-IRI; Paulus, 2009), a German version of the *Interpersonal Reactivity Index,* originally developed by Davis (1980, 1983). It includes the four subscales perspective-taking, fantasy, empathic concern and personal distress. To keep questionnaire length to a minimum, we did not use all four subscales in the post-questionnaire. Based on our previous research (Mulders, 2023), perspective-taking was chosen as the subscale most closely related to historical perspective-taking and its measurements (Hartmann, 2008). The statements (e.g., *When I see someone being exploited, I feel I have to protect them.*) could be rated on a Likert scale ranging from 1 (*does not suit her situation*) to 5 (*suits her situation very much*). The questionnaire's internal consistency as shown by Cronbach's α lies between .78 and .80 and can be considered good (Paulus, 2009).

In addition, students' experience of physical and self-presence was measured. The experience of physical presence is to be understood as the feeling that participants are actually present in Anne Frank's room. With the experience of self-presence, the participants have the feeling that they are able to interact as themselves in Anne Frank's room. At the same time, participants can experience a kind of connection between their real body and their virtual body (Makransky et al., 2017), so that they get the impression that they are picking up Anne Frank's diary with their real hand. Makransky et al. (2017) developed, based on the definition of presence by Lee (2004), a standardized method to measure presence in VR, called the *Multimodal Presence Scale* (MPS). In order to measure the students' presence, we used the German translation by Volkmann et al. (2018). For the purposes of this study, we only focused on physical and self-presence. We decided against including the social presence subscale, since there are no social actors to interact with within the virtual environment. Hence, we included the 10 remaining items in the post-questionnaire (e.g., *The virtual environment seemed real to me.*). The 10 items were measured on a five-point Likert-scale from 1 (*completely disagree*) to 5 (*completely agree*). For the items used here, the internal consistencies (Cronbach's α) in the original study are between .69 and .82 for physical presence and between .84 and .89 for self-presence (Volkmann et al., 2018). This indicates acceptable to high internal consistency.

The control variables in this study were age, prior technological experience, and gender, which were assessed in the pre-questionnaire. Participants were asked to fill in their age, rate their experience level, and select their gender.

4. Results

R version 4.2.2 was used for data analysis (Fox et al., 2023; R Core Team, 2022). The following results section first presents the descriptive statistics to provide a more detailed description of the sample. Subsequently, we perform inferential statistical analyses to test our hypothesis.

4.1. Descriptive statistics

The original study found no significant difference between its three randomly assigned experimental conditions (Mulders et al., 2025). An analysis of variance using Levene's test revealed homogeneity regarding perspective taking ($F(2, 71) = .28$, $p = .758$), knowledge score ($F(2, 71) = 1.69$, $p = .192$), and presence ($F(2, 71) = 1.00$, $p = .372$) between the three conditions. We therefore treat the entire sample of this study as a single group for the purposes of the present paper.

To further justify this approach, we tested whether the three original

groups differed with regard to demographic variables. Participants were between 18 and 66 years old ($M = 24.82$; $SD = 8.41$) across the entire sample. We found homogeneity of variances for age between groups ($F(2, 71) = 1.87$, $p = .161$) and a similar distribution regarding gender (Table 1). Looking at the control variable experience with VR revealed that the majority of participants (45 out of 74) had no prior experience with VR technology. Out of those that had used VR before, 22 indicated that they had *only ever tested* the technology, and the remaining 7 stated that they use VR *rarely*, meaning less than once a month. The other options for *occasional* (weekly to monthly) or *regular* (daily or multiple times a week) use were not selected by any participant. Expressed in a 5-point Likert-scale ranging from 0 to 4, that means the sample reached a mean of .49 ($SD = .67$), indicating very low experience with VR technology in the present sample. Overall, we believe that the sample can fairly be treated as a single group for the following analyses.

4.2. Testing the hypothesis

Linear regression models were implemented, where presence predicted either empathy as measured by the SPF-IRI (Paulus, 2009), or the knowledge score. Table 2 shows distribution characteristics for presence in full as well as divided by subscale, empathy, and knowledge score. It is notable that physical presence was somewhat higher than self-presence, however this might be explained by the fact that learners did not have an embodied avatar in the VR environment and might therefore have struggled to feel themselves represented within the virtual environment (Steed et al., 2016). It is also remarkable that the SPF-IRI runs on a 5-point Likert-scale, indicating that the average sum score of 16.5 is somewhat high (Paulus, 2012). Reliability for all Likert-scales according to Cronbach's α was satisfactory, while only perspective-taking fell just short of the .70 threshold (Cronbach, 1951). For the knowledge items, interrater reliability between two raters was calculated according to weighted Cohen's κ (Cohen, 1968). Since consensus between raters was generally very high, ratings of the more experienced rater were used for the following calculations.

Homogeneity of variances has been explored in the descriptive statistics section above. Another prerequisite for linear regression is normal distribution of residuals. Shapiro-Wilk normality tests (Shapiro & Wilk, 1965) revealed deviation from the normality assumption neither for the model where presence predicts perspective taking ($W = .99$; $p = .949$), nor for the model where presence predicts knowledge score ($W = .98$; $p = .194$).

Table 3 shows the values for the regression models. Presence is shown to have a significant predictive effect on perspective-taking, but not on knowledge score. As is supported by the Pearson correlations in Table 4, knowledge score and presence did not seem to correlate in any remarkable way at all.

5. Discussion

For this study, we set out to deepen our understanding of the relation between presence and both cognitive and affective variables when learning in virtual environments. First, we will discuss the results of our study and how they relate to the literature laid out in the first sections. Afterwards, we will address the limitations of our study. Finally, we will derive practical implications and future research directions for history education in VR.

Table 2
Descriptive statistics for dependent and independent variables.

	Min	*Md*	*M*	*Max*	*SD*	Reliability
Presence	1.90	3.80	3.75	5.00	.72	.88
Presence physical	2.20	4.20	4.03	5.00	.64	.79
Presence self	1.40	3.60	3.47	5.00	.95	.87
Perspective-taking	11.0	17.0	16.5	20.0	2.47	.68
Knowledge score	.50	3.75	4.03	9.00	1.69	.91

Note. Reliability is Cronbach's α for the Likert-scale items and weighted Cohen's κ for knowledge score.

Table 3
Linear regression characteristics.

	F	*df*	*p*	Multiple R^2	Intercept	Estimate
Perspective taking	21.56	1, 72	<.001	.231	2.58	.41
Knowledge score	.00	1, 72	.949	<.001	4.10	−.02

Table 4
Pearson intercorrelations of dependent and independent variables.

	Knowledge score	Perspective taking	Presence	Presence physical
Knowledge score	1	X	X	X
Perspective taking	−.104	1	X	X
Presence	−.007	.480	1	X
Presence physical	.042	.430	.862	1
Presence self	−.040	.441	.940	.638

5.1. Interpretation of the results

In this study, we investigated how exploring a virtual replica of Anne Frank's hiding place during World War II impacted affective and cognitive learning variables. The average score on the knowledge test is 4.03 out of a maximum of 9 points with a fairly large standard deviation of 1.69. In contrast, the perspective-taking sum score of 16.5 out of a maximum of 20 is somewhat high. It can therefore be assumed that the participants consistently succeeded in putting themselves in someone else's situation and empathizing with other individuals. The feeling of presence can also be classified as high on average. This applies to both subscales, physical presence and self-presence. Accordingly, the students felt present in Anne Frank's room and experienced themselves acting as individuals within the hiding place.

In line with our first hypothesis, we found that the feeling of being present in the room of Anne Frank was predictive of perspective-taking as an affective outcome. This is supported by other research that suggests that higher levels of immersion contribute to greater levels of affect (Calvert & Hume, 2023; Frentzel-Beyme & Krämer, 2023; Spangenberger et al., 2022).

Not as expected in the second hypothesis, there was no significant correlation between presence and the knowledge score as a cognitive outcome. The fact that the knowledge score and presence did not seem

Table 1
Gender distribution between original test conditions.

	Drawing condition			Explaining condition			Control group		
	Male	Female	Non-binary	Male	Female	Non-binary	Male	Female	Non-binary
Participants	5	18	1	6	17	1	6	20	0
Percent	20.8	75.0	4.2	25.0	70.8	4.2	23.1	76.9	.0

to correlate in any remarkable way at all is also worth mentioning, as it indicates that presence did not actually influence the acquisition of knowledge in any manner. This does not align with research that finds immersive VR to be beneficial to knowledge acquisition (Calvert & Hume, 2023; Dengel & Mägdefrau, 2020; Liu et al., 2022; Mulders & Träg, 2023). As Calvert and Hume (2023) point out, a higher sense of presence may not only be related to knowledge transfer, but the perceived sense of presence might also be affected by prior knowledge, which we did not control for. Additionally, immersive VR might shift cognitive resources away from the contents of a history lesson by causing emotional arousal (Parong & Mayer, 2021). This may be corroborated by the fact that correlations between perspective-taking and presence and its sub-facets in our sample are consistently positive and above .43.

Our results speak in favor of differentiation between various types of learning (e.g., affective, cognitive, procedural) and of considering the relationship between presence and learning depending on the learning objectives. On the one hand, we were able to show that presence is positively related to affective learning, while we were unable to uncover any correlation with cognitive learning. Hence, our findings indicate that high presence seems especially effective in fostering emotional engagement. This supports prior research (e.g., Frentzel-Beyme & Krämer, 2023; Patterson et al., 2022), which emphasized the potential of VR environments to reinforce moral and democratic values. Thus, when users feel present, they are more likely to experience a sense of personal relevance or relatedness. In other words, VR applications may facilitate a qualitatively different approach to learning materials by allowing users to fully immerse themselves in a probably unknown and temporally or spatially distant world and experience a sense of presence within that world. This, in turn, may lead to a more engaged participation in the learning process and a stronger emotional connection to the content presented.

However, our results showed no significant effect of presence on knowledge acquisition, a finding consistent with other studies that have also failed to establish a direct link between presence and cognitive outcomes (e.g., Loureiro Krassmann et al., 2020). In our study, we did not control for cognitive load. High cognitive load can interfere with learning (Makransky et al., 2019) and future studies should include such a measure to gain a clearer understanding of how cognitive factors interact with presence.

Another key point for future research is the differentiation between types of presence including physical, social, and self-presence. In our study, no avatars were used, which could have fostered the feeling of presence, neither for the users themselves nor for Anne Frank. This is a potential lever to enhance the feeling of presence. Future studies could replicate our research project using a VR application where users are represented as avatars alongside Anne Frank. Such a study could investigate how the existence of avatars affects both presence and affective learning. However, in this context, the ethical challenge of depicting deceased individuals should also be discussed, as it raises the risk of blurring the boundaries between reality and virtuality (e.g., Bunnenberg, 2020; Lewers, 2022).

5.2. Limitations

Despite the insights gained, several limitations must be addressed. First, we were not able to use a specific scale for perspective-taking for this paper. Instead, we utilized a global measurement of perspective-taking, which does not refer specifically to the person Anne Frank. Other measurement methods, for example the scale for historical perspective-taking by Hartmann (2008), which we have already adapted to the topic of Anne Frank in previous studies (Mulders, 2023; Mulders et al., 2025) proved to be unsuitable in terms of internal consistency for calculating further statistics. In the future, a new instrument should be developed, validated, and used in various studies to appropriately record perspective-taking in specific individuals such as Anne Frank.

Another limitation is that we have only measured the perspective-taking dimension of empathy. Other facets of empathy, according to SPF-IRI (Paulus, 2009) such as fantasy, personal distress, and empathic concern, were not included. These additional dimensions might have provided a more comprehensive picture of how VR experiences influence empathy development. Future studies should incorporate these facets to better understand the complex relationship between presence, empathy, and learning outcomes in VR environments.

While we focused on the relationship between presence and perspective-taking in our study, I. Han et al. (2024) additionally integrated the aspect of immersive tendency and revealed that the relationship between immersive tendency and empathy is more meaningful than that between presence and empathy. This could possibly be a confounding of our results. At least, this suggests that immersive tendency is a potential unexplored mitigating factor and that subsequent studies should consider the ability of individuals to engage with the virtual environment. In addition to immersive tendency, we have unfortunately also neglected other field-specific constructs such as embodiment (Kilteni et al., 2012) and cybersickness (Chattha et al., 2020).

A further limitation is that we solely focused on an application that the learner enters and experiences alone. However, as some empirical studies have already successfully shown (Papadopoulou et al., 2024), so-called SocialVR environments, in which users explore a virtual environment together with other learners, are also frequently used in the field of history education.

Next, the generalizability of our findings is constrained by the homogeneous nature of our sample, which predominantly consisted of education students with limited prior experience in VR. To enhance the applicability of the results, future studies should aim to include a more diverse participant pool, incorporating individuals from various disciplines and those with greater familiarity with VR technologies. This broader approach may provide insights into how different backgrounds influence the efficacy of VR as a learning tool.

Finally, we measured knowledge acquisition with items that could be seen as rather surface-level. The knowledge questions mainly dealt with small details about Anne Frank's life and the items within the room that the participants explored. There is a chance that participants did not find those details memorable, or did not pay attention to them, thinking that they were not relevant to the learning experience. While we found no effects of presence on knowledge score, those surface-level questions somewhat challenged the assumption that a meaningful interpretation of results could have been possible. We will reflect on whether conveying knowledge through VR-environments is even necessary in the next section.

5.3. Practical implications and future research directions

The present paper shows that history education via VR can achieve the goal of instilling a sense of empathy in learners. This begs perhaps a rather underrepresented but important question for education research: Does history education have to primarily convey knowledge? The participants in the present study generally did not seem to remember many details about Anne Frank's life, like her aspiration to study art history or the exact appearance of her diary but did feel empathy towards her. Addressing emotions by taking the perspective of a historical figure and connecting their experience to one's own might be an effective way of engaging learners in highly relevant, but emotionally charged socio-political topics, such as political and religious persecution (Frentzel-Beyme & Krämer, 2023; Mulders, 2023), climate change (Mulders & Träg, 2023; Spangenberger et al., 2024), or the treatment of refugees (Herrera et al., 2018). Especially for education about the Holocaust, there is a balance to be struck between remembering those who perished, making the voices of survivors heard, and equipping learners with knowledge on how to prevent atrocities in the future (Bickman & Hamner, 1998; Knoch, 2021; Pearce & Chapman, 2017; Traum et al.,

2015). Part of this goal might be achievable by invoking empathy in learners, and making learners relate to historical figures through VR-experiences.

In this context, it is worth mentioning the in-depth discourse of various researchers who raise the question of the extent to which knowledge acquisition should be a primary focus of history education. Neglecting affective qualities in history education has been emphasized, for example, by Andolina and Conklin (2021), who argue that cultivating empathic listening in democratic education is crucial for promoting historical empathy. Similarly, Endacott and Brooks (2013) propose an updated theoretical and practical model for promoting historical empathy, highlighting the need for educators to consider the affective qualities of history education. Furthermore, Gilbert (2019) suggests that video games, such as *Assassin's Creed*, can be used to promote empathy and understanding of historical events, demonstrating the potential of affective approaches to history education.

These practical implications point back to the theoretical framework presented in the first sections. To be able to research the emotional impact of history education aided by VR, VR-based learning frameworks need to address affective learning variables. The CAMIL accounts for interest and motivation as process variables that positively affect factual, conceptual, and procedural knowledge as well as knowledge transfer, but does not include emotional learning or other affective variables (Makransky & Petersen, 2021). The EFiL seemingly includes emotional factors only in regards to academic emotions (Pekrun & Linnenbrink-Garcia, 2012) affecting the perception and interpretation of presence, but not directly interacting with learning outcomes (Dengel & Mägdefrau, 2020). Outcomes in this model also refer mainly to cognitive and behavioral effects. The EFiL leaves some space for emotional or affective learning by stating that these can be educational (Dengel & Mägdefrau, 2020). This contributes to the impression that affective variables have been underrepresented in VR research, even though VR as a technology lends itself to experiences and perspectives that might otherwise be difficult to access (Frentzel-Beyme & Krämer, 2023; Mulders & Träg, 2023; Spangenberger et al., 2024; Zhang, 2019). Existing models might need to be adjusted, or new models will have to be developed to represent this, and for researchers to be able to adequately address emotion as a component in VR-based learning environments.

We would like to stress that our discussion mainly touches on the effects of presence and the lack of embedding of emotion in VR-based learning models for affective learning outcomes. For learning scenarios that focus on conveying declarative knowledge, like the workings of the bloodstream (Parong & Mayer, 2018), or procedural knowledge, like car detailing (Mulders et al., 2022; Tai et al., 2022), increased presence might not be beneficial after all (Makransky et al., 2019). For affective learning goals, however, presence may be able to facilitate personal relevance within learners. When investigating the effects of presence on learning, it is therefore important to clearly differentiate between types of desired learning outcomes and to create a fit between the learning method and the to-be-learned material (Träg & Mulders, 2025).

6. Conclusion

The present study demonstrates a significant correlation between the level of presence and users' perspective-taking, supporting the hypothesis that emotional variables are enhanced through VR experiences. In contrast, no significant relationship was found between presence and participants' knowledge scores, highlighting the need to differentiate between various types of learning.

Overall, our results indicate that VR environments are more effective for fostering emotional engagement than cognitive learning, especially in educational settings where it is not about conveying facts but about empathizing with the otherwise unfamiliar reality of another person's life.

Statements on open data and ethics

This study has been reviewed and approved by the Institutional Review Board of the faculty of Education Sciences at the University of Duisburg-Essen. All procedures were performed in compliance with relevant laws and institutional guidelines. Informed consent was obtained from all participants within this study. In addition, assent was obtained from each participant. The study was voluntary and all participants knew that they could withdraw from the study at any time. The participants were protected by hiding their personal information in this study. All data associated with this study are stored in an appropriate protected repository. The data can be provided upon requests by sending e-mails to the corresponding author.

CRediT authorship contribution statement

Miriam Mulders: Writing – review & editing, Writing – original draft, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Data curation, Conceptualization. **Kristian H. Träg:** Writing – review & editing, Writing – original draft, Visualization, Methodology, Formal analysis. **Lilly Kaninski:** Writing – review & editing, Data curation. **Lara Rahner:** Writing – review & editing, Data curation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.cexr.2025.100114.

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