

The Impact of Racial Congruence Between Instructor and Learner on Memorization Outcomes in a Virtual Reality Environment

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Abstract: The interaction between teachers and learners is crucial for knowledge transmission and socio-emotional development. Studies have shown that ethnic congruence between teachers and students can enhance the sense of belonging, academic performance, and motivation, especially among female students. Furthermore, racial stereotypes and perceived discrimination also influence the perception of teachers' competencies, with varying effects depending on specific ethnic groups. Virtual reality (VR) offers a way to study these dynamics by controlling variables, but empirical research is still limited. It is therefore observed that multiple variables can influence the outcomes of racial congruence between students and teachers, highlighting the importance of identifying and measuring these impacts within a virtual reality context to better understand the impact of these factors in education. This study investigated the impact of racial congruence between instructors and learners on memorization outcomes within a virtual reality (VR) environment. Participants (N = 29) were randomly assigned to interact with either a racially congruent or incongruent virtual instructor while undergoing safety training in a virtual construction site. Results indicated that participants in the racially congruent condition demonstrated significantly better memorization scores compared to those in the incongruent condition. These findings highlight the potential of VR for investigating the nuances of social dynamics in educational settings and emphasize the importance of representation in learning environments.

1 INTRODUCTION

The relationship between teachers and learners is fundamental to the educational process, impacting not only the transfer of knowledge but also the socio-emotional development of learners (Kisida et al., 2015). Research suggests that the ethnic or racial background of teachers can significantly influence students (Hart, 2020), particularly when there is congruence between the teacher's and the student's background (Kisida et al., 2015). This congruence can foster a sense of identification and belonging, improved among female student (Oyserman et al., 2001), leading to improved academic performance and increased motivation among learners (Redding, 2019).

Studies have also explored the role of racial stereotypes in shaping perceptions of teachers' competencies (Fox, 2020). These stereotypes and perceived discriminations can have varying effects depending on the specific ethnic groups involved. For instance, research indicates that racial stereotypes can negatively impact African American students while

positively influencing Asian American students, reflecting the differing societal stereotypes associated with these groups (Beady & Hansell, 1981). These stereotypes can bias the perception of teachers' abilities and influence their pedagogical approaches. But then again, empirical research is still limited.

The integration of virtual reality (VR) in education offers a promising avenue for investigating these dynamics. VR enables researchers to control variables more precisely and provides unique opportunities for representing teachers in novel ways. For example, in a virtual environment, it is possible to manipulate the perceived characteristics of teachers, such as their ethnicity, and directly observe the effects on learners without the confounding factors inherent in real-world settings.

Despite the potential of VR, empirical research in this area remains limited. Some research has explored the topic of user avatar ethnicity (Do, 2024), but the ethnicity of the instructor and its congruence with that of the learner remains understudied. There is a need for robust studies to examine whether the findings observed in traditional learning contexts hold true in

VR environments. This research aims to address this gap by investigating how racial congruence affect teacher-learner interactions in virtual settings. Such research can enhance our understanding of these dynamics and inform the design of educational programs and teacher training in an increasingly digital world.

2 LITERATURE REVIEW

2.1 Racial Congruence

Racial or ethnic congruence in education refers to the match or similarity between the racial or ethnic background of a teacher and their students. This alignment can influence the relationship between teachers and learners (Johnson et al., 2001). Research suggests that students' attachment to learning and their school (Banerjee, 2017; Banerjee, 2017), particularly when the school has a historical connection to their perceived ethnic group, can significantly impact their academic engagement (Johnson et al., 2001). Students with a strong sense of academic utility tend to perform better than those who lack it.

2.2 Impact of Racial Congruence

Several studies have validated the positive impact of racial congruence between learners and teachers (Fox, 2016). Redding (2019) highlighted the significant impact of this congruence on the inclusion of students from minority groups. When students see teachers who look like them, their sense of belonging increase (Cherng et al., 2016), leading to improved engagement and academic performance. This is particularly beneficial for students from minority groups, this also and particularly affects groups of students from disadvantaged socio-economic backgrounds (Dee, 2005) as it boosts their self-confidence and academic motivation (Kisida et al., 2015).

Oyserman et al. (2001) explored the concept of racial identification, breaking it down into distinct factors such as a sense of belonging, perception of teacher competence, and academic expectations (Fox, 2016). Their findings reinforced the significant impact of racial congruence on learners, which can either promote or hinder feelings of accomplishment and academic efficacy. Students who feel represented in their academic environment tend to develop a better sense of competence and greater resilience in facing academic challenges. Conversely, the lack of

representation can reinforce feelings of alienation and marginalization, negatively affecting academic performance and student well-being.

2.3 Gender as a Variable

Oyserman et al. (2001) also observed that the impact of racial identity is subject to the variable of gender. Female individuals seem to be more impacted by their racial identification than male individuals, who appear to be more independent of this factor regarding their feeling of academic efficacy. This suggests that gender dynamics play a crucial role in how racial identity influences the learning experience.

2.4 Perceived Discrimination

Thomas et al. (2009) conducted a study with 1170 young African Americans, highlighting the impact of perceived discrimination by teachers on learners. This perception plays a role in their racial identification and, consequently, their academic results. The more an individual feels victimized by discrimination, the more their academic results tend to decline. However, a lower perception of society's view of one's racial group tends to protect against this effect. Similarly, a more marked racial centrality or a perceived positive public view also seems to protect against the adverse effects of discrimination and could even encourage better academic performance (Chavous et al., 2003).

2.5 Virtual Reality

Virtual Reality (VR) technology, which began in the 1960s with driving simulators, underwent substantial progress in the last years. Virtual reality constructs an artificial environment, whether fictional, symbolic, or a simulation of reality, allowing users to engage through sensory and motor inputs (Fuchs et al., 2003). This interactivity, enabled by equipment such as headset and controllers, provides a very immersive experience (Burkhardt et al., 2003). Nonetheless, technical obstacles like latency and sensory discrepancies might interrupt this immersion.

Beyond its technological applications, virtual reality possesses significant potential to transform education, especially for students from disadvantaged or minority racial and cultural backgrounds. Students from economically disadvantaged places could gain access to virtual excursions to museums worldwide, or those in isolated regions could engage in experiential learning within virtual laboratories. Virtual reality can overcome geographical barriers

and offer equitable access to engaging educational opportunities.

Furthermore, virtual reality helps cultivate culturally relevant educational settings. Researchers can examine the effects of representation on student engagement and learning outcomes by modifying variables such as the appearance and ethnicity of instructors' avatars, as investigated in this study. Moreover, virtual reality can provide immersive simulations that tackle delicate issues such as racial bias and discrimination within a secure and regulated environment, fostering empathy and comprehension.

Nonetheless, actualizing the complete potential of VR in education also poses problems. The cost of VR equipment and software may hinder accessibility, intensifying pre-existing disparities. It is essential to ensure that VR instructional content is culturally appropriate and free from stereotypes. Moreover, tackling possible challenges such as motion sickness and the necessity for educator training are crucial measures for the effective incorporation of VR in various educational settings.

3 HYPOTHESES

Based on the literature review, the following hypotheses were formulated:

H1: Racial congruence between learners and instructors in virtual reality positively influences learning performance.

H2: The positive effect of racial congruence between the instructor and the student in virtual reality on learning performance will be stronger in students with a low sense of perceived discrimination.

H3: The positive effect of racial congruence between the instructor and the student in virtual reality on learning performance will be stronger in female students than in male students.

4 METHODOLOGY

4.1 Participants

The study included 29 participants (15 men, 14 women) with a mean age of 28 years for men ($sd = 6$) and 29 years for women ($sd = 9$). Participants were recruited through personal networks, professional contacts, and community events. Races were represented by 2 Asians, 11 North Africans, 10 Blacks and 6 Caucasians participants. Individuals under 18 or over 60 years old, with prior knowledge

of construction site safety, with incapacitating illnesses, or conditions that could introduce bias (e.g., colour blindness) were excluded. Questions were included to screen for participants experiencing significant fatigue.

4.2 Experimental Design

Participants were randomly assigned to one of two groups:

- Group 1 ($N = 12$): Exposed to a racially congruent virtual instructor.
- Group 2 ($N = 17$): Exposed to a racially incongruent virtual instructor.

All participants were exposed to an instructor of the same gender to avoid potential gender-related bias.

4.3 Materials

- VR Headset: Meta Quest 3 with a single controller.
- VR Simulation: A custom-designed VR construction site safety training program developed in Unity by the AD2RV non-profit association.
- Instructors' avatars: 4 customized Meta Horizon avatars (Asian, North African, Black and Caucasians).
- Instructor Voices: Male voice recorded by the research director; female voice generated through AI modification of the male voice.
- Questionnaires: Two online questionnaires were developed and then distributed via Qualtrics to collect and then analyse the data. The first questionnaire was composed of 13 questions designed to collect participation consent, demographic data and information on perceived discrimination (Likert scale between 1 and 3), and VR experience. The second assessed learning outcomes related to the VR training through a list of (10) multiple-choice questions divided into modules, each associated with an image and a contextualization related to the training.

4.4 Procedure

The experiment took place in a controlled environment. Participants completed the first questionnaire, underwent the VR simulation (figure 1 and 2) with their assigned instructor, and then completed the second questionnaire. The VR simulation consisted of a 7 minutes guided tour of a

virtual construction site (including a 2 minutes familiarization with virtual reality). During the tour, the instructor's avatar was moving from place to place, highlighting potential hazards and safety signage. The participants had full control of their movements but they had to follow the instructor. Then, the second questionnaire assessed participants' recall of the information presented in the simulation (figure 3).



Figure 1: VR simulation with a Black instructor.



Figure 2: VR simulation with a Caucasian instructor.

5 RESULTS

5.1 Descriptive Statistics

Before conducting inferential statistics, descriptive analyses were performed to understand the distribution of the data. All statistics were computed with the Jamovi software.

The post-test, designed to assess participants' memorization of the safety information presented in the VR simulation, had a possible score range of 0 to 24. No participant achieved either the minimum or

maximum score, indicating that the test adequately captured variability in performance.

The mean memorization performance score for participants in the racially congruent condition (Group 1, $n = 12$) was 17.8, with a standard deviation of 3.1. In contrast, the mean score for those in the racially incongruent condition (Group 2, $n = 17$) was 14.6, with a standard deviation of 3.8. This initial observation suggests a potential trend in favour of the racially congruent condition (H1), where participants exposed to a virtual instructor of the same race tended to have an average score higher on the memorization test.

To visualize the distribution of scores (between 0 and 24) and the difference between the groups, a boxplot was generated (see Figure 4). The boxplot illustrates the median, interquartile range, and range of scores for each group, providing a visual representation of the variability and central tendency of the data.

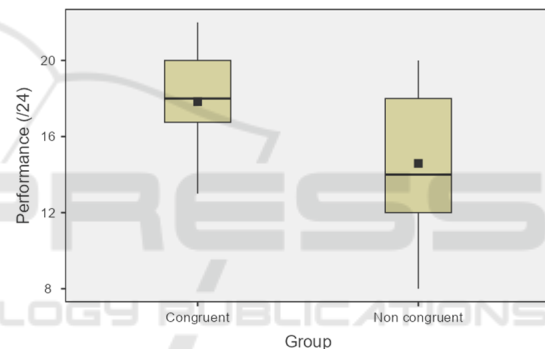


Figure 4: Boxplot of performance between the two groups.

5.2 Inferential Statistics

To examine the statistical significance of the observed difference between the groups, a Welch's t-test was conducted. This test was chosen due to the normal distribution of the two groups (as indicated by Shapiro-Wilk's test for normality $p = .0545$ for group 1 and $p = .131$ for group 2) and the unequal variances between the groups (as indicated by Levene's test for equality of variances, $F(1, 27) = 4.35$, $p = .047$).

The results of the Welch's t-test revealed a significant difference between the two groups $p = .006$, with a large effect size (Cohen's $d = .974$). This finding supports the H1 hypothesis that racial congruence between instructors and learners in a VR environment positively influences learning performance.

5.3 Moderation Analyses

To assess the potential moderating of perceived discrimination (H2) and gender (H3), separate multiple regression models were constructed with memorization score as the outcome variable, racial congruence as the predictor variable, the potential moderator as the second predictor, and the interaction term between racial congruence and the moderator. Racial congruence was encoded as -1 for non-congruence and 1 for congruence.

The results of these analyses are summarized below:

(H2) Perceived Discrimination: The interaction term between racial congruence and perceived discrimination was not statistically significant, $b = -0.148$, $SE = 0.805$, $t = -0.183$, $p = .856$. This indicates that the relationship between racial congruence and memorization score was not significantly moderated by participants' perceived discrimination.

(H3) Gender was encoded as -1 for male and 1 for female. The interaction term between racial congruence and gender was also not statistically significant, $b = -0.164$, $SE = 0.673$, $t = -0.244$, $p = .809$. This suggests that the effect of racial congruence on memorization score did not differ significantly between male and female participants.

The moderation analyses failed to demonstrate any significant moderating effects of perceived discrimination, or gender on the relationship between racial congruence and learning performance in the VR environment.

6 DISCUSSION

6.1 Summary of Results

The results of this study provide evidence that racial congruence between instructors and learners can positively impact learning outcomes, even in a virtual reality environment. Participants who interacted with a racially congruent virtual instructor demonstrated significantly better memorization scores compared to those who interacted with a racially incongruent instructor. These findings align with previous research conducted in traditional learning settings (e.g., Johnson et al., 2001; Oyserman et al., 2001; Redding, 2019), extending the understanding of the impact of racial congruence to the realm of virtual learning environments.

The study also sought to explore the potential moderating roles of perceived discrimination and gender. However, the analyses did not reveal any

significant moderation effects from these variables. While this may seem surprising in light of some prior research (e.g., Oyserman et al., 2001; Thomas et al., 2009), it is important to consider the unique characteristics of the VR environment and the specific learning task employed in this study. It is possible that the immersive nature of VR and the focus on visual and auditory learning may have minimized the influence of these individual difference factors.

The findings of this study have important implications for the design and implementation of VR-based educational interventions. By incorporating principles of representation and inclusivity, developers can create VR learning experiences that cater to the needs of diverse learners. The ability of VR to manipulate social cues and create controlled environments opens up exciting possibilities for future research on the nuances of social dynamics in learning.

6.2 Limitations and Future Directions

Despite the valuable insights gained from this study, it is essential to acknowledge its limitations. The sample size was relatively small, which may limit the generalizability of the findings. Future studies with larger and more diverse samples are needed to validate and extend these results. Additionally, the study focused on a specific type of learning task (memorization of safety information in a virtual construction site). Further research should investigate the impact of racial congruence on other types of learning outcomes and in different VR learning contexts.

Another limitation relates to the artificiality of the female instructor's voice, which was generated through AI modification of the male voice. While this approach was adopted due to resource constraints, it may have introduced an unintended variable that could have influenced participants' perceptions and responses. Future studies should prioritize the use of authentic voice recordings to enhance the realism and ecological validity of the virtual instructors.

7 CONCLUSION

This study contributes to the existing research on the impact of social factors in learning by demonstrating the significant effect of racial congruence between instructors and learners in a VR environment. The findings underscore the importance of representation and inclusivity in educational settings, even those

mediated by technology. As VR technology continues to advance and become more integrated into educational practices, it is crucial to consider the social and cultural factors that can influence learning outcomes in these immersive environments. By leveraging the unique capabilities of VR to create engaging and culturally responsive learning experiences, educators can foster a sense of belonging and promote academic success for all learners.

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