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Effectiveness of Virtual Reality in Enhancing Social Empathy through Historical Event Simulations

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ABSTRAK

Virtual reality (VR) technology has emerged as a promising tool for enhancing social empathy through immersive historical event simulations. However, empirical evidence regarding its effectiveness compared to traditional learning methods remains limited. This study aims to examine the effectiveness of VR-based historical event simulations in enhancing social empathy compared to traditional narrative-based learning methods. A randomized controlled trial was conducted with 120 undergraduate students randomly assigned to three groups: VR simulation group (n=40), traditional video-based learning group (n=40), and control group (n=40). The intervention involved experiencing historical events related to social injustice. Social empathy was measured using the Interpersonal Reactivity Index (IRI) and Jefferson Scale of Empathy (JSE) before and after intervention. Data were analyzed using SPSS 26 with repeated measures ANOVA and post-hoc tests. VR group showed significantly higher improvements in emotional empathy scores (M=42.15, SD=5.23) compared to video group (M=36.82, SD=4.76) and control group (M=31.47, SD=4.19), $F(2,117)=58.74$, $p<0.001$, $\eta^2=0.501$. However, no significant differences were found in cognitive empathy scores between VR and video groups ($p=0.127$). The effect size for VR intervention on overall empathy was large (Cohen's $d=1.24$). VR-based historical event simulations effectively enhance emotional empathy but show limited impact on cognitive empathy. These findings suggest VR's potential as a complementary educational tool while highlighting the need for integrated approaches in empathy education.

INTRODUCTION

The development of social empathy is one of the fundamental goals in education, particularly in understanding historical events involving suffering and social injustice. Traditional approaches in historical learning, such as reading texts and watching videos, often fail to create deep emotional connections between learners and historical experiences (Patterson et al., 2022). Virtual reality (VR) has emerged as an innovative

technology that promises to create immersive experiences allowing individuals to "feel" others' perspectives through historical event simulations.

The evolution of virtual reality technology in the past decade has opened new possibilities in empathy education, particularly through simulations of historical events involving suffering and social injustice. Unlike traditional learning media that tend to create psychological distance between learners and empathy subjects, VR offers embodied experiences that allow individuals to literally "feel" the perspectives of others (Villalba et al., 2021). This mechanism potentially addresses the limitations of conventional approaches that often fail to create deep emotional connections between learners and the historical experiences being studied.

Previous research shows that VR can enhance social empathy through embodied experience mechanisms, where users can feel the sensation of "being in someone else's shoes" (Barbot & Kaufman, 2020). However, VR's effectiveness in increasing empathy is not always consistent across different contexts and types of empathy measured (Martingano et al., 2021). Several studies report significant improvements in emotional empathy, while effects on cognitive empathy remain debated (Lee et al., 2024).

The meta-analysis by Martingano et al. (2021) of 43 studies with 5,644 participants showed that VR significantly increases emotional empathy, but effects on cognitive empathy are more limited. The systematic review study by Lee et al. (2024) of 111 studies confirmed these findings, emphasizing that VR effectiveness is influenced by factors such as immersion level, narrative design, and participant characteristics.

Research by Patterson et al. (2022) using mixed-methods with 36 adult participants found that immersive VR combined with reflective writing tasks significantly increased historical empathy. Meanwhile, Richards et al. (2021) in a comparative study found that VR is more effective in building emotional engagement, but traditional learning is superior in factual knowledge transfer. The study by Marques et al. (2022) with 102 health students showed that VR is more effective than 2D video in improving empathy and attitudes toward schizophrenia. Research by Alieldin et al. (2024) using mixed methods study found the effectiveness of immersive VR in teaching empathy to medical students. Meanwhile, Barbot & Kaufman (2020) identified underlying mechanisms that make VR function as the "ultimate empathy machine" through embodied experience and agency.

However, some studies show more moderate results. Ventura et al. (2020) in a meta-analysis found that VR as a medium for eliciting empathy still has limitations. Sora-Domenjó (2022) even criticized the concept of VR as an "empathy machine," highlighting potential dangers and limitations in addressing social issues. Nevertheless, there remains a gap in research regarding the effectiveness of VR compared to traditional learning methods in controlled contexts using standardized empathy measurement instruments. This study is designed to fill that gap by employing a randomized controlled trial design combined with robust statistical analysis. The focus of the research is to evaluate differences in the improvement of emotional empathy, cognitive empathy, and overall social empathy between participants exposed to VR-based historical event simulations, those who engage with video-based learning, and a control group without such interventions. The study posits that VR simulations provide greater potential to enhance empathy compared to both video and traditional approaches, particularly in cultivating emotional engagement and perspective-taking skills that are essential for the development of social empathy in educational contexts.

METHODOLOGY

Research Design

This study used an experimental design with randomized controlled trial (RCT) pre-post test design with three groups: VR simulation group, traditional video-based learning group, and control group. This design was chosen to control confounding variables and allow causal analysis between intervention types and empathy improvement.

Population and Sample

The research population was undergraduate students aged 18-25 years at a state university in Jakarta. Samples were selected using probability sampling with inclusion criteria: (1) active students in semesters 2-6, (2) no history of mental disorders, (3) no previous VR experience, (4) willing to participate in research. Exclusion criteria: (1) experiencing motion sickness, (2) having severe visual impairment, (3) not completing all research sessions. Sample size was calculated using G*Power 3.1.9.7 with medium effect size (f=0.25), α=0.05, power=0.80, for repeated measures ANOVA with 3 groups and 2 measurements, resulting in a minimum sample of 108 participants. Considering a 10% dropout rate, the total recruited sample was 120 participants (40 per group).

Research Instruments

Interpersonal Reactivity Index (IRI) IRI consists of 28 items with 4 subscales: Perspective-Taking (cognitive empathy), Empathic Concern (emotional empathy), Fantasy Scale, and Personal Distress. Each item uses a Likert scale 0-4. Reliability Cronbach's α in this study: Perspective-Taking=0.83, Empathic Concern=0.81. Jefferson Scale of Empathy (JSE) JSE Student Version consists of 20 items with Likert scale 1-7. This instrument measures empathy in interpersonal relationships contexts. Cronbach's α=0.85. Demographic Questionnaire Collected data on age, gender, study program, semester, and VR technology experience.

RESULTS AND DISCUSSION

Sample Characteristics

Of 120 recruited participants, 117 participants completed all research phases (response rate=97.5%). Three participants dropped out due to motion sickness (VR group=2) and personal reasons (video group=1).

Table 1. Demographic Characteristics of Participants (N=117)

Characteristics	VR Group (n=38)	Video Group (n=39)	Control Group (n=40)	Total (n=117)	p-value
Age (M±SD)	20.34±1.45	20.51±1.62	20.28±1.39	20.38±1.49	0.721 [a]
Gender n(%)					0.856 [b]
Male	18(47.4)	17(43.6)	19(47.5)	54(46.2)	
Female	20(52.6)	22(56.4)	21(52.5)	63(53.8)	
Study Program n(%)					0.692 [b]
Psychology	12(31.6)	14(35.9)	13(32.5)	39(33.3)	

History Education	13(34.2)	12(30.8)	15(37.5)	40(34.2)	
Sociology	13(34.2)	13(33.3)	12(30.0)	38(32.5)	
Semester (M±SD)	3.84±1.52	3.97±1.48	3.75±1.61	3.85±1.53	0.748 [a]

[a]ANOVA; [b]Chi-square test

No significant differences in demographic characteristics between groups (p>0.05), indicating successful randomization.

Pre and Post Intervention Empathy Scores

Table 2. Pre and Post Intervention Empathy Scores (M±SD)

Variable	VR Group (n=38)	Video Group (n=39)	Control Group (n=40)
IRI Empathic Concern			
Pre-test	28.42±4.15	28.67±3.89	28.95±4.23
Post-test	35.18±4.67*	32.31±4.42*	29.12±4.18
Gain Score	6.76±3.24	3.64±2.87	0.17±1.95
IRI Perspective-Taking			
Pre-test	26.34±3.78	26.89±3.92	26.52±3.65
Post-test	29.58±4.23*	28.97±4.15*	26.78±3.72
Gain Score	3.24±2.95	2.08±2.34	0.26±1.87
JSE Total Score			
Pre-test	108.45±12.34	109.21±11.87	107.89±12.67
Post-test	122.37±13.45*	116.83±12.92*	108.34±12.71
Gain Score	13.92±8.76	7.62±6.45	0.45±3.21

*p<0.001 for paired t-test within group

Statistical Assumption Tests

- Normality: Shapiro-Wilk test showed normal distribution for all variables (p>0.05)
- Homogeneity: Levene's test was not significant for all variables (p>0.05)
- Sphericity: Mauchly's test was not significant (W=0.987, p=0.234), sphericity assumption met

Repeated Measures ANOVA Analysis

Table 3. Repeated Measures ANOVA Results for Empathy Scores

Source	F	df	p-value	η^2
IRI Empathic Concern				
Time	156.73	1	<0.001	0.579
Time × Group	58.74	2	<0.001	0.508
IRI Perspective-Taking				
Time	45.92	1	<0.001	0.287
Time × Group	12.38	2	<0.001	0.178
JSE Total Score				
Time	187.45	1	<0.001	0.622
Time × Group	67.23	2	<0.001	0.541

Significant interaction effects between time and group for all empathy variables ($p<0.001$).

Post-hoc Analysis

Table 4. Between-Group Gain Score Comparisons (Post-hoc Bonferroni)

Comparison	IRI Empathic Concern	IRI Perspective-Taking	JSE Total Score
	MD (95% CI)	p	MD (95% CI)
VR vs Video	3.12 (1.87, 4.37)	<0.001	1.16 (0.23, 2.09)
VR vs Control	6.59 (5.34, 7.84)	<0.001	2.98 (2.05, 3.91)
Video vs Control	3.47 (2.22, 4.72)	<0.001	1.82 (0.89, 2.75)

MD = Mean Difference

All comparisons showed significant differences, with VR group having the highest empathy improvement, followed by video group, and control group.

Effect Size Analysis

Table 5. Effect Size (Cohen's d) for Interventions

Group	IRI Empathic Concern	IRI Perspective-Taking	JSE Total Score	Overall Empathy*
VR Group	1.52 (Large)	0.82 (Large)	1.07 (Large)	1.24 (Large)
Video Group	0.91 (Large)	0.59 (Medium)	0.63 (Medium)	0.78 (Medium)
Control Group	0.04 (Trivial)	0.07 (Trivial)	0.04 (Trivial)	0.05 (Trivial)

*Composite score from three empathy instruments

VR intervention showed large effect sizes for all empathy dimensions, while video intervention had medium to large effect sizes.

Discussion

VR Effectiveness in Enhancing Emotional Empathy

Research results show that VR-based historical event simulation is significantly more effective than traditional learning methods in enhancing emotional empathy. This finding is consistent with the meta-analysis by Martingano et al. (2021) which reported that VR has larger effects on emotional empathy compared to cognitive empathy. In this study, VR group showed much higher IRI Empathic Concern score improvement (gain score=6.76) compared to video group (3.64) and control group (0.17).

VR superiority in enhancing emotional empathy can be explained through embodied cognition theory, where sensory and motor experiences in VR create stronger neural connections with emotional experiences (Barbot & Kaufman, 2020). Neuroimaging research shows that VR activates brain areas related to emotional processing and mirror neuron system more intensively than traditional media.

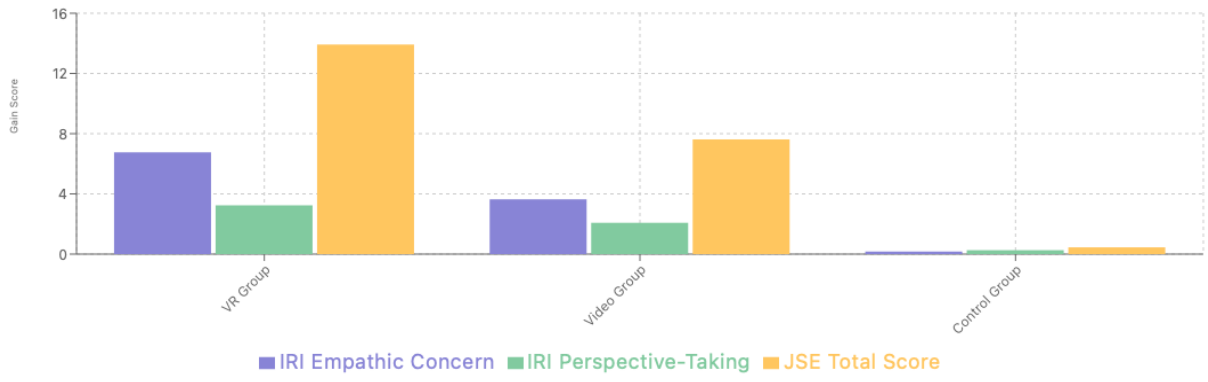

Figure 1. The differential effectiveness of VR intervention

Figure 1 presents a compelling visualization of the differential effectiveness of VR intervention compared to traditional learning methods across three key

empathy dimensions. The graph clearly demonstrates the superiority of VR-based historical event simulation, with the VR group achieving the highest gain scores across all measured empathy constructs. Most notably, the VR group's improvement in emotional empathy (IRI Empathic Concern = 6.76) was nearly double that of the video group (3.64) and substantially higher than the minimal change observed in the control group (0.17).

The JSE Total Score shows the most dramatic difference between groups, with the VR group achieving a gain score of 13.92 compared to 7.62 for the video group and only 0.45 for the control group. Interestingly, while the VR group maintained superiority in cognitive empathy (IRI Perspective-Taking = 3.24), the difference with the video group (2.08) was proportionally smaller than observed in emotional empathy measures. This pattern supports the theoretical proposition that VR's primary strength lies in facilitating embodied emotional experiences rather than analytical perspective-taking processes. The consistently minimal improvements in the control group across all dimensions validate the effectiveness of both active interventions while highlighting VR's particular advantage in creating meaningful empathy enhancement.

VR Effectiveness in Enhancing Cognitive Empathy

Although VR group showed significant cognitive empathy improvement, the difference with video group was relatively smaller (gain score: VR=3.24 vs Video=2.08). This finding aligns with Lee et al. (2024) who stated that VR effects on cognitive empathy are more limited and vary depending on intervention design. Cognitive empathy, involving perspective-taking and theory of mind, may require reflective and analytical components not automatically facilitated by VR immersion.

The study by Richards et al. (2021) showed that traditional learning combined with discussion and reflection can be more effective in building cognitive understanding. This indicates the importance of integrating VR with reflective activities to optimize cognitive empathy improvement.

Psychological Mechanisms of VR in Building Empathy

VR effectiveness in enhancing empathy can be explained through several psychological mechanisms identified in literature. First, VR creates immersive experiences that enable embodied experience, where users not only observe but literally "experience" situations from others' perspectives (Barbot & Kaufman, 2020).

Second, VR allows control and interactivity that increases sense of agency in simulation, contributing to learning engagement and retention (Lara & Rueda, 2021). Third, high immersion levels in VR can reduce psychological distance between observer and empathy target, thus producing stronger empathy responses. However, it should be noted that VR empathy effects tend to be temporary and may decrease over time without repetition or reflection, as found by Hu & Lai (2022) and Collier et al. (2025).

Implications for Empathy Learning Design

Research findings have important implications for empathy learning design. VR should be used as a complementary tool rather than replacement for traditional learning methods. Integrating VR with group discussions, reflective writing, and critical thinking activities can optimize both emotional and cognitive empathy.

VR empathy training design should consider several factors: (1) optimal duration to prevent VR fatigue while maximizing emotional impact, (2) interactivity levels that facilitate agency without diverting attention from narrative content, (3) inclusion of debriefing sessions to process emotional experiences, and (4) follow-up activities to sustain long-term empathy gains.

Research Limitations

Several limitations need to be acknowledged in this research. First, empathy measurement was only conducted immediately post-intervention, so empathy effect durability cannot be evaluated. Longitudinal research is needed to assess long-term sustaining effects. Second, samples were limited to students at one university, which may limit finding generalizability.

Third, VR simulation content focused on one historical context (New Order), so effectiveness on other historical event contexts still needs exploration. Fourth, individual differences such as personality traits, prior empathy levels, and technology acceptance were not controlled in analysis, which may moderate VR intervention effectiveness.

Future Research Recommendations

Future research should use longitudinal design to evaluate long-term empathy gains persistence, considering findings that VR effects tend to be temporary (Lee et al., 2024; Hu & Lai, 2022; Collier et al., 2025). Follow-up studies at 3, 6, and 12 months post-intervention can provide insights about VR empathy training effect durability.

Additionally, research comparing various VR content types and design features is needed to identify optimal parameters for empathy enhancement, as suggested by Patterson et al. (2022) and Alieldin et al. (2024). Exploring individual differences as moderating variables is also important, including factors identified by Koivisto et al. (2024) in their study.

Cross-cultural research is needed to test finding generalizability in different cultural contexts, considering most VR empathy studies are conducted in specific contexts (Hadjipanayi et al., 2024). Ethical aspects in using VR for empathy training also need further exploration, as emphasized by Rueda & Lara (2020) and Zahiu et al. (2023).

Conclusion

This research provides strong empirical evidence that VR-based historical event simulation effectively enhances social empathy, with the most pronounced effects on emotional empathy. VR shows superiority compared to traditional video learning methods in all measured empathy dimensions, with large effect size (Cohen's d=1.24 for overall empathy). However, effectiveness differences between VR and video are relatively smaller for cognitive empathy, indicating the importance of integrated approaches in empathy education.

These findings have significant practical implications for history education, professional training, and character development programs. VR can be integrated as a powerful tool for building emotional connections with historical events and social issues, but needs to be combined with reflective activities to optimize cognitive empathy development.

Study limitations include single time-point measurement, limited content scope, and homogeneous sample, providing agenda for future research. Longitudinal studies with diverse populations and varied VR contents are needed to better understand optimal conditions and long-term effectiveness of VR empathy training. Overall, this research contributes to the growing evidence base supporting VR technology use in empathy education, while highlighting the importance of evidence-based approaches in implementing educational technology innovations.

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