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The Impact of Augmented Reality (AR) Environments on Learning Outcomes in Ideological and Political Courses: A Personality-Tailored Approach

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ABSTRACT

This study explores the effectiveness of integrating Augmented Reality (AR) environments into ideological and political courses, with a specific focus on the moderating role of the Big Five personality traits. Guided by personalized learning theory, contextual learning theory, and cognitive load theory, the research addresses key challenges in current ideological and political education—including the abstract nature of theoretical content, insufficient connection to real-world contexts, and a lack of personalized teaching strategies. A mixed-methods approach was employed, involving 170 undergraduate students divided into an experimental group (receiving AR-integrated learning) and a control group (receiving traditional lecture-based learning). Quantitative data were collected via pre-test/post-test assessments and personality inventories, while qualitative data were gathered through semi-structured interviews and focus group discussions. Results indicate that AR-based learning significantly improves students' comprehension of abstract political theories, enhances learning engagement, and boosts academic performance compared to traditional teaching methods. Personality traits exert a notable moderating effect: Openness and Conscientiousness positively predict learning gains in AR environments; Extraversion correlates with higher engagement in interactive AR tasks; and Neuroticism is associated with lower emotional engagement and increased cognitive load. These findings contribute to the development of a conceptual framework that integrates AR technology, learning theories, and personality psychology, offering practical implications for designing personalized educational technologies in ideological and political education.

Keywords: Augmented Reality (AR); Ideological and Political Courses; Big Five Personality Traits; Learning Engagement; Academic Performance

INTRODUCTION

Research Background

Ideological and political courses play a pivotal role in shaping students' ideological orientations and political consciousness within Chinese higher education, serving as a core component in fostering socialist values and civic responsibility [1,2]. However, traditional teaching methodologies in these courses are often criticized for over-reliance on lectures, leading to issues such as difficulty comprehending abstract content, limited connection to real-life scenarios, and failure to adapt to diverse learning styles [3,4]. With the rapid advancement of educational technology, Augmented Reality (AR)—which overlays digital information onto the real-world environment in real time—has emerged as a transformative tool for creating immersive and interactive learning experiences [5,6]. Unlike Virtual Reality (VR), which constructs fully artificial environments, AR preserves real-

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world contexts while enhancing them with virtual elements, making it particularly well-suited for translating abstract theoretical concepts into tangible, experiential learning opportunities [7,8].

Technological innovations in education have paved the way for AR integration across various disciplines, from STEM education to vocational training [9,10]. In ideological and political education, AR offers unique value by simulating historical political events, visualizing complex political structures, and enabling interactive exploration of ideological concepts [11,12]. Yet, the effectiveness of AR in educational settings is not universal: individual differences—especially personality traits—significantly influence how students interact with and benefit from technology-enhanced learning environments [13,14]. The Big Five personality traits (Openness, Conscientiousness, Extraversion, Agreeableness, and Neuroticism) are widely recognized as key predictors of learning behavior and outcomes, shaping students' receptivity to new technologies, learning preferences, and emotional responses to educational interventions [15,16].

Research Gaps

Despite growing interest in AR applications in education, several critical research gaps remain. First, most existing studies focus on STEM or vocational education, with limited attention to ideological and political courses—disciplines with unique educational objectives and content characteristics [17,18]. Second, few studies have explored the interaction between personality traits and AR-based learning, overlooking the need for personalized teaching strategies tailored to individual differences [19,20]. Third, there is a lack of empirical evidence regarding how AR influences learning outcomes in ideological and political courses, including comprehension of abstract theories, learning engagement, and academic performance [21,22]. Finally, the theoretical integration of AR technology with learning theories (e.g., cognitive load theory, personalized learning theory) in the context of ideological and political education remains insufficient, hindering the development of evidence-based teaching practices [23,24].

Research Objectives and Questions

This study aims to address these gaps by investigating the impact of AR environments on learning outcomes in ideological and political courses, while accounting for the moderating role of the Big Five personality traits. The specific research objectives are:

1. Design and implement AR-based learning modules tailored to the content and objectives of ideological and political courses.
2. Evaluate the usability of AR modules in improving students' comprehension of abstract political theories across different personality traits.
3. Assess the impact of AR-based learning on student engagement and academic performance.
4. To achieve these objectives, the following research questions are proposed:
5. How can AR-based learning modules be effectively designed and implemented to enhance students' understanding of abstract political theories in ideological and political courses?
6. What is the usability of AR modules in improving comprehension among students with varying Big Five personality traits?
7. How does AR-based learning influence student engagement and academic performance compared to traditional teaching methods?

Significance of the Study

This study holds both theoretical and practical significance. Theoretically, it enriches the literature on educational technology by integrating AR with personality psychology and learning theories, providing new empirical evidence for personalized learning and contextual learning frameworks. Practically, it offers actionable strategies for educators to integrate AR into ideological and political courses, guiding the design of personalized teaching interventions based on students' personality traits. Additionally, the findings can inform education policymakers in advancing digital teaching reforms and promoting the integration of technology and psychology in higher education.

Figure 1: AR Technology Application Scenario

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LITERATURE REVIEW

AR in Education

Augmented Reality (AR) is defined as the real-time integration of digital information with the user's physical environment, supporting multi-sensory interaction [25]. Key characteristics of AR include the fusion of real and virtual elements, real-time interactivity, and 3D tracking and registration [26]. In education, AR has been widely applied to enhance learning experiences by visualizing abstract concepts, facilitating hands-on interaction, and creating immersive contextual learning opportunities [27,28]. For example, AR has been used to teach astronomical concepts by simulating celestial movements [29] and to enhance chemistry education through interactive molecular models [30]. In ideological and political education, AR can simulate historical political events—allowing students to "participate" in historical processes—and visualize complex political structures, thereby deepening their understanding of political theories [31,32].

Ideological and Political Courses

Ideological and political courses in Chinese higher education are designed to cultivate students' socialist values, political awareness, and civic responsibility. They cover content such as Marxism, the history of the Communist Party of China, and contemporary Chinese political systems [33,34]. These courses have evolved over time to adapt to societal changes, integrating theoretical knowledge with practical activities [35]. However, traditional teaching methods in these courses often rely on lectures and textbook learning, leading to low student engagement and limited comprehension of abstract content [36,37]. The integration of innovative technologies like AR offers opportunities to address these challenges by making learning more interactive, relevant, and personalized [38,39].

Big Five Personality Traits and Learning

The Big Five personality framework encompasses five core dimensions:

- Openness: Curiosity, creativity, and receptivity to new experiences;
- Conscientiousness: Self-discipline, organization, and goal orientation;
- Extraversion: Sociability, energy, and preference for social interaction;
- Agreeableness: Cooperation, empathy, and a focus on harmony;
- Neuroticism: Emotional instability, anxiety, and sensitivity to stress [40,41].

These traits influence learning outcomes by shaping students' learning styles, motivation, and responses to educational technologies [42,43]. For instance, students high in Openness tend to embrace new learning technologies and benefit from exploratory tasks [44], while Conscientious students thrive in structured environments with clear goals and feedback [45]. Extraverted students prefer interactive and collaborative learning activities [46], whereas Neurotic students may experience higher cognitive load and anxiety in complex learning environments [47].

Learning Theories

Several learning theories provide a theoretical foundation for this study:

- Personalized learning theory emphasizes tailoring content and activities to individual differences, including personality traits and learning needs [48];
- Contextual learning theory highlights the importance of learning in real-world contexts, arguing that knowledge is best acquired and applied in relevant situations [49];
- Cognitive load theory focuses on optimizing instructional design to reduce extraneous cognitive load (irrelevant information) and enhance germane cognitive load (active knowledge construction), thereby improving learning efficiency [50].

These theories support the integration of AR into ideological and political courses, as AR can create personalized, context-rich environments that effectively manage cognitive load [51,52].

Conceptual Framework

Based on the literature review, a conceptual framework was developed to guide the study (Figure 1). The independent variables are AR implementation and Big Five personality traits; the mediating variables are learning engagement and academic self-efficacy; and the dependent variable is academic performance (measured by comprehension of political theories and test scores). The framework posits that AR implementation influences academic performance through learning engagement and academic self-efficacy, with personality traits moderating these relationships.

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Independent Variable (IV)	Moderating Variable (MV)	Dependent Variable (DV)
AR Implementation	↔ Personality Traits	Comprehension
AR teaching methods and environments	Openness, Conscientiousness, Extraversion, Agreeableness, Neuroticism	Understanding of theories through AR
↔	↔	
		Engagement
		Involvement and Enthusiasm in AR learning
↔		
		Academic Performance
		Assessment Scores (Test results)

METHODOLOGY

Research Design

A mixed-methods approach was adopted, combining quantitative and qualitative research to comprehensively analyze the impact of AR on learning outcomes. A quasi-experimental design was used to compare an experimental group (AR-integrated learning) and a control group (traditional lecture-based learning). Quantitative data were collected via pre-test/post-test assessments, personality inventories, and engagement questionnaires. Qualitative data were obtained through semi-structured interviews, focus group discussions, and classroom observations. This design allowed for the triangulation of results, combining statistical evidence with in-depth insights into students' experiences.

Participants

Participants were 170 undergraduate students enrolled in ideological and political courses at a vocational college in Guangzhou, China. They were divided into two groups: an experimental group (n=85) and a control group (n=85). The experimental group received AR-integrated instruction, while the control group received traditional lecture-based instruction covering the same content. The demographic characteristics of the participants are summarized in Table 1.

Table 1: Demographic Characteristics of Participants

Characteristic	Experimental Group (n=85)	Control Group (n=85)
Gender (Male/Female)	41/44	43/42
Age (Mean ± SD)	20.3 ± 1.2	20.5 ± 1.1
Major (Social Sciences/Other)	68/17	70/15
Prior AR Experience (None/Limited/Moderate)	52/28/5	55/26/4

AR Learning Modules: Design and Implementation

AR-based learning modules were designed to align with the curriculum of ideological and political courses, focusing on key abstract concepts (e.g., Marxism, historical political events, political systems). The modules included three core components:

1. ***Historical Scene Simulation:*** Simulating pivotal historical political events (e.g., the May Fourth Movement) to allow students to interact with historical figures and processes;

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2. ***Political Theory Visualization:*** Using 3D models and interactive diagrams to visualize abstract political theories (e.g., the structure of China's political system);
3. ***Personality-Tailored Interactive Tasks:*** Designing tasks aligned with students' traits—exploratory tasks for Openness, structured tasks for Conscientiousness, and collaborative tasks for Extraversion.

The AR modules were implemented using mobile devices (smartphones and tablets) with AR applications developed via Unity3D and Vuforia. The experimental group participated in AR-based learning activities for 8 weeks, with 2 sessions per week (each lasting 90 minutes). The control group received traditional lecture-based instruction covering the same content.

Data Collection Instruments

Quantitative Instruments

1. ***Pre-test and Post-test:*** Standardized tests were developed to assess students' comprehension of ideological and political theories, including multiple-choice, short-answer, and essay questions. The tests demonstrated good reliability (Cronbach's α=0.87) and validity, verified through expert review.
2. ***Big Five Personality Inventory:*** The Big Five Inventory (BFI-44) was used to assess personality traits, with 44 items rated on a 5-point Likert scale (1=Strongly Disagree to 5=Strongly Agree). This inventory has been validated in Chinese contexts, with robust reliability and validity [53].
3. ***Learning Engagement Questionnaire:*** Based on Fredricks et al.'s [54] framework, this questionnaire measured behavioral, emotional, and cognitive engagement, with 20 items rated on a 5-point Likert scale (Cronbach's α=0.85).
4. ***Cognitive Load Scale:*** A 9-item scale developed by Paas et al. [55] was used to measure intrinsic (inherent task complexity), extraneous (irrelevant information), and germane (knowledge construction) cognitive load (Cronbach's α=0.82).

Qualitative Instruments

Semi-structured Interviews: Interviews were conducted with 15 students (8 from the experimental group, 7 from the control group) and 6 instructors to explore their experiences and perceptions of AR-based learning.

Focus Group Discussions: Four focus groups (8–10 students per group) were held to discuss topics such as the usability of AR modules, learning experiences, and suggestions for improvement.

Classroom Observations: Observations were conducted during AR learning sessions to record student interaction with AR content, engagement levels, and classroom dynamics.

Data Analysis

Quantitative data were analyzed using SPSS 26.0. Descriptive statistics summarized the data, while inferential statistics (independent samples t-tests, paired t-tests, correlation analysis, and regression analysis) tested the research hypotheses. Qualitative data were analyzed via thematic analysis using NVivo 12 Plus, following three stages: open coding (identifying initial concepts), axial coding (clustering codes into themes), and selective coding (refining core themes).

RESULTS

Quantitative Results

Pre-Test and Post-Test Comparisons

Table 2 presents the pre-test and post-test scores of the experimental and control groups. No significant differences in pre-test scores were observed between the two groups (t=0.12, p=0.90). However, the experimental group achieved a significantly higher post-test score (M=80.5, SD=7.2) than the control group (M=64.5, SD=8.7) (t=13.92, p<0.001). The mean score gain in the experimental group (+24.7) was substantially higher than that in the control group (+8.5), indicating that AR-based learning significantly improves students' comprehension of ideological and political theories.

Table 2: Descriptive Statistics of Pre-test and Post-test Scores

Group	Pre-test (Mean ± SD)	Post-test (Mean ± SD)	Mean Gain	t-value (Post-test)	p-value
Experimental	55.8 ± 8.4	80.5 ± 7.2	+24.7	13.92	<0.001
Control	56.0 ± 8.1	64.5 ± 8.7	+8.5	—	—

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Personality Traits and Learning Outcomes

Correlation analysis examined the relationship between Big Five personality traits and post-test score improvement in the experimental group (Table 3). Openness ($r=0.52$, $p<0.01$) and Conscientiousness ($r=0.34$, $p<0.05$) showed significant positive correlations with score improvement, while Neuroticism showed a significant negative correlation ($r=-0.25$, $p<0.05$). Extraversion and Agreeableness were not significantly correlated with score improvement.

Table 3: Correlation Between Personality Traits and Post-test Score Improvement (Experimental Group)

Personality Trait	Correlation Coefficient (r)	p-value
Openness	0.52	<0.01
Conscientiousness	0.34	<0.05
Extraversion	0.23	0.08
Agreeableness	0.16	0.12
Neuroticism	-0.25	<0.05

Multiple regression analysis further explored the predictive power of personality traits on learning outcomes (Table 4). Openness ($\beta=0.45$, $p<0.001$) and Conscientiousness ($\beta=0.30$, $p<0.01$) were significant positive predictors of post-test score improvement, while Neuroticism ($\beta=-0.22$, $p<0.05$) was a significant negative predictor.

Table 4: Multiple Regression Analysis of Personality Traits on Learning Outcomes

Variable	β	SE	t-value	p-value
Openness	0.45	0.08	5.63	<0.001
Conscientiousness	0.30	0.09	3.22	<0.01
Extraversion	0.18	0.10	1.80	0.07
Agreeableness	0.12	0.08	1.50	0.13
Neuroticism	-0.22	0.10	-2.20	<0.05
R^2	0.42	—	—	<0.001

Learning Engagement and Cognitive Load

The experimental group scored significantly higher in behavioral ($t=8.12$, $p<0.001$), emotional ($t=7.34$, $p<0.001$), and cognitive engagement ($t=6.87$, $p<0.001$) compared to the control group (Table 5). Regarding cognitive load, the experimental group had significantly lower extraneous load ($t=-9.48$, $p<0.001$) and higher germane load ($t=8.53$, $p<0.001$) than the control group, with no significant difference in intrinsic load ($t=-0.46$, $p=0.65$).

Table 5: Comparison of Learning Engagement and Cognitive Load Between Groups

Variable	Experimental Group (Mean ± SD)	Control Group (Mean ± SD)	t-value	p-value
Behavioral Engagement	4.2 ± 0.6	3.1 ± 0.7	8.12	<0.001
Emotional Engagement	4.1 ± 0.7	2.9 ± 0.8	7.34	<0.001
Cognitive Engagement	4.0 ± 0.6	2.8 ± 0.7	6.87	<0.001
Intrinsic Load	4.35 ± 0.92	4.42 ± 1.01	-0.46	0.65
Extraneous Load	3.15 ± 0.88	4.72 ± 1.12	-9.48	<0.001
Germane Load	5.81 ± 0.97	4.56 ± 1.03	8.53	<0.001

Qualitative Results

Theme 1: Enhanced Conceptual Understanding

Students in the experimental group reported that AR modules helped them visualize abstract political theories and historical events, leading to deeper comprehension. For example, one student noted: "The AR simulation of the May Fourth Movement made me feel like I was actually there. I could see the demonstrations and hear the speeches—this helped me understand the historical context and significance far better than just reading a textbook." Instructors also observed that students were more capable of applying theoretical knowledge to practical scenarios after using AR.

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Theme 2: Personality-Dependent Learning Experiences

Students with different personality traits had distinct experiences with AR-based learning:

High Openness: "I enjoyed the exploratory AR tasks. I could dive into different aspects of historical events and form my own opinions."

High Conscientiousness: "The structured AR tasks with clear goals and feedback helped me stay organized and focused on what I needed to learn."

High Extraversion: "Working with classmates on AR group tasks was fun. We could discuss political theories and solve problems together."

High Neuroticism: "Some AR scenes felt too complex—there was too much information at once, which made me feel stressed."

Theme 3: Increased Learning Engagement

Both students and instructors reported that AR-based learning significantly boosted engagement. Students were more active in class, participated in discussions more frequently, and showed greater interest in course content. One instructor commented: "AR made the class more dynamic and interactive. Even students who were previously quiet started participating actively—asking questions and sharing their ideas."

Theme 4: Challenges and Suggestions

Key challenges identified included technical issues (e.g., device compatibility, network stability), cognitive overload in complex AR tasks, and the need for instructor training. Suggestions for improvement included simplifying AR interfaces for Neurotic students, providing more technical support, and offering training for instructors on AR integration.

DISCUSSION

Impact of AR on Learning Outcomes

The results confirm that AR-based learning significantly improves students' comprehension of abstract political theories and academic performance compared to traditional teaching methods. This aligns with previous research showing that AR enhances learning by visualizing abstract concepts, facilitating interactive exploration, and creating immersive contexts [56,57]. In ideological and political education, AR simulations of historical events and visualizations of political structures help students connect theoretical knowledge to real-world contexts, deepening their understanding [58,59].

AR also significantly enhances student engagement—including behavioral, emotional, and cognitive engagement. The interactive and immersive nature of AR makes learning more engaging and relevant, motivating students to participate actively in class [60,61]. Additionally, AR reduces extraneous cognitive load (by minimizing irrelevant information) and increases germane cognitive load (by promoting active knowledge construction), optimizing the learning process [62,63].

Moderating Role of Personality Traits

Personality traits exert a significant moderating effect on the relationship between AR-based learning and learning outcomes:

Openness and Conscientiousness: These traits positively predict learning gains, consistent with prior research [64,65]. Open students' curiosity and receptivity to new experiences make them more likely to embrace AR and benefit from exploratory tasks [66], while Conscientious students thrive in structured AR tasks with clear goals and feedback [67].

Extraversion: Extraverted students show higher engagement in interactive AR tasks (due to their preference for social interaction [68]), but Extraversion does not significantly predict academic performance—suggesting that social engagement may enhance participation but not directly translate to test scores.

Agreeableness: This trait is not significantly correlated with learning outcomes, possibly because the collaborative AR tasks in this study did not fully leverage agreeable students' strengths (e.g., empathy, cooperation [69]).

Neuroticism: Neurotic students experience lower emotional engagement and higher cognitive load in AR environments, as they are more sensitive to stress and complexity [70]. These students may benefit from simplified AR interfaces, step-by-step guidance, and emotional support to reduce anxiety [71].

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Theoretical and Practical Implications

Theoretically, this study contributes to the literature by developing a conceptual framework that integrates AR technology, the Big Five personality traits, and learning theories. It provides empirical evidence for the moderating role of personality in AR-based learning, extending the application of personalized learning and cognitive load theory to educational technology research.

Practically, the findings offer actionable implications for educators and policymakers:

- ***Design Personality-Tailored AR Modules:*** Develop exploratory tasks for Openness, structured tasks for Conscientiousness, and collaborative tasks for Extraversion. For Neurotic students, simplify AR interfaces and provide clear guidance.
- ***Optimize Cognitive Load:*** Design AR content to minimize extraneous load (e.g., avoid redundant information) and enhance germane load (e.g., include activities that promote knowledge application).
- ***Enhance Instructor Training:*** Provide training on AR integration—including technical skills and strategies for personalized teaching—to help instructors effectively implement AR in the classroom.
- ***Improve Technical Support:*** Ensure stable network connectivity and device compatibility, and establish technical support teams to address issues during AR implementation.

LIMITATIONS AND FUTURE RESEARCH

This study has several limitations. First, the sample was limited to students from a single vocational college, which may limit the generalizability of findings. Future research should include students from diverse institutions and regions. Second, the 8-week research period focused on short-term effects; longitudinal studies are needed to explore the long-term impact of AR-based learning. Third, the AR modules covered a narrow range of ideological and political content; future work should develop more diverse AR content to address a broader set of topics. Finally, this study focused on the Big Five traits—future research could explore other individual differences (e.g., learning styles, cognitive styles).

CONCLUSIONS

This study investigates the impact of AR environments on learning outcomes in ideological and political courses, with a focus on the moderating role of the Big Five personality traits. Results show that AR-based learning significantly improves students' comprehension of abstract political theories, enhances engagement, and boosts academic performance. Personality traits moderate these effects: Openness and Conscientiousness positively predict learning gains; Extraversion correlates with higher engagement in interactive tasks; and Neuroticism is associated with lower emotional engagement and higher cognitive load. These findings highlight the importance of designing AR modules tailored to students' personality traits, providing theoretical and practical guidance for integrating AR into ideological and political education. Future research should address the study's limitations and further explore the long-term and broader applications of AR in education.

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