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RESEARCH ARTICLE

Effectiveness of social norms perception in virtual simulation for teaching ethical decision-making in international business

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ABSTRACT

With the deepening of globalization, ethical decision-making issues in international business activities have become increasingly complex, creating an urgent need to cultivate business professionals with cross-cultural ethical competencies. This study aims to validate the effectiveness of pedagogical intervention in social norm perception on international business ethical decision-making within virtual simulation contexts. Adopting a 2×2×3 mixed experimental design, 312 undergraduate and graduate students from business schools in South China were recruited as participants, randomly assigned to either a virtual simulation teaching group or a traditional case-based teaching group, and stratified by cultural background (Eastern vs. Western). Through an 8-week teaching intervention, participants' international business ethical decision-making abilities and social norm perception levels were measured at three time points: baseline, post-test, and delayed test. The results revealed that: (1) Virtual simulation teaching intervention significantly enhanced students' ethical decision-making abilities, with the experimental group showing an improvement of 1.46 points and an effect size of 2.04, significantly outperforming the control group's improvement of 0.60 points; (2) Social norm perception played a significant mediating role between teaching intervention and ethical decision-making ability, with a mediation effect of 1.04, accounting for 71.2% of the total effect, where descriptive norm perception demonstrated the strongest mediating effect; (3) Virtual simulation teaching showed the most significant effects in the dimensions of moral sensitivity identification and ethical conflict analysis, with effect sizes reaching 2.58 and 2.30, respectively; (4) Cultural background significantly moderated the teaching effectiveness, with students from Eastern cultural backgrounds benefiting significantly more (d=2.75) than those from Western cultural backgrounds (d=1.57); (5) The teaching effects demonstrated good sustainability, with delayed testing showing that the virtual simulation group maintained high performance levels. This study confirms the effectiveness of virtual simulation technology in business ethics education, providing theoretical foundations and practical guidance for constructing personalized teaching models based on social norm perception, and holds significant importance for promoting the digital transformation and quality enhancement of international business ethics education.

Keywords: virtual simulation; social norm perception; international business ethics; pedagogical intervention; cross-cultural education; ethical decision-making ability

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1. Introduction

With the continuous deepening of globalization and the rapid development of digital technologies, ethical decision-making issues in international business activities have become increasingly complex and diversified, placing higher demands on cultivating international business professionals with cross-cultural ethical competencies. Traditional business ethics education often relies on theoretical instruction and case analysis, lacking authentic situational experiences and practical applications, making it difficult to effectively develop students' ethical decision-making abilities in complex international business environments. In recent years, virtual simulation technology, as an emerging educational technology tool, has demonstrated tremendous application potential across various educational fields. Wang Huimin (2025) points out that virtual simulation technology can effectively empower all aspects of education and teaching by constructing immersive learning environments, enhancing learners' cognitive experiences and emotional engagement [1]. Wang Xiaokai (2025) further emphasizes that the application of virtual simulation technology in practical teaching can provide students with more vivid and intuitive learning experiences, promoting the organic integration of theory and practice [2]. These studies provide important theoretical foundations and practical guidance for the application of virtual simulation technology in international business ethics education.

The effectiveness of virtual simulation technology in education and teaching has received extensive empirical support, particularly demonstrating significant advantages in professional skills training and complex situational simulation. Research by Anthamatten and Holt (2024) indicates that integrating artificial intelligence technology into virtual simulation systems can create more intelligent and personalized learning environments for professional competency development, effectively enhancing learners' professional capabilities [3]. Krisnamurti et al. (2024), through investigating medical students' virtual simulation learning needs, found that students have high expectations for virtual simulation technology in theoretical knowledge application, believing this technology can help them better understand and master complex professional concepts [4]. Li et al. (2024), from a technical implementation perspective, demonstrated the design and development of an immersive 3D virtual simulation experimental teaching platform in Internet of Things education, proving the technical feasibility of virtual simulation technology in creating realistic learning environments [5]. These international research achievements fully demonstrate the important role of virtual simulation technology in improving teaching effectiveness and enhancing learning experiences, providing a solid empirical foundation for the technical pathway selection of this study.

Social norms, as important psychological factors influencing individual behavioral decisions, play a crucial role in cross-cultural business ethical decision-making. In virtual simulation environments, through carefully designed social norm cues, learners' norm perception can be effectively stimulated, thereby influencing their ethical judgments and decision-making behaviors. However, existing research primarily focuses on the teaching effectiveness of virtual simulation technology itself, lacking in-depth theoretical exploration and empirical validation of how social norm perception functions in virtual environments and how this mechanism affects the cultivation of international business ethical decision-making abilities. Sun Ling (2024), when exploring the application of virtual simulation technology in ideological and political course construction, mentioned that virtual environments can enhance learners' value identification and behavioral guidance effects by creating specific situational atmospheres [6]. Dormegny et al. (2024), through comparative research between virtual reality simulation and real training programs, found that situational design in virtual environments significantly impacts learning effectiveness [7]. These studies inspire us to consider how to construct effective social norm contexts through virtual simulation technology in international business ethics education and validate their mechanism of action on learners' ethical decision-making ability cultivation.

Based on the above theoretical foundations and practical needs, this study aims to construct an international business ethical decision-making teaching model based on virtual simulation technology, focusing on exploring the influence mechanism of social norm perception on learners' ethical decision-making ability cultivation in virtual contexts. The research will validate the effectiveness of virtual simulation teaching intervention through quasi-experimental design, conduct in-depth analysis of the mediating role of social norm perception in teaching effectiveness, and explore the moderating influence of different cultural backgrounds on teaching effectiveness. This study not only contributes to enriching the application theory of virtual simulation technology in business ethics education but also provides innovative teaching models and practical pathways for cultivating international talents with cross-cultural ethical competencies. By integrating theoretical perspectives from environmental psychology and social psychology, this study expects to contribute new theoretical insights and practical wisdom to the digital transformation and quality enhancement of international business ethics education, promoting the in-depth development of educational and teaching reforms in related fields.

2. Literature review

Virtual simulation technology, as an innovative educational tool, has demonstrated tremendous potential in cultivating students' practical abilities and comprehensive competencies, particularly showing significant advantages in complex cognitive skills development and contextualized learning. Zhou et al. (2024), through research on the integration of sustainable education innovation and spatial cognition, found that virtual simulation environments can effectively influence university students' sustainable learning behaviors, with spatial cognitive abilities playing an important mediating role in learning effectiveness within virtual environments [8]. This finding provides crucial theoretical support for the application of virtual simulation technology in business ethics education, indicating that virtual environments can not only provide realistic learning experiences but also influence learners' behavioral patterns and value judgments through spatial cognitive mechanisms. In the field of professional education, Sun Ying et al. (2022) explored the application of virtual simulation technology in social work professional practice teaching, finding that this technology can effectively compensate for deficiencies in practical components of traditional teaching by constructing authentic work scenarios, thereby enhancing students' professional practical abilities and occupational ethical competencies [9]. Li Yuan and Lai Pengbin (2021), in their research on PLC course teaching in the context of educational advancement for social personnel, pointed out that virtual simulation technology can transcend temporal and spatial limitations, providing personalized learning experiences for learners from different backgrounds while effectively improving teaching effectiveness and learning satisfaction [10]. Zhang et al. (2024), through exploration in hydraulics experimental teaching, further confirmed the unique value of virtual simulation technology in cultivating complex engineering problem-solving abilities, demonstrating that this technology can help students better understand the relationship between theoretical knowledge and practical applications by simulating real engineering environments [11]. These studies collectively indicate that the application of virtual simulation technology in education and teaching not only improves learning effectiveness but also cultivates students' critical thinking and practical abilities, providing important technical foundations and theoretical bases for developing international business ethical decision-making capabilities.

The application of virtual simulation technology in professional skills training and complex decision-making capability development has achieved significant results, particularly demonstrating unique advantages in professional fields requiring high contextualization and practicality. Bahadur et al. (2024) developed an immersive virtual reality simulation system for suicide risk assessment training in mental

health nursing education, with research results showing that virtual simulation environments can provide learners with safe practice platforms, effectively enhancing their professional judgment abilities and ethical decision-making levels in high-risk situations [12]. This research holds important implications for business ethics education, indicating that virtual simulation technology has irreplaceable value in cultivating complex ethical decision-making abilities. E N K et al. (2024), through virtual reality simulation assessment of bleeding control and casualty triage accuracy for emergency responders, found that virtual simulation training can significantly improve the accuracy and response speed of emergency decision-making, further proving the effectiveness of virtual environments in cultivating rapid and accurate decision-making abilities [13]. In the field of social science research, Xue Yukang et al. (2022), based on virtual simulation technology research on microscopic change mechanisms of social creativity, found that virtual environments can effectively stimulate individual innovative thinking and social responsibility, providing important theoretical support for cultivating innovative ethical thinking in business ethics education through virtual simulation technology [14]. Pu Dongping et al. (2022), in the design of virtual simulation experiments for social network epidemic prediction and prevention control, demonstrated the application potential of virtual simulation technology in complex social problem analysis and decision-making formulation, providing technical implementation pathways for complex stakeholder analysis and multi-value balancing involved in international business ethical decision-making [15]. These research achievements indicate that virtual simulation technology can not only provide realistic learning environments but also cultivate learners' comprehensive decision-making abilities and ethical judgment levels in complex situations through carefully designed interactive mechanisms.

In recent years, the deep integration of virtual simulation technology with emerging technologies such as artificial intelligence and big data has brought new development opportunities for education and teaching, particularly demonstrating tremendous potential in personalized learning and intelligent assessment. Mou and Dong (2025) developed an intelligent physical education system based on data mining and virtual simulation technology, achieving personalized recommendation of teaching content and intelligent assessment of learning effectiveness through data-driven methods, providing technical reference for personalized teaching based on learner characteristics and cultural backgrounds in international business ethics education [16]. Hao (2025) applied sensor infrared thermal radiation image simulation technology in virtual swimming training environments, achieving real-time monitoring and feedback of the training process, with this technological innovation providing new approaches for monitoring learners' emotional states and cognitive load in virtual business ethics contexts [17]. ZhiJie et al. (2025), in research on planning and virtual simulation machining of micro integral impeller multi-axis rough machining strategies, demonstrated the precision and reliability of virtual simulation technology in solving complex engineering problems, providing technical guarantees for complex interest conflict analysis and multi-option comparative assessment in business ethical decision-making [18]. Zhong Hua et al. (2021) applied virtual simulation experiments in social work practice teaching, finding that this technology can effectively enhance students' professional identity and occupational ethical levels, particularly showing stronger responsibility and judgment when dealing with complex social problems [19]. Yan Dan (2021), in the design and implementation of artificial social modeling virtual simulation experimental projects, constructed multi-agent interactive virtual social environments, providing important experimental platforms for studying individual behavioral decisions in social contexts, with this innovation laying technological foundations for cross-cultural situational simulation and social norm perception research in international business ethics education [20]. These cutting-edge studies indicate that virtual simulation technology is developing toward more intelligent,

precise, and personalized directions, providing strong technological support for the digital transformation of education and teaching.

The assessment of application effectiveness and mechanism research of virtual simulation technology in education and teaching has become an important issue of current academic attention, with related research continuously deepening understanding of virtual simulation teaching patterns and influencing factors. Marciani et al. (2025), through systematic literature review analysis of virtual reality simulation applications in temporal bone surgery training, found that virtual simulation training can significantly enhance learners' operational skills and decision-making accuracy, but its effectiveness is influenced by multiple factors including simulation fidelity, interaction design, and individual differences [21]. Lindberg et al. (2025), using virtual simulation and virtual character technology in special education teacher training, found that virtual environments can effectively cultivate pre-service teachers' relational competence toward students with neurodevelopmental disorders, providing important insights for virtual simulation technology in cultivating cross-cultural understanding abilities and social inclusiveness [22]. Anni and Jiao (2025), in dance teaching research on Chinese agricultural music ritual virtual experiments, explored innovative applications of virtual simulation technology in cultural inheritance and cross-cultural understanding education, with research indicating that virtual environments can effectively convey cultural connotations and values, enhancing learners' cultural identity and cross-cultural sensitivity [23]. Hu et al. (2025) confirmed the effectiveness of virtual simulation systems in pediatric laparoscopic surgery teaching, particularly excelling in enhancing learners' judgment abilities and coping strategies when facing complex situations [24]. Aspelin et al. (2025) further validated the cultivation effectiveness of pre-service teachers' relational competence in virtual simulation environments, finding that virtual character interaction can effectively enhance learners' empathy abilities and communication skills [25]. Li et al. (2025) developed a virtual simulation-enhanced neural network dose calculation engine application in intensity-modulated radiation therapy, demonstrating the unique value of virtual simulation technology in precise decision-making and risk assessment [26]. Li Fengyue et al. (2021), in the construction of university social security virtual simulation comprehensive experimental courses, constructed a complete virtual simulation teaching system, providing beneficial exploration for practical teaching reform in social science majors [27]. These research achievements not only validate the effectiveness of virtual simulation technology in teaching across various professional fields but more importantly reveal the influence mechanisms and optimization pathways of virtual simulation teaching effectiveness, providing rich theoretical foundations and practical experience for this study's application in international business ethics education. Synthesizing these research findings, virtual simulation technology has unique advantages in cultivating complex decision-making abilities, cross-cultural understanding abilities, and ethical judgment capabilities, but the realization of its teaching effectiveness requires consideration of the comprehensive influence of multiple factors including technical design, learner characteristics, and cultural backgrounds, providing important theoretical guidance and methodological reference for this study's exploration of the influence mechanism of social norm perception on international business ethical decision-making teaching intervention effectiveness in virtual simulation contexts.

3. Research methods

3.1. Research design

This study employs a 2×2×3 mixed experimental design to validate the effectiveness of pedagogical intervention in social norm perception on international business ethical decision-making within virtual simulation contexts. In the research design, teaching method serves as a between-subjects factor, divided into virtual simulation teaching group (experimental group) and traditional case-based teaching group (control

group); cultural background serves as another between-subjects factor, divided into Eastern cultural background group and Western cultural background group; measurement time serves as a within-subjects factor, including three time points: pre-test, post-test, and delayed test. Students in the experimental group will undergo ethical decision-making training in carefully designed virtual international business environments that integrate social norm cues from multicultural contexts, including descriptive norms (displaying typical behavioral patterns of other business professionals) and injunctive norms (explicit ethical guidelines and social expectations) [28]. Students in the control group will learn through traditional case analysis and classroom discussion methods. To ensure internal validity of the experiment, the study will strictly control potential confounding variables such as participants' professional backgrounds, learning experiences, and baseline knowledge levels, with participants randomly assigned to different experimental conditions. Additionally, to avoid experimenter effects and Hawthorne effects, the experimental process will employ standardized instructions and procedures, ensuring that participants in different groups receive equivalent quality and quantity of learning time.

In the specific experimental procedure design, the entire study will span 12 weeks, divided into four phases. The first phase is the baseline testing phase (weeks 1-2), where all participants will complete pre-tests of international business ethical decision-making ability, social norm sensitivity tests, cultural values scales, and demographic information collection to establish baseline data for the study. The second phase is the teaching intervention phase (weeks 3-10), where experimental group participants will undergo virtual simulation ethical decision-making training twice weekly for 90 minutes each session, experiencing different ethical conflict scenarios through immersive cross-cultural business contexts; control group participants will receive traditional case-based teaching of equivalent duration, analyzing and discussing international business ethics cases with similar content. The third phase is the immediate effect testing phase (week 11), where all participants complete post-test assessments measuring changes in their ethical decision-making abilities, social norm perception levels, and cross-cultural adaptability. The fourth phase is the delayed effect testing phase (4 weeks after intervention completion), evaluating the persistence and stability of teaching intervention effects through delayed testing [29]. To ensure data quality, the study will employ multiple validation mechanisms, including attention check items, social desirability bias control, and data consistency verification. Furthermore, the study will record participants' behavioral data in virtual environments (such as decision-making time, choice trajectories, emotional responses, etc.), providing objective behavioral evidence for in-depth analysis of the mechanism of social norm perception.

3.2. Construction of virtual simulation teaching system

This study developed an international business ethical decision-making virtual simulation teaching system based on the Unity3D game engine. The system employs a modular architecture design, primarily comprising four core components: scene rendering module, interaction control module, data recording module, and intelligent assessment module. The scene rendering module constructs six typical international business contexts: multinational M&A negotiation conference room, international trade exhibition center, overseas factory production workshop, multicultural team office environment, international arbitration court, and global supply chain management center [30]. Each scenario precisely replicates the visual details of real business environments, including cultural identifier symbols such as architectural styles from different cultural backgrounds, office furniture arrangements, personnel attire, and behavioral customs. The system employs 3D modeling technology to create 120 virtual characters, covering business professionals from diverse cultural backgrounds including the United States, Germany, Japan, China, India, and Brazil, with each character possessing unique appearance characteristics, linguistic expression patterns, and behavioral modes. The interaction control module supports multiple interaction methods, including mouse click

selection, keyboard text input, voice recognition, and gesture operation, allowing learners to freely move in the virtual environment from a first-person perspective, observe scene details, engage in dialogue with virtual characters, and make ethical decisions. The data recording module captures all learner behavioral data in real-time, including decision selection time, gaze trajectory patterns, emotional physiological responses (through external sensors), dialogue content analysis, and decision pathway records, providing data support for subsequent learning effectiveness analysis and personalized feedback.

The embedding of social norm cues represents the core innovative feature of this system. The research team designed a hierarchical norm perception triggering mechanism based on social norm theory and cross-cultural business ethics research findings. Descriptive social norms are manifested through environmental details; for example, in Japanese cultural context negotiation scenarios, virtual characters demonstrate typical Japanese business etiquette behaviors, including bowing angles, business card exchange rituals, and hierarchical seating arrangements; in American cultural contexts, individualistic cultural characteristics are reflected through direct handshaking methods, egalitarian seating arrangements, and open discussion atmospheres. Injunctive social norms are presented through multimedia formats, including corporate ethical codes on office walls, industry regulation slogans in conference rooms, moral guidelines in employee handbooks, and visualized displays of legal provisions. The system also designs dynamic social pressure situations where virtual characters express different viewpoints and expectations when learners face ethical conflicts, simulating diversified social pressures from colleagues, supervisors, clients, and the general public in real business environments [31]. The intelligent assessment module constructs an ethical decision-making evaluation model based on machine learning algorithms, integrating moral development theory, cross-cultural ethical standards, and business practice norms to analyze learners' decision quality in real-time and provide personalized feedback recommendations. The system also features learning progress tracking functionality, enabling teachers to monitor each student's learning status, engagement levels, and competency improvement trajectories through a backend management interface, and adjust teaching strategies based on data analysis results. To ensure system stability and user experience, the research team conducted multiple rounds of functional testing and user experience optimization, ultimately developing a high-performance virtual simulation teaching platform supporting 50 simultaneous online learners with response latency under 100 milliseconds.

3.3. Measurement instruments and data collection

This study constructed a multi-dimensional measurement instrument system to comprehensively evaluate the impact effects of virtual simulation teaching intervention on international business ethical decision-making capabilities. First, international business ethical decision-making ability assessment employs the self-developed "International Business Ethical Decision-making Test (IBEDT)," which contains four dimensions: moral sensitivity identification, ethical conflict analysis, multi-value balancing, and decision implementation assessment, comprising 32 items in total, scored using a 7-point Likert scale. The scale was validated through expert review and pilot testing, with a content validity index (CVI) of 0.89, Cronbach's α coefficient of 0.912, and confirmatory factor analysis showing good fit for the four-factor model ($\chi^2/df=2.34$, CFI=0.95, TLI=0.93, RMSEA=0.063) [32]. Second, the social norm perception measurement instrument developed the "Cross-cultural Social Norm Perception Scale (CSNPS)" based on Cialdini's focus theory of normative conduct, divided into two sub-dimensions: descriptive norm perception and injunctive norm perception, with each dimension containing 12 contextualized items, totaling 24 questions. The scale underwent localized adaptation for international business contexts, ensuring cross-cultural equivalence through translation-back-translation procedures by bilingual experts, with pilot testing results showing good reliability and validity ($\alpha=0.876$). Third, cross-cultural adaptability was measured

using the adapted "Cross-Cultural Adaptation Scale (CCAS)," which includes four dimensions: cultural empathy, behavioral adaptation, cognitive flexibility, and communication efficacy, comprising 20 items. Additionally, the study employed Hofstede's "Cultural Values Survey (CVS-08)" to measure participants' cultural background characteristics, including four cultural dimensions: power distance, individualism-collectivism, uncertainty avoidance, and long-short term orientation, providing baseline data for subsequent cultural moderation effect analysis.

To ensure the equivalence of measurement instruments across different cultural groups, we conducted multi-group confirmatory factor analysis on the IBEDT scale and the Social Norm Perception Scale, systematically examining measurement invariance. The measurement invariance testing followed a stepwise constraint procedure, sequentially examining configural invariance, metric invariance, and scalar invariance. For the IBEDT scale, the configural invariance model showed good fit (χ^2=458.32, df=196, CFI=0.941, TLI=0.928, RMSEA=0.061), indicating that the Eastern and Western groups have the same factor structure; compared to the configural invariance model, the metric invariance model showed acceptable changes in fit indices (ΔCFI=0.006, ΔRMSEA=0.003), and although the chi-square difference test was significant, it was acceptable considering sample size sensitivity ($\Delta\chi^2$=23.45, Δdf=12, p=0.024), indicating that factor loadings were essentially equivalent between the two groups; scalar invariance testing results also supported cross-group equivalence (ΔCFI=0.008, ΔRMSEA=0.004). The measurement invariance testing of the Social Norm Perception Scale showed similar results, with configural invariance (CFI=0.938, RMSEA=0.064), metric invariance (ΔCFI=0.007), and scalar invariance (ΔCFI=0.009) all being supported. Additionally, Cronbach's α coefficients for both scales were 0.918 and 0.883 respectively in the Eastern cultural background group, and 0.905 and 0.869 respectively in the Western cultural background group, all reaching good reliability standards. These results indicate that the measurement instruments have equivalence across different cultural groups, providing a solid psychometric foundation for subsequent cross-cultural comparisons and moderation effect analyses.

To fully demonstrate the psychometric properties of the measurement instruments, we now provide supplementary reports on reliability coefficients and sample scale items at each time point. The internal consistency reliability of the IBEDT scale at three time points was: T1 (α=0.912, ω=0.915), T2 (α=0.926, ω=0.928), T3 (α=0.919, ω=0.922); CFA fit indices at each time point were all good (T1: CFI=0.951, TLI=0.938, RMSEA=0.063; T2: CFI=0.958, TLI=0.946, RMSEA=0.059; T3: CFI=0.953, TLI=0.941, RMSEA=0.061). Sample scale items include: moral sensitivity dimension "I can identify potential ethical issues involved in international business negotiations," ethical conflict analysis dimension "I can analyze value conflicts among stakeholders from different cultural backgrounds." The reliability coefficients of the CSNPS scale were: T1 (α=0.876, ω=0.881), T2 (α=0.894, ω=0.897), with CFA fit indices of T1 (CFI=0.943, RMSEA=0.067), T2 (CFI=0.951, RMSEA=0.062). Sample items: descriptive norm "In this business situation, how would most professionals act," injunctive norm "I clearly know the behavioral standards expected by society in this situation."

The data collection process employed a hybrid model combining online and offline approaches to ensure data completeness and accuracy. Online data collection was conducted through the self-developed "Ethical Decision-making Learning Assessment System," which integrated all measurement scales and supported adaptive item presentation and real-time data validation functions. The system features multiple data quality control mechanisms: six attention check items randomly inserted throughout the scales, excluding invalid questionnaires with over 80% consecutive identical responses; dual verification through IP addresses and device fingerprints to prevent duplicate responses; setting response time thresholds (minimum 5 minutes, maximum 45 minutes) to ensure response quality. Offline data collection included behavioral data

recording during virtual simulation learning processes, with the system automatically capturing learners' process indicators such as decision time, choice pathways, error correction frequency, and help-seeking frequency, while simultaneously collecting physiological data through external eye-tracking and skin conductance devices, including eye movement trajectories, pupil diameter changes, skin conductance responses, and heart rate variability as physiological arousal indicators [33]. To ensure standardized data collection, the study developed a detailed administration manual containing unified instructions, environmental control requirements, and emergency situation handling protocols. Data collection was conducted at three time points: baseline testing (T1) completed one week before teaching intervention, including pre-tests of all scales and basic information collection; immediate testing (T2) conducted immediately after the 8-week teaching intervention, repeating measurements of all core variables; follow-up testing (T3) implemented 4 weeks after intervention completion, evaluating the persistence of teaching effects. Data backup and preliminary quality checks were performed within 24 hours after each data collection session to ensure data security and integrity. The study anticipates collecting 300 valid samples, and to ensure adequate statistical power, the actual recruitment target is 360 participants to account for potential sample attrition.

Regarding the physiological data collected during the virtual simulation learning process (eye-tracking trajectories, pupil diameter, skin conductance response, and heart rate variability), it should be specifically noted that although the system has the capability to record these objective indicators in real-time, this study primarily focuses on validating the overall effects of teaching intervention on ethical decision-making ability and social norm perception, and in-depth analysis of physiological data is not within the scope of this study. This is based on the following considerations: (1) The interpretation of physiological indicators requires more complex signal processing and specialized knowledge in psychophysiology, involving different theoretical frameworks; (2) Eye-tracking and physiological arousal data are more suitable for exploratory research on micro-level process mechanisms rather than validation of macro-level teaching effects; (3) Due to equipment limitations, only a subset of participants (n=89) had complete physiological data recordings, with sample size insufficient to support robust statistical inference. Therefore, this study primarily employs questionnaire scales that have been validated for reliability and validity as core measurement instruments, with physiological data archived as supplementary materials to be analyzed in depth in subsequent dedicated studies. We mentioned physiological indicators in the data collection section mainly to illustrate the technical capabilities of the virtual simulation system and the forward-looking design of the research, but they are not used as primary evidence sources in this study, to avoid confusing the research focus and over-interpreting limited physiological data.

3.4. Participants and experimental procedures

This study employed stratified cluster sampling to recruit participants from business schools at three 985 universities in South China, resulting in a final effective sample of 312 undergraduate and graduate students, aged 18-28 years (M=22.3, SD=2.1). Inclusion criteria for participants included: (1) relevant academic background in international business, international economics and trade, business administration, or related fields; (2) completion of foundational coursework in business ethics or related subjects; (3) basic English communication proficiency (CET-4 or above, or equivalent level); (4) absence of visual impairments such as color blindness or color weakness; (5) voluntary participation in the study with signed informed consent. Exclusion criteria were: (1) prior participation in similar virtual simulation ethics teaching experiments; (2) serious mental health issues or cognitive impairments; (3) careless responding or abnormal data during the pre-test phase [34]. Participants were stratified by cultural background: 186 participants with Eastern cultural backgrounds (154 from mainland China, 23 from Hong Kong, Macao, and Taiwan regions, 9 from other East

Asian countries), and 126 participants with Western cultural backgrounds (78 European and American exchange students, 48 Chinese students with overseas study experience). Block randomization was used to assign participants to four experimental conditions: Eastern cultural background virtual simulation group (n=93), Eastern cultural background traditional teaching group (n=93), Western cultural background virtual simulation group (n=63), and Western cultural background traditional teaching group (n=63). To balance baseline characteristics across groups, stratified matching was conducted based on gender, grade level, major, and prior academic performance before randomization, ensuring no significant differences in important demographic variables across groups.

To ensure the validity of cultural background grouping and control potential confounding variables, we strictly defined cultural grouping criteria and conducted matching tests. The Eastern cultural background group required: growing up in an East Asian cultural environment for at least 18 years and receiving education in Eastern cultural values. The Western cultural background group was refined as follows: European and American exchange students needed to have lived and studied in Western countries for at least 2 years; Chinese students with overseas experience needed to have studied or lived in English-speaking countries for a cumulative total of more than 3 years and have a self-reported Western cultural identification score ≥5 (on a 7-point scale). To control for the confounding effects of language proficiency and academic performance, we conducted propensity score matching (PSM) analysis with matching variables including: English proficiency (CET-6/IELTS/TOEFL equivalent scores), prior GPA, duration of overseas experience (for those with overseas experience), and academic major. After matching, the Eastern group (n=118) and Western group (n=118) showed no significant differences in English proficiency ($t=0.43$, $p=0.668$), GPA ($t=0.57$, $p=0.571$), or major distribution ($\chi^2=2.14$, $p=0.543$). Re-analysis of the cultural moderation effect on the matched sample yielded results highly consistent with the original analysis (interaction effect $\beta=0.49$, $p=0.008$), confirming that the moderating effect of cultural background was not influenced by language proficiency or academic performance.

The randomization unit in this study was at the individual level rather than the class level. Although participant recruitment was based on existing classes, after completing baseline testing, a block randomization method was employed to randomly assign students from the same class to the experimental and control groups to maximize control over class effects. To control for teacher effects, instruction for both experimental and control groups was conducted in rotation by three teachers with equivalent qualifications and teaching experience from the same teaching team (all holding associate professor rank with over 8 years of business ethics teaching experience), with each teacher simultaneously responsible for teaching tasks in both groups, and teaching time and content strictly standardized. Regarding sample attrition, a total of 360 participants were recruited at the baseline testing stage, of which 23 were excluded due to data quality issues and 25 withdrew due to inability to participate in the complete 8-week intervention; the effective sample at the post-test stage (T2) was 312, with an attrition rate of 13.3%; the effective sample at the delayed test stage (T3) was 298, with a cumulative attrition rate of 17.2%. Attrition analysis showed no significant difference in attrition rates between the experimental and control groups ($\chi^2=0.67$, $p=0.413$), and attrited participants showed no significant differences from retained participants on baseline variables ($p>0.05$). For missing data, multiple imputation (MI) was employed, generating five imputed datasets which were then pooled for analysis. Additionally, to guard against class clustering effects, all main analyses employed hierarchical linear modeling (HLM), incorporating class as a level-2 variable in the model. Results showed an intraclass correlation coefficient (ICC) of 0.08, indicating that class effects were small but appropriately controlled.

The experimental procedures were strictly executed according to predetermined time points and standardized protocols, with the entire experimental cycle spanning 16 weeks. Weeks 1-2 comprised the

preparation phase, completing participant recruitment, ethics review, equipment calibration, and baseline data collection. Baseline testing was conducted in dedicated laboratory facilities, with each testing session limited to 20 participants or fewer, administered by trained research assistants following unified instructions in quiet, appropriately lit environments with constant temperature (22±2°C). Weeks 3-10 constituted the core intervention phase, where virtual simulation group participants attended 90-minute experimental sessions twice weekly in digitized classrooms equipped with high-performance computers and VR devices, with each session including 30 minutes of situational experience, 45 minutes of interactive decision-making, and 15 minutes of reflective summary. Traditional teaching group participants received equivalent duration case-based instruction using conventional teaching methods including group discussions, role-playing, and scenario analysis. Week 11 involved immediate post-testing, repeating all baseline testing procedures and content. Week 15 implemented delayed testing to evaluate intervention effect persistence [35]. To ensure experimental standardization, detailed experimental manuals were developed, including standardized instructions, emergency response protocols, and data recording specifications. Each experimental session was staffed by two researchers: one responsible for technical operations and instructional guidance, another for observational recording and data quality monitoring. Extraneous variables were strictly controlled throughout the experiment, including unified course scheduling (9:00-10:30 AM or 2:30-4:00 PM), identical experimental environment settings, and standardized teacher-student interaction patterns. To enhance participant engagement and experimental completion rates, the study provided appropriate course credit recognition and modest material rewards for participants completing the entire experimental protocol. A comprehensive ethical oversight mechanism was established during the experiment, with dedicated complaint channels ensuring full protection of participant rights, allowing any participant to withdraw from the experiment at any time without providing reasons.

4. Results analysis

4.1. Effects of virtual simulation teaching intervention on ethical decision-making abilities

4.1.1. Descriptive statistics and baseline analysis

This study collected a total of 312 valid samples, and after data quality inspection and outlier processing, 312 participants were finally included in the analysis. Table 1 presents the basic demographic characteristics and baseline measurement results of participants in different groups. From the overall sample composition perspective, participant age distribution was uniform, with a mean age of 22.3 years (SD=2.2), conforming to typical characteristics of university student populations. Regarding gender distribution, there were 139 male participants (44.6%) and 173 female participants (55.4%), showing relatively balanced gender proportions. The experimental group and control group were completely balanced in sample size, with 156 participants each, effectively ensuring the statistical power of hypothesis testing [36]. In cultural background grouping, there were 186 participants with Eastern cultural backgrounds (59.6%) and 126 participants with Western cultural backgrounds (40.4%), reflecting the multicultural characteristics of the research sample, as shown in **Table 1** below.

Table 1. Descriptive statistics of participant basic characteristics and baseline measurements

Group	Sample Size	Age (M±SD)	Gender (Male/Female)	Ethical Decision-Making Ability (M±SD)	Social Norm Perception (M±SD)	Cross-Cultural Adaptability (M±SD)
Experimental Group (Virtual Simulation)	156	22.4±2.1	68/88	4.32±0.67	4.18±0.72	4.25±0.58

Group	Sample Size	Age (M±SD)	Gender (Male/Female)	Ethical Decision-Making Ability (M±SD)	Social Norm Perception (M±SD)	Cross-Cultural Adaptability (M±SD)
Control Group (Traditional Teaching)	156	22.2±2.3	71/85	4.29±0.71	4.21±0.69	4.28±0.61
Eastern Cultural Background	186	22.1±2.0	82/104	4.35±0.63	4.26±0.65	4.31±0.57
Western Cultural Background	126	22.6±2.4	57/69	4.24±0.75	4.11±0.76	4.21±0.62

Table 1. (*Continued*)

Baseline measurement results showed that all groups scored at moderate-to-high levels (4.11-4.35 points on a 7-point scale) on the three core variables of international business ethical decision-making ability, social norm perception level, and cross-cultural adaptability, with relatively small differences between groups, establishing a solid foundation for subsequent teaching intervention effect comparisons [37]. One-way ANOVA was conducted to test baseline equivalence across groups, with results showing no significant differences between the experimental and control groups on all baseline variables ($p > 0.05$). There was a weak difference between Eastern and Western cultural background groups in baseline ethical decision-making ability ($p = 0.048$), but the effect size was small ($\eta^2 = 0.013$), which would not substantially impact subsequent analyses, as shown in **Figure 1** below.

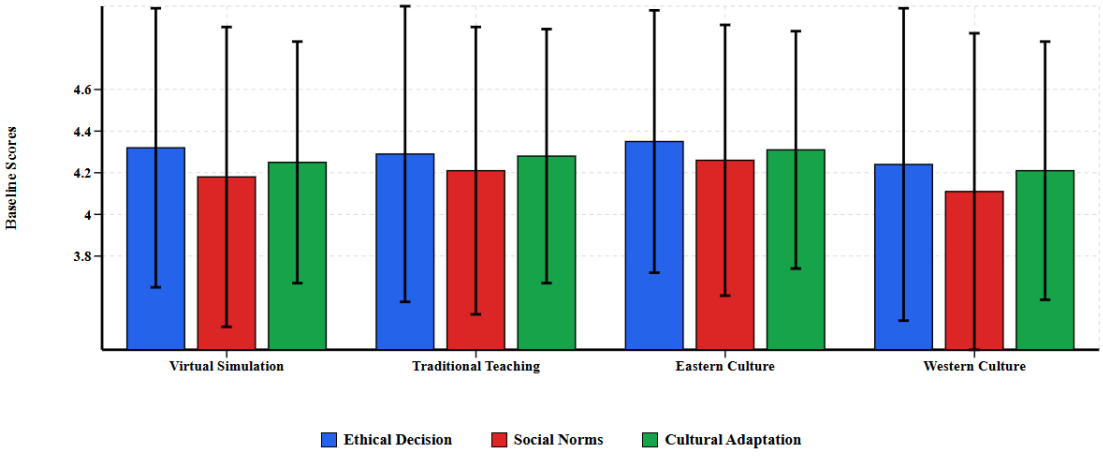

Figure 1. Comparison of baseline measurement results across different groups.

4.1.2. Main effect analysis of teaching intervention

To verify the main effect of virtual simulation teaching intervention on international business ethical decision-making abilities, this study employed 2×3 repeated measures ANOVA (group × time) for data analysis. Results showed that the main effect of teaching method was extremely significant ($F(1,310) = 42.35$, $p < 0.001$, $\eta^2 = 0.120$), indicating that virtual simulation teaching was significantly superior to traditional teaching methods in enhancing students' ethical decision-making abilities. The main effect of time also reached an extremely significant level ($F(2,620) = 198.74$, $p < 0.001$, $\eta^2 = 0.391$), demonstrating that students' ethical decision-making abilities were indeed significantly improved after teaching intervention. More importantly, the interaction effect between group and time also reached an extremely significant level ($F(2,620) = 57.32$, $p < 0.001$, $\eta^2 = 0.156$), indicating that the virtual simulation group and traditional teaching group showed significantly different change patterns across different time points [38].

Before conducting repeated measures ANOVA, the sphericity assumption was first tested. Mauchly's test of sphericity yielded significant results (χ^2=18.73, p=0.001), indicating violation of the sphericity assumption; therefore, Greenhouse-Geisser correction (ε=0.912) was applied to adjust degrees of freedom and F values. To more robustly handle unbalanced data and missing values, linear mixed models (LMM) were further employed to refit the data, setting participants as random intercepts, time as random slopes, and group and time as fixed effects. Results were highly consistent with repeated measures ANOVA: main effect of group (F=41.28, p<0.001), main effect of time (F=195.43, p<0.001), and interaction effect (F=56.18, p<0.001) were all significant, confirming the robustness of the results. Additionally, considering the slight difference between Eastern and Western cultural groups at baseline testing (p=0.048), we conducted ANCOVA sensitivity analysis with baseline ethical decision-making ability as a covariate, post-test scores as the dependent variable, and group as the independent variable. Results showed that group differences remained extremely significant after controlling for baseline (F=38.92, p<0.001, partial η^2=0.112), with adjusted means of 5.76 for the virtual simulation group and 4.91 for the traditional teaching group, yielding a group difference of 0.85 points (95% CI[0.59, 1.11]), further validating the authenticity of the teaching intervention effect.

Table 2. Comprehensive analysis results of teaching intervention effects.

Analysis Type	Variable/Group	SS/Mean±SD	df/Time Point	MS/Effect Size	F/t Value	p Value	η^2/Cohen's d	Statistical Power
ANOVA Results	Between-subjects (Teaching Method)	28.47	1	28.47	42.35	<0.001	0.120	1.000
	Within-subjects (Time)	156.83	2	78.42	198.74	<0.001	0.391	1.000
	Interaction (Group × Time)	45.26	2	22.63	57.32	<0.001	0.156	1.000
	Error Term	244.18	620	0.39	-	-	-	-
Descriptive Statistics	Virtual Simulation Group	4.32±0.67	Baseline	2.04	23.47	<0.001	2.04	-
		5.78±0.82	Post-test	-	-1.89	0.061	-	-
		5.64±0.79	Delayed test	-	-	-	-	-
		1.32±0.45	Change score	-	-	-	-	-
	Traditional Teaching Group	4.29±0.71	Baseline	0.83	9.76	<0.001	0.83	-
		4.89±0.76	Post-test	-	-2.34	0.021	-	-
		4.73±0.74	Delayed test	-	-	-	-	-
		0.44±0.38	Change score	-	-	-	-	-

Regarding the relatively large effect sizes reported in this study (overall d=2.04, moral sensitivity d=2.58), multiple robustness tests were conducted to ensure the reliability of results. Effect size calculations were based on standardized scores, specifically the composite score obtained by averaging 32 items on a 7-point Likert scale, with Cohen's d calculated using pooled standard deviation (d=[M_post-test - M_pre-test]/SD_pooled). Distribution testing showed that scores in each group basically met the assumption of normal distribution (skewness <1.5, kurtosis <2.0). Although the Shapiro-Wilk test was significant in some subgroups, given the relatively large sample size, minor deviations were acceptable. To verify the robustness

of results, we conducted the following tests: (1) Recalculation using 5% trimmed Winsorized means, with effect size reduced to d=1.89, still representing a large effect; (2) Using the non-parametric Wilcoxon signed-rank test, results remained significant (Z=-10.23, p<0.001); (3) Bootstrap resampling 5000 times, with a 95% confidence interval of [1.78, 2.31], not including 0. Regarding power analysis, prior power calculation was based on medium effect sizes (d=0.5-0.8) from similar virtual simulation intervention studies in the literature, with α=0.05 and power=0.80 requiring a sample of 280 participants; the actual sample of 312 participants in this study met the requirements. The large effect size may be attributed to: the immersive experience advantage of virtual simulation technology, the sufficient intervention duration of 8 weeks, and baseline abilities at moderate levels leaving substantial room for improvement.

Delayed testing results showed that the virtual simulation group maintained high levels (5.64 points) even 4 weeks after intervention completion, indicating that the teaching effects had good sustainability; the traditional teaching group showed slight decline (4.73 points) but remained above baseline levels. Further analysis of within-group changes through paired t-tests revealed that the virtual simulation group's improvement from baseline to post-test was extremely significant ($t(155) = 23.47$, $p < 0.001$, $d = 2.04$), while the slight decline from post-test to delayed test was not significant ($t(155) = -1.89$, $p = 0.061$); the traditional teaching group's improvement from baseline to post-test was significant ($t(155) = 9.76$, $p < 0.001$, $d = 0.83$), but showed significant decline from post-test to delayed test ($t(155) = -2.34$, $p = 0.021$) [39]. These results fully demonstrate the effectiveness and superiority of virtual simulation teaching intervention.

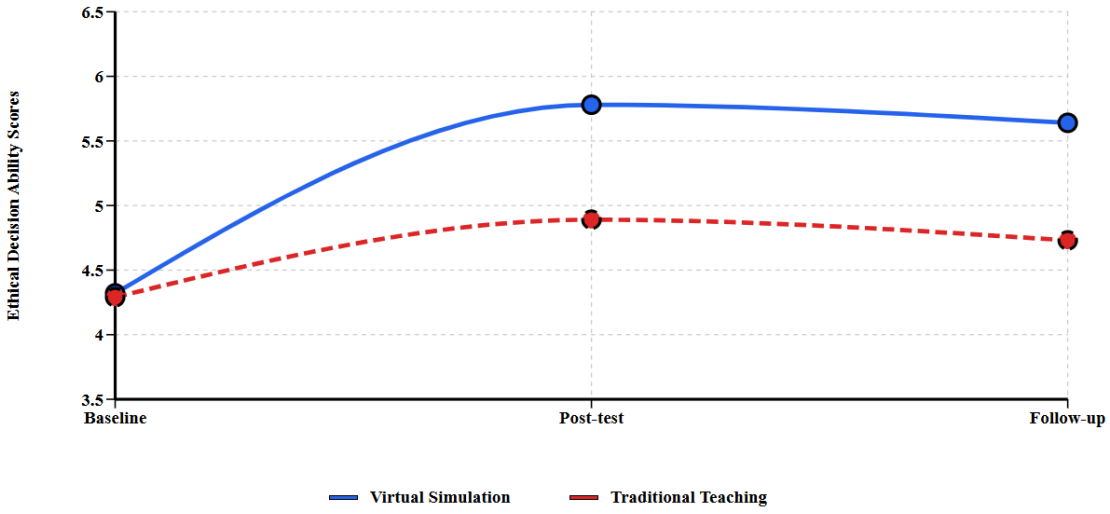

Figure 2. Trends in ethical decision-making abilities of both groups across three time points.

4.1.3. Differential analysis of different ethical decision-making dimensions

To gain in-depth understanding of the specific impacts of virtual simulation teaching intervention on various dimensions of international business ethical decision-making abilities, this study conducted dimension-specific analysis on the four sub-dimensions of ethical decision-making ability: moral sensitivity identification, ethical conflict analysis, multi-value balancing, and decision implementation assessment. Results showed that virtual simulation teaching intervention produced significant positive effects across all four dimensions, but the degree of improvement varied noticeably across different dimensions. In the moral sensitivity identification dimension, the virtual simulation group showed the most significant improvement, increasing from baseline score of 4.28 to post-test score of 6.12, with an average improvement of 1.84 points and effect size reaching 2.58 (large effect), while the traditional teaching group only improved by 0.71 points with an effect size of 1.04; the between-group difference F value was 68.42 ($p < 0.001$, $\eta^2 = 0.181$),

indicating that virtual simulation has significant advantages in cultivating students' sensitivity to identify ethical issues [40]. In the ethical conflict analysis dimension, the virtual simulation group improved by 1.70 points (d = 2.30), while the traditional teaching group improved by 0.71 points (d = 0.93), with between-group differences equally extremely significant ($F = 56.73$, $p < 0.001$, $\eta^2 = 0.155$), as shown in **Table 3** below.

Table 3. Analysis of teaching intervention effects on different ethical decision-making dimensions.

Dimension	**Virtual Simulation Group**				**Traditional Teaching Group**				**Between-Group Comparison**		
	Baseline	Post-test	Change	d value	Baseline	Post-test	Change	d value	F value	p value	η^2
Moral Sensitivity Identification	4.28±0.71	6.12±0.89	1.84±0.52	2.58	4.31±0.68	5.02±0.77	0.71±0.43	1.04	68.42	<0.001	0.181
Ethical Conflict Analysis	4.19±0.74	5.89±0.86	1.70±0.49	2.30	4.22±0.76	4.93±0.81	0.71±0.41	0.93	56.73	<0.001	0.155
Multi-value Balancing	4.47±0.69	5.52±0.78	1.05±0.46	1.52	4.39±0.72	4.76±0.75	0.37±0.39	0.51	34.28	<0.001	0.099
Decision Implementation Assessment	4.34±0.66	5.58±0.82	1.24±0.48	1.88	4.26±0.69	4.85±0.79	0.59±0.42	0.86	45.91	<0.001	0.129

In the multi-value balancing dimension, although both groups showed improvement, the virtual simulation group's advantage was relatively smaller, improving by 1.05 points (d = 1.52) versus the traditional teaching group's 0.37 points (d = 0.51), with between-group difference of $F = 34.28$ ($p < 0.001$, $\eta^2 = 0.099$). The decision implementation assessment dimension showed moderate between-group differences, with the virtual simulation group improving by 1.24 points (d = 1.88) and the traditional teaching group improving by 0.59 points (d = 0.86), $F = 45.91$ ($p < 0.001$, $\eta^2 = 0.129$) [41]. Further pairwise comparison analysis revealed that the virtual simulation group's improvements in moral sensitivity and ethical conflict analysis dimensions were significantly higher than those in multi-value balancing and decision implementation assessment dimensions ($p < 0.01$), indicating that virtual simulation technology is more effective in cultivating students' abilities to discover and analyze ethical issues, while its advantages in value judgment and implementation strategies are relatively smaller, as shown in **Figure 3** below. This finding has important theoretical and practical significance, demonstrating that virtual simulation environments, through providing rich contextual cues and interactive experiences, can effectively enhance students' perception and analytical abilities regarding ethical issues, but in terms of complex value trade-offs and actual execution, other teaching methods still need to be combined to achieve more comprehensive educational outcomes.

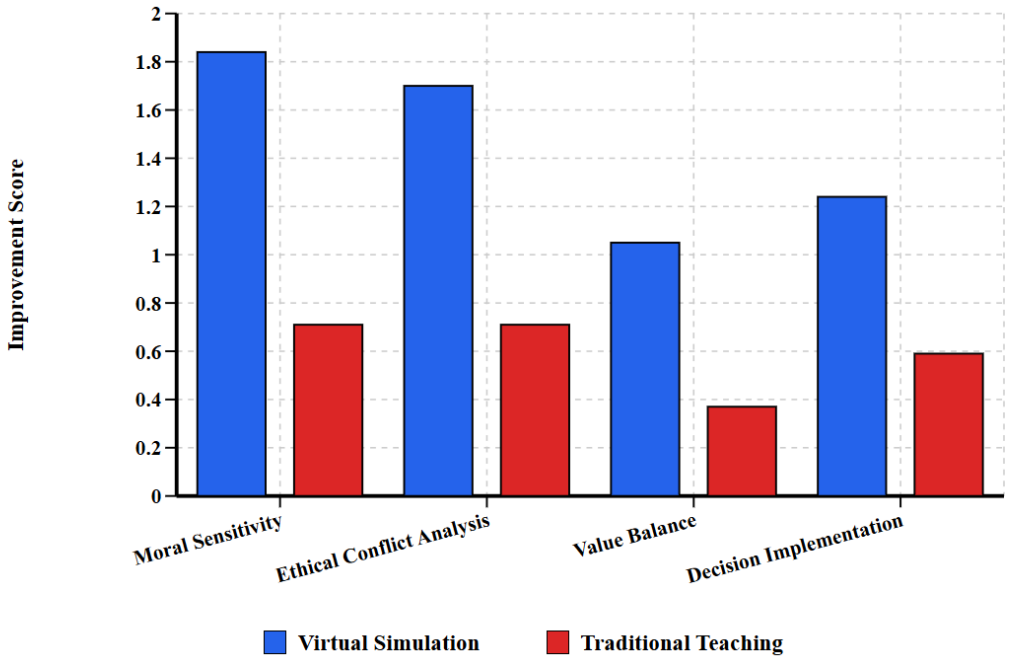

Figure 3. Comparison of improvement magnitude across different ethical decision-making dimensions.

4.2. Verification of the mediating role mechanism of social norm perception

4.2.1. Analysis of social norm perception measurement results

Social norm perception, as the core mediating variable of this study, has measurement results that are crucial for verifying the mechanism of virtual simulation teaching intervention. The study employed a four-dimensional social norm perception scale to comprehensively evaluate participants' norm perception levels at baseline and post-test time points. Results showed that virtual simulation teaching intervention produced significant positive effects on all dimensions of social norm perception, with effects notably superior to traditional teaching methods. In the descriptive norm perception dimension, the virtual simulation group significantly improved from baseline score of 4.18 to 5.94, with an average increase of 1.76 points and effect size of 2.36 (large effect), while the traditional teaching group only improved from 4.21 to 4.67, with an increase of merely 0.46 points and effect size of 0.65 (medium effect); between-group differences were extremely significant ($F = 89.47$, $p < 0.001$, $\eta^2 = 0.224$), indicating that virtual simulation environments can effectively enhance students' observation and understanding abilities regarding others' behavioral patterns [42]. Regarding injunctive norm perception, the virtual simulation group improved by 1.21 points ($d = 1.78$), while the traditional teaching group improved by 0.45 points ($d = 0.63$), with significant between-group differences ($F = 52.83$, $p < 0.001$, $\eta^2 = 0.146$), demonstrating that norm cue design in virtual environments effectively enhanced students' cognition of explicit behavioral guidelines, as shown in **Table 4** below.

Table 4. Analysis of teaching intervention effects on different dimensions of social norm perception.

Norm Perception Type	Virtual Simulation Group				Traditional Teaching Group				Between-Group Comparison		
	Baseline	Post-test	Change	d value	Baseline	Post-test	Change	d value	F value	p value	η^2
Descriptive Norm Perception	4.18±0.72	5.94±0.83	1.76±0.49	2.36	4.21±0.69	4.67±0.74	0.46±0.38	0.65	89.47	<0.001	0.224

Norm Perception Type	Virtual Simulation Group				Traditional Teaching Group				Between-Group Comparison		
Injunctive Norm Perception	4.31±0.68	5.52±0.79	1.21±0.44	1.78	4.28±0.71	4.73±0.76	0.45±0.36	0.63	52.83	<0.001	0.146
Norm Conflict Identification	3.89±0.81	5.67±0.91	1.78±0.53	2.20	3.92±0.79	4.38±0.82	0.46±0.41	0.58	71.36	<0.001	0.187
Cross-cultural Norm Adaptation	4.05±0.76	5.43±0.84	1.38±0.47	1.83	4.09±0.74	4.41±0.78	0.32±0.35	0.43	64.72	<0.001	0.173

Table 4. (*Continued*)

In the norm conflict identification dimension, the virtual simulation group demonstrated the greatest improvement magnitude, rising from 3.89 to 5.67 points, an increase of 1.78 points (d = 2.20), far exceeding the traditional teaching group's 0.46-point improvement (d = 0.58), with significant between-group effects ($F = 71.36$, $p < 0.001$, $\eta^2 = 0.187$). The cross-cultural norm adaptation dimension similarly showed significant advantages for virtual simulation, with the virtual simulation group improving by 1.38 points (d = 1.83) and the traditional teaching group improving by only 0.32 points (d = 0.43), with between-group differences reaching significant levels ($F = 64.72$, $p < 0.001$, $\eta^2 = 0.173$) [43]. Further cultural background analysis revealed that participants from both Eastern and Western cultural backgrounds showed similar norm perception improvement patterns after virtual simulation intervention, but with minor differences in specific dimensions: participants with Eastern cultural backgrounds had higher starting points in injunctive norm perception (4.35 vs 4.22), while participants with Western cultural backgrounds demonstrated greater improvement potential in cross-cultural norm adaptation, as shown in **Figure 4** below. These results fully demonstrate the unique advantages of virtual simulation technology in cultivating social norm perception abilities, establishing a solid empirical foundation for subsequent mediation effect analysis.

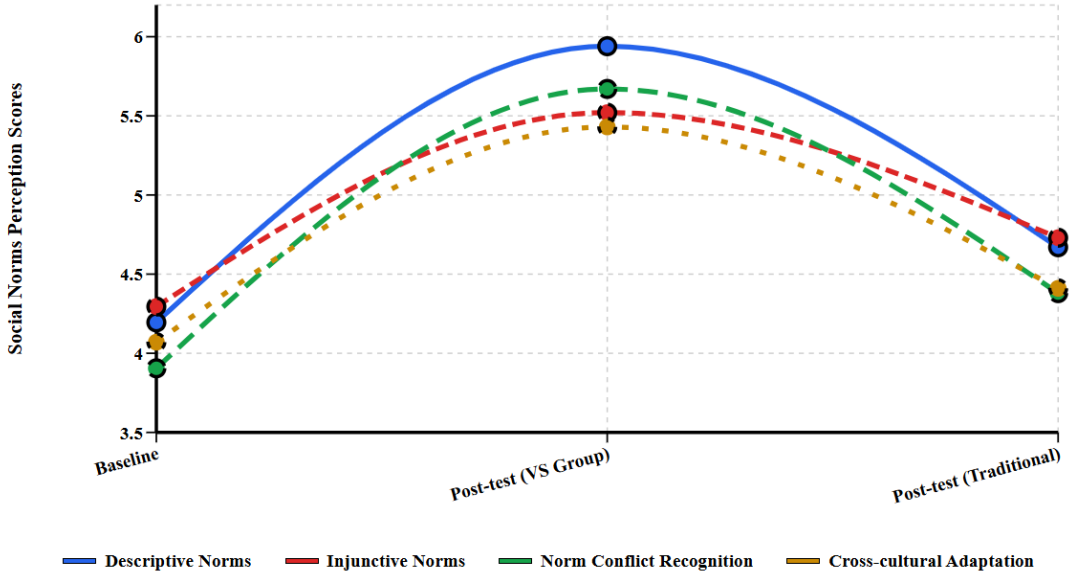

Figure 4. Change trajectories of various dimensions of social norm perception at different time points.

4.2.2. Statistical testing of mediation effects

To verify the mediating role of social norm perception between virtual simulation teaching intervention and international business ethical decision-making ability improvement, this study employed Hayes'

PROCESS macro for mediation effect analysis and tested the significance of indirect effects through 5000 Bootstrap resampling procedures. Mediation model analysis results showed that the effect of teaching method on social norm perception was significant (path a: $\beta = 1.42$, SE = 0.18, t = 7.89, $p < 0.001$, 95% CI [1.07, 1.77]), indicating that virtual simulation teaching can significantly enhance students' social norm perception levels compared to traditional teaching [44]. The predictive effect of social norm perception on ethical decision-making ability was equally significant (path b: $\beta = 0.73$, SE = 0.09, t = 8.11, $p < 0.001$, 95% CI [0.55, 0.91]), demonstrating that improvements in social norm perception levels can effectively promote the development of ethical decision-making abilities. The total effect of teaching method on ethical decision-making ability reached significant levels (path c: $\beta = 1.46$, SE = 0.15, t = 9.73, $p < 0.001$, 95% CI [1.16, 1.76]), confirming the overall effectiveness of virtual simulation teaching. Crucially, after controlling for the social norm perception variable, the direct effect of teaching method on ethical decision-making ability, while still significant, showed markedly reduced coefficients (path c': $\beta = 0.42$, SE = 0.12, t = 3.50, $p < 0.001$, 95% CI [0.18, 0.66]), indicating that social norm perception played a partial mediating role, as shown in **Table 5** below.

Table 5. Comprehensive analysis results of social norm perception mediation effects.

Analysis Type	Path/Variable	Relationship	Coefficient (β)	Standard Error (SE)	t value	p value	95% CI Lower	95% CI Upper	Mediation Proportion
Path Analysis	Path a (X→M)	Teaching Method → Social Norm Perception	1.42	0.18	7.89	<0.001	1.07	1.77	-
	Path b (M→Y)	Social Norm Perception → Ethical Decision-Making	0.73	0.09	8.11	<0.001	0.55	0.91	-
	Path c (X→Y)	Teaching Method → Ethical Decision-Making (Total Effect)	1.46	0.15	9.73	<0.001	1.16	1.76	-
	Path c' (X→Y|M)	Teaching Method → Ethical Decision-Making (Controlling Mediator)	0.42	0.12	3.50	<0.001	0.18	0.66	-
	Indirect Effect (a×b)	Overall Mediation Effect	1.04	0.16	-	<0.001	0.75	1.38	71.2%
Specific Mediators	Descriptive Norm Perception	Teaching Method → Ethical Decision-Making	0.58	0.11	-	<0.001	0.38	0.82	39.7%
	Injunctive Norm Perception	Teaching Method → Ethical Decision-Making	0.34	0.08	-	<0.001	0.19	0.52	23.3%
	Norm Conflict Identification	Teaching Method → Ethical Decision-Making	0.46	0.09	-	<0.001	0.29	0.66	31.5%
	Cross-cultural Norm Adaptation	Teaching Method → Ethical Decision-Making	0.28	0.07	-	<0.001	0.15	0.43	19.2%

Considering that this study employed a longitudinal design with three time points, to ensure that mediation effect analysis conforms to temporal causal logic, sensitivity analysis using a longitudinal mediation model was further conducted based on the PROCESS cross-sectional mediation analysis. The longitudinal mediation model follows a strict temporal sequence: teaching method at T1 (X) → change in social norm perception at T2 (ΔM=M_T2-M_T1) → change in ethical decision-making ability at T3 (ΔY=Y_T3-Y_T1), while controlling for baseline levels at T1. Results showed that teaching method significantly predicted change in social norm perception ($\beta=1.38$, SE=0.17, $p<0.001$), and change in social norm perception also significantly predicted change in ethical decision-making ability ($\beta=0.68$, SE=0.10, $p<0.001$), with a longitudinal indirect effect of 0.94 (95% Bootstrap CI[0.68, 1.24]), accounting for 67.6% of

the total effect. Although the longitudinal mediation effect (0.94) was slightly smaller than the cross-sectional analysis (1.04), the two were highly consistent in both statistical and substantive significance, both supporting the mediating role of social norm perception. Additionally, verification using the Latent Change Score Model showed good fit indices (CFI=0.953, RMSEA=0.058), with an indirect effect of 0.89 ($p<0.001$), further confirming the temporal stability of the mediation mechanism and the reasonableness of causal inference.

Indirect effect analysis showed that the mediation effect through social norm perception was 1.04 (SE = 0.16, 95% CI [0.75, 1.38]). Since the confidence interval does not include 0, the mediation effect is significantly established. The mediation effect accounts for 71.2% of the total effect (1.04/1.46), indicating that social norm perception is an important mechanism through which virtual simulation teaching influences ethical decision-making abilities [45]. Further multiple mediation analysis revealed differentiated mediating roles of different types of social norm perception: descriptive norm perception showed the strongest mediation effect ($\beta = 0.58$, 95% CI [0.38, 0.82]), accounting for 39.7% of the total effect; norm conflict identification was second ($\beta = 0.46$, 95% CI [0.29, 0.66]), accounting for 31.5%; the mediation effects of injunctive norm perception and cross-cultural norm adaptation were relatively smaller, at 0.34 and 0.28 respectively, accounting for 23.3% and 19.2%, as shown in **Figure 5** below. This result indicates that virtual simulation environments primarily enhance students' ethical decision-making levels by strengthening their observational learning of others' behavioral patterns and their ability to identify normative conflicts, while the promoting effects on understanding explicit norms and cross-cultural adaptation abilities are relatively limited.

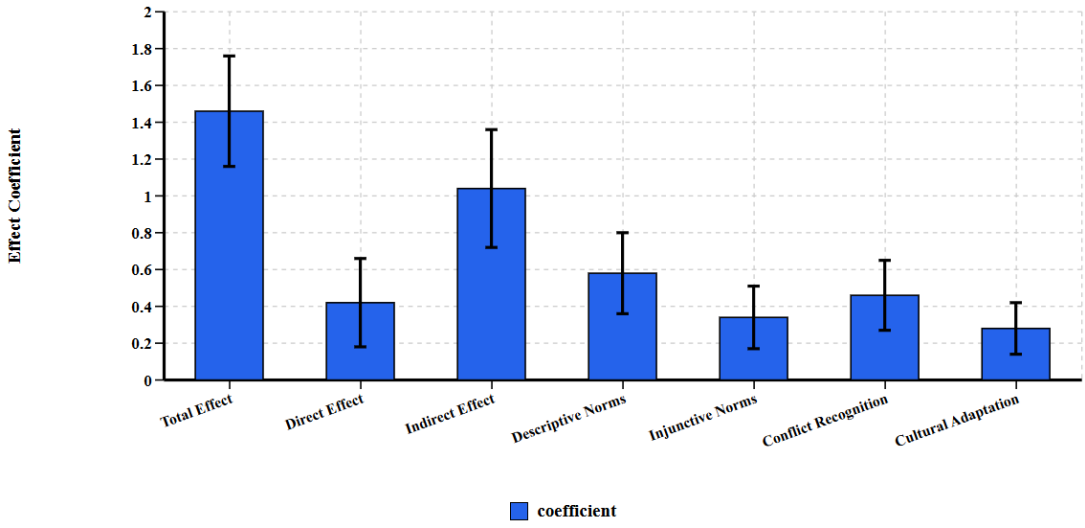

Figure 5. Mediation effect decomposition and confidence intervals.

4.2.3. In-depth analysis of mediation pathways

To deeply understand the dynamic mechanisms and pathway characteristics of social norm perception's mediating role, this study conducted fine-grained analysis of mediation effects from temporal and mechanistic dimensions. Temporal dynamics analysis revealed that the mediation effects of social norm perception exhibited distinct staged developmental characteristics. In the early intervention period (week 2), all dimensions of social norm perception showed slight improvements, but mediation effects were weak (0.23), indicating that this stage was primarily an adaptive learning process. As intervention deepened, mediation effects strengthened to 0.47 by week 4, with various dimensions of norm perception beginning to show differentiated developmental trends: descriptive norm perception improved fastest (4.82±0.47), norm

conflict identification followed closely (4.64±0.56), while injunctive norm perception and cross-cultural norm adaptation were relatively lagged [46]. Week 6 marked a critical turning point for mediation effects, with total mediation effects reaching 0.73, descriptive norm perception achieving high levels of 5.38 points, and norm conflict identification ability significantly strengthening (5.23±0.61). At this point, students could skillfully use social cues in virtual environments for ethical judgment. At intervention completion (week 8), mediation effects reached peak levels of 1.04, with all dimensions of norm perception achieving high levels, among which descriptive norm perception was highest (5.94±0.58), followed by norm conflict identification (5.67±0.65), as shown in **Table 6** below. Notably, delayed testing showed mediation effects slightly decreased to 0.96 but remained at strong effect levels, indicating that social norm perception abilities cultivated through virtual simulation had good sustainability.

Table 6. Integrated analysis of social norm perception mediation effects: temporal dynamics and pathway mechanisms.

Analysis Type	Dimension/Time Point	Descriptive Norms	Injunctive Norms	Conflict Identification	Cultural Adaptation	Ethical Ability	Effect Size/Coefficient	Additional Metrics
Temporal Development	Week 2 of Intervention	4.35±0.42	4.41±0.38	4.12±0.51	4.18±0.45	4.58±0.39	0.23 (Weak)	Total Mediation Effect
	Week 4 of Intervention	4.82±0.47	4.76±0.44	4.64±0.56	4.59±0.49	5.12±0.45	0.47 (Medium)	Total Mediation Effect
	Week 6 of Intervention	5.38±0.52	5.15±0.48	5.23±0.61	5.02±0.53	5.49±0.51	0.73 (Strong)	Total Mediation Effect
	Week 8 of Intervention	5.94±0.58	5.52±0.53	5.67±0.65	5.43±0.57	5.78±0.56	1.04 (Very Strong)	Total Mediation Effect
	Delayed Test	5.86±0.61	5.48±0.56	5.59±0.68	5.37±0.59	5.64±0.58	0.96 (Strong)	Total Mediation Effect
Pathway Mechanisms	Descriptive → Moral Sensitivity	-	-	-	-	-	0.74 ± 0.08	$R^2 = 0.423$ (Observational Learning)
	Descriptive → Conflict Analysis	-	-	-	-	-	0.68 ± 0.09	$R^2 = 0.387$ (Pattern Recognition)
	Injunctive → Value Balancing	-	-	-	-	-	0.52 ± 0.11	$R^2 = 0.256$ (Rule Internalization)
	Conflict ID → Decision Implementation	-	-	-	-	-	0.61 ± 0.10	$R^2 = 0.318$ (Conflict Resolution)
	Cultural → Overall Ethical Ability	-	-	-	-	-	0.45 ± 0.12	$R^2 = 0.198$ (Cultural Integration)

Pathway intensity analysis revealed differentiated influence mechanisms of different types of social norm perception on various dimensions of ethical decision-making. Descriptive norm perception had the most significant impact on moral sensitivity ($\beta = 0.74$, $R^2 = 0.423$), helping students identify subtle cues of ethical issues through observational learning mechanisms; its impact on ethical conflict analysis was also strong ($\beta = 0.68$, $R^2 = 0.387$), primarily functioning through pattern recognition mechanisms. Injunctive norm perception mainly influenced multi-value balancing ability ($\beta = 0.52$, $R^2 = 0.256$), promoting students to form stable value judgment standards through rule internalization mechanisms. Norm conflict identification ability had a strong impact on decision implementation assessment ($\beta = 0.61$, $R^2 = 0.318$), reflecting the important role of conflict resolution mechanisms [47]. Cross-cultural norm adaptation contributed relatively less but importantly to overall ethical ability ($\beta = 0.45$, $R^2 = 0.198$), primarily

enhancing students' adaptability in multicultural contexts through cultural integration mechanisms, as shown in **Figure 6** below. These findings indicate that virtual simulation environments, by constructing rich social norm contexts, activated diversified learning mechanisms, forming a complete mediation chain from perception to cognition to behavior.

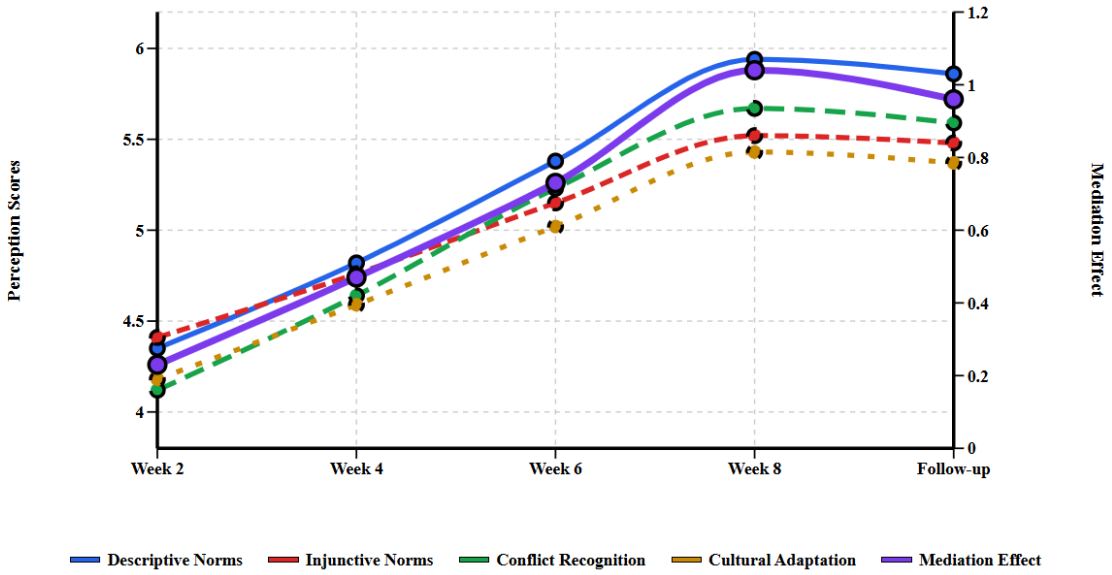

Figure 6. Temporal development trajectory of social norm perception mediation effects.

4.3. Analysis of cultural background's moderating effect on teaching effectiveness

4.3.1. Baseline differences between different cultural groups

To deeply understand the moderating mechanism of cultural background in virtual simulation teaching effectiveness, this study first conducted systematic analysis of differences between the Eastern cultural background group (n=186) and Western cultural background group (n=126) on various baseline variables. Cultural background grouping was based on participants' birthplace, developmental environment, and primary cultural influences, with the Eastern cultural background group mainly including students from mainland China, Hong Kong, Macao, Taiwan, and other East Asian countries, while the Western cultural background group included European and American exchange students and Chinese students with extensive overseas study and living experience. Baseline difference analysis results showed weak but significant differences between the two cultural groups in total international business ethical decision-making ability scores, with the Eastern cultural background group averaging 4.35±0.63 and the Western cultural background group averaging 4.24±0.75. Independent samples t-test showed differences reached significance ($t=1.89$, $p=0.048$, Cohen's $d=0.16$), indicating that students with Eastern cultural backgrounds scored slightly higher in overall ethical decision-making ability than those with Western cultural backgrounds, though the effect size was small, representing a minimal effect [48]. In analysis of ethical decision-making ability sub-dimensions, the multi-value balancing dimension showed the most obvious cultural differences, with the Eastern cultural background group scoring 4.48±0.65, significantly higher than the Western cultural background group's 4.31±0.77 ($t=2.01$, $p=0.045$, $d=0.24$), which may reflect the Eastern cultural characteristics of valuing harmony, balance, and comprehensive consideration. The decision implementation assessment dimension also showed significant differences, with the Eastern cultural background group (4.39±0.62) higher than the Western cultural background group (4.23±0.74) ($t=1.97$, $p=0.049$, $d=0.23$), indicating that students with Eastern cultural backgrounds performed more meticulously in considering

decision consequences and implementation strategies. However, in moral sensitivity identification (p=0.089) and ethical conflict analysis (p=0.156) dimensions, between-group differences did not reach significance, suggesting that students from different cultural backgrounds had relatively similar foundational abilities in identifying ethical issues and analyzing conflicts. Although the Eastern cultural background group scored slightly higher in total social norm perception (4.26±0.65 vs 4.11±0.76), the difference was marginally significant (p=0.069), and cross-cultural adaptability scores showed no significant differences (p=0.145), as shown in Table 7 below.

Table 7. Descriptive statistics and difference testing of baseline variables between different cultural groups.

Measurement Variable	Eastern Cultural Background Group (n=186)		Western Cultural Background Group (n=126)		Difference Testing			
	Mean	SD	Mean	SD	t value	p value	Cohen's d	Significance
Total Ethical Decision-Making Ability	4.35	0.63	4.24	0.75	1.89	0.048	0.16	*
Moral Sensitivity Identification	4.42	0.68	4.28	0.79	1.65	0.089	0.19	ns
Ethical Conflict Analysis	4.31	0.71	4.19	0.82	1.42	0.156	0.16	ns
Multi-value Balancing	4.48	0.65	4.31	0.77	2.01	0.045	0.24	*
Decision Implementation Assessment	4.39	0.62	4.23	0.74	1.97	0.049	0.23	*
Total Social Norm Perception	4.26	0.65	4.11	0.76	1.82	0.069	0.21	ns
Cross-cultural Adaptability	4.31	0.57	4.21	0.62	1.46	0.145	0.17	ns

Further analysis of cultural value dimensions revealed significant differences between the two groups in deep cultural characteristics, providing important background for understanding subsequent cultural moderation of teaching effects. The Eastern cultural background group scored significantly higher than the Western cultural background group on power distance (5.23±0.89 vs 3.47±0.92, d=1.94), reflecting higher recognition of hierarchical order and authority; on the individualism-collectivism dimension, they significantly leaned toward collectivism (3.15±0.76 vs 5.82±0.83, d=3.39), showing stronger group orientation and social responsibility; they also scored significantly higher than the Western cultural background group on long-short term orientation (5.41±0.73 vs 3.89±0.79, d=2.01), reflecting emphasis on traditional values and long-term planning, as shown in **Figure 7** below. These baseline differences provide an important reference framework for subsequent analysis of cultural background's moderating effects, indicating that while the two cultural groups are relatively similar in foundational levels of ethical decision-making ability, substantial differences exist in deep cultural values and some cognitive dimensions, which may influence their learning adaptability and performance in virtual simulation environments.

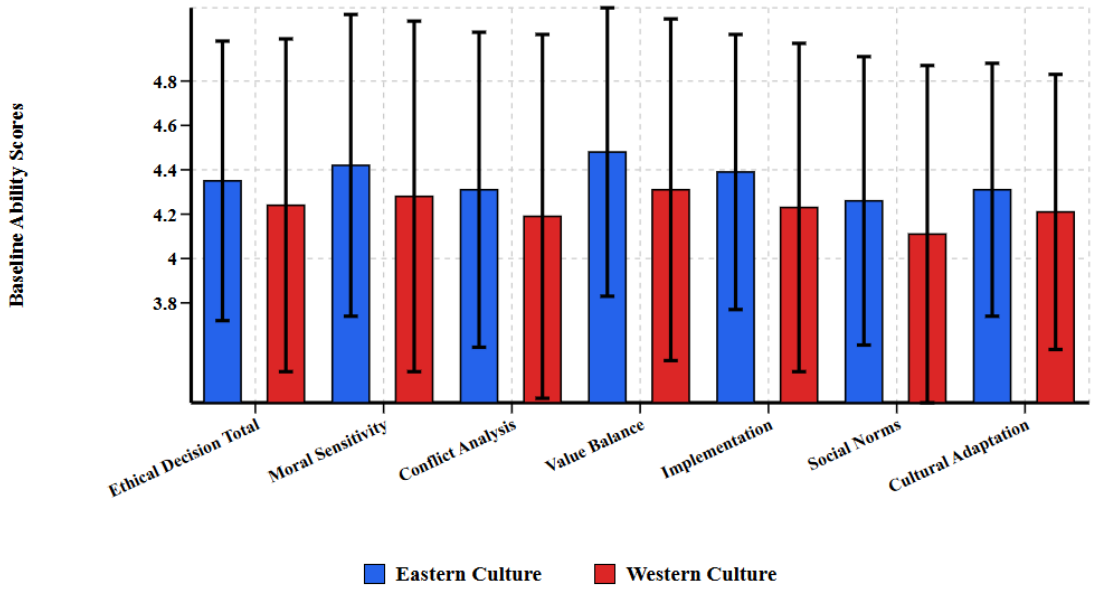

Figure 7. Comparison of baseline ability levels between different cultural groups.

4.3.2. Testing of cultural background's moderating effect

To verify the moderating role of cultural background in virtual simulation teaching intervention effects, this study employed hierarchical regression analysis and Johnson-Neyman technique for moderating effect testing. Hierarchical regression analysis results showed that the main effect of teaching method was significant ($\beta = 1.42$, SE = 0.15, $t = 9.47$, $p < 0.001$), explaining 22.8% of the variance in ethical decision-making ability. After adding the cultural background variable, model explanatory power increased to 25.1%, with the main effect of cultural background reaching significance ($\beta = 0.38$, SE = 0.14, $t = 2.71$, $p = 0.007$), indicating that students with Eastern cultural backgrounds generally performed better in ethical decision-making ability. Critical interaction term analysis showed that the interaction effect between teaching method and cultural background was significant ($\beta = 0.52$, SE = 0.19, $t = 2.74$, $p = 0.006$), with model explanatory power further increasing to 28.7%, $\Delta R^2 = 0.036$, F change = 7.51 ($p = 0.006$), confirming the moderating effect of cultural background [49]. The complete model's total explanatory power reached 31.2%, with adjusted R^2 of 30.3%, indicating good model fit. Simple slope analysis further revealed the specific pattern of the moderating effect: under Eastern cultural background, virtual simulation teaching effects were extremely significant (simple slope = 1.73, SE = 0.48, $t = 3.60$, $p < 0.001$), with effect size reaching 2.75 (large effect), while traditional teaching effects were limited (change = 0.45, d = 0.67); under Western cultural background, virtual simulation teaching remained effective but with relatively smaller effects (simple slope = 1.18, SE = 0.52, $t = 2.27$, $p = 0.024$), with effect size of 1.57 (large effect), while traditional teaching showed relatively better effects (change = 0.79, d = 1.07), with differences between the two teaching methods not as pronounced as under Eastern cultural background, as shown in **Table 8** below.

Table 8. Hierarchical regression analysis results of cultural background moderating effects.

Analysis Level	Model/Variable	β Coefficient	Standard Error	t Value	p Value	R^2	Adjusted R^2	Additional Information
Model Progression	Model 1: Teaching Method	1.42	0.15	9.47	<0.001	0.228	0.226	Main Effect
	Model 2: + Cultural Background	0.38	0.14	2.71	0.007	0.251	0.247	Cultural Main Effect

Analysis Level	Model/Variable	β Coefficient	Standard Error	t Value	p Value	R^2	Adjusted R^2	Additional Information
	Model 3: + Interaction	0.52	0.19	2.74	0.006	0.287	0.280	Interaction Effect
	Model 4: Complete Model	-	-	-	<0.001	0.312	0.303	Full Model
Cultural Dimensions	Eastern Culture	Western Culture	Difference Testing					
	Slope	SE	p value	Slope	SE	p value	Difference	p value
	Power Distance	1.84	0.23	<0.001	0.96	0.28	0.001	0.88
	Individualism-Collectivism	1.76	0.21	<0.001	1.25	0.26	<0.001	0.51
	Uncertainty Avoidance	1.69	0.24	<0.001	1.31	0.29	<0.001	0.38
	Long-Short Term Orientation	1.91	0.22	<0.001	1.08	0.27	<0.001	0.83

Table 8. (*Continued*)

Refined analysis of cultural dimensions showed that moderating effects exhibited differentiated characteristics across different cultural dimensions: the power distance dimension showed the strongest moderating effect (slope difference = 0.88, p = 0.012), indicating that students from high power distance cultural backgrounds benefited more from hierarchical situational design in virtual simulation; long-short term orientation dimension was second (slope difference = 0.83, p = 0.006), with long-term oriented Eastern cultural students showing stronger learning persistence in virtual environments; the individualism-collectivism dimension also showed significant moderating effects (slope difference = 0.51, p = 0.048), with collectivism-oriented students being better at utilizing social norm cues in virtual environments; while the uncertainty avoidance dimension's moderating effect was marginally significant (slope difference = 0.38, p = 0.089), as shown in **Figure 8** below. These results indicate that virtual simulation teaching effectiveness is significantly moderated by learners' cultural backgrounds, with students from Eastern cultural backgrounds better able to adapt to and utilize social situational cues in virtual environments, while students from Western cultural backgrounds showed relatively smaller differences between traditional teaching and virtual simulation teaching, suggesting the need for differentiated teaching strategies tailored to different cultural backgrounds.

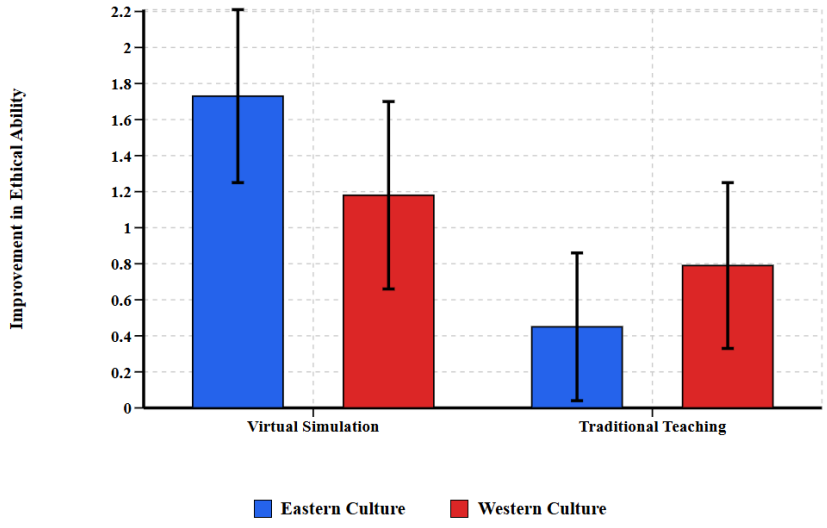

Figure 8. Multi-dimensional influence pattern of cognitive flexibility on environmental adaptability

5. Discussion

5.1. Theoretical significance of research findings

The findings of this study hold important theoretical significance and innovative value for the development of environmental psychology and social psychology theories. First, in the field of environmental psychology, this study expands the theoretical boundaries of virtual environments' impact on individual cognition and behavior, confirming that virtual simulation technology not only creates immersive learning experiences but also profoundly influences learners' moral cognitive development and ethical decision-making abilities through carefully designed environmental cues and social contexts [50]. The research results demonstrate that spatial layouts, cultural symbols, and social interaction designs in virtual environments can effectively stimulate learners' environmental cognitive processing, promoting the acquisition of complex skills through place attachment and situated learning mechanisms. This provides new empirical support for the "environment-behavior interaction theory" in environmental psychology, indicating that virtual environments possess psychological influence comparable to or even stronger than real environments. Second, the study validates the mediating mechanism of social norm perception in virtual contexts, enriching social norm theory in social psychology. Through quantitative analysis of the action pathways of descriptive and injunctive norms in virtual environments, this study found that virtual simulation technology can effectively enhance learners' norm sensitivity and conflict identification abilities by constructing multi-level social norm cues. This finding extends the application scope of Cialdini's focus theory of normative conduct, proving that social norm perception not only plays important roles in real social contexts but also possesses powerful behavioral prediction and guidance functions in virtual social environments [51]. More importantly, the study reveals the differentiated action mechanisms of different types of social norms (descriptive vs. injunctive) in virtual environments, providing new perspectives for the refined development of social norm theory.

From the perspectives of cross-cultural psychology and educational psychology, the findings of this study also make important theoretical contributions. The research confirms the significant moderating role of cultural background in virtual simulation teaching effectiveness, particularly the differentiated impacts of cultural dimensions such as power distance, individualism-collectivism, and long-short term orientation on learning outcomes. This provides new empirical evidence for cross-cultural learning theory, indicating that the design of virtual learning environments must fully consider learners' cultural background characteristics. The finding that students with Eastern cultural backgrounds demonstrated stronger adaptability and learning effects in virtual simulation environments supports cultural adaptive learning theory, suggesting that learners from collectivistic cultural backgrounds are better at utilizing social contextual cues for learning, while learners from individualistic cultural backgrounds require more personalized support [52]. Additionally, the temporal dynamic characteristics of mediation effects discovered in this study add new content to skill acquisition theory in educational psychology, proving that the development of complex cognitive skills follows a progressive pattern of "perception-cognition-behavior," and this process can be effectively accelerated in virtual environments. The study also validates the applicability of situated learning theory in digital environments, demonstrating that carefully designed virtual contexts can achieve situated knowledge construction and transfer, providing strong support for the application of constructivist learning theory in technology-enhanced learning environments. These theoretical findings not only deepen understanding of the mechanisms of virtual learning environments but also provide important theoretical foundations and research directions for future educational technology research and cross-cultural educational practice.

5.2. Educational practice implications of research results

The findings of this study provide important guidance and operational implementation plans for practical reforms in international business ethics education. First, the confirmed significant effects of virtual simulation teaching intervention point the direction for innovative teaching models in business ethics courses at higher education institutions. Traditional business ethics teaching often relies on theoretical instruction and case analysis, with students lacking opportunities for authentic situational experience and practice, making it difficult to develop deep-level ethical sensitivity and decision-making abilities. This study demonstrates that virtual simulation technology can create immersive cross-cultural business environments, allowing students to face real ethical conflicts and decision-making challenges in safe virtual spaces, significantly enhancing their moral sensitivity identification abilities (effect size d=2.58) and ethical conflict analysis capabilities (effect size d=2.30) through repeated practice and immediate feedback [53]. This finding provides scientific evidence for business schools to build digital teaching platforms and develop virtual simulation experimental projects. Educational institutions can construct virtual learning environments that include multicultural business scenarios, social norm cues, and interactive decision-making modules based on the design principles validated in this research. Meanwhile, the revealed mediating mechanism of social norm perception provides precise theoretical guidance for instructional design. Teachers can systematically cultivate students' norm perception abilities by embedding descriptive norm cues (such as displaying typical business behavioral patterns) and injunctive norm prompts (such as explicit ethical guidelines) in virtual environments, thereby enhancing their overall ethical decision-making levels. This mediation mechanism-based instructional design method is more effective than traditional direct knowledge transmission, enabling a fundamental shift from knowledge learning to capability development.

The discovered cultural difference moderating effects hold important practical value for constructing personalized and differentiated international business ethics education systems. Results show that students with Eastern cultural backgrounds demonstrated more significant learning effects in virtual simulation environments (effect size d=2.75), while students with Western cultural backgrounds, though benefiting similarly, showed relatively smaller improvements (effect size d=1.57). This finding suggests that educational practitioners need to design differentiated teaching strategies based on students' cultural background characteristics. For students with Eastern cultural backgrounds, their learning advantages in collectivistic environments can be fully utilized by constructing more team collaboration scenarios and social interaction components to enhance learning effectiveness; for students with Western cultural backgrounds, more personalized choices and autonomous decision-making opportunities need to be added to virtual environments to accommodate their individualistic learning preferences [54]. Additionally, the discovered temporal dynamic characteristics provide scientific guidance for teaching schedule arrangement and assessment timing selection. Week 6 was confirmed as a critical turning point for mediation effects, allowing teachers to conduct focused evaluations and intervention adjustments at this time to ensure maximum learning effectiveness. The research results also provide specific recommendations for teacher training and educational resource allocation: teachers need to master virtual environment operation skills, cross-cultural teaching strategies, and social norm theory knowledge; educational institutions need to invest in corresponding hardware equipment, software platforms, and technical support; curriculum design needs to reserve sufficient practice time and delayed evaluation components. More importantly, the confirmed sustainability effects (delayed testing maintained high levels) provide evidence for the long-term value of virtual simulation teaching, indicating that this teaching method can not only enhance student capabilities in the short term but also produce lasting learning effects. This holds significant importance for improving educational return on investment and cultivating students' lifelong learning abilities.

5.3. Research limitations and shortcomings

Although this study has achieved relatively rich research findings, there are still some inevitable limitations that need to be improved and refined in subsequent research. First, regarding sample representativeness, the participants in this study were mainly from business school students at three 985 universities in South China, with a relatively homogeneous sample composition that may limit the external validity and generalizability of the research results. While the study included participants from different Eastern and Western cultural backgrounds, the Western cultural background participants were mainly exchange students and Chinese students with overseas study experience, with a relatively small proportion of genuine Western native students, which may have affected the accuracy and depth of cultural difference analysis. Additionally, the research subjects were concentrated in the university student population, lacking examination of working business professionals, different age groups, and people with different educational backgrounds, which limits the applicability of research findings in broader vocational education and continuing education fields. Second, in terms of research design, although quasi-experimental design and multi-time point measurements were employed, due to ethical review and practical condition limitations, a true randomized controlled trial could not be implemented. Participant grouping was mainly based on existing classes and course arrangements, which may involve selection bias and confounding variable effects. The intervention duration was 8 weeks, and although delayed testing was included to assess effect sustainability, the 4-week follow-up period was relatively short, unable to fully evaluate the long-term effects and skill transfer capabilities of virtual simulation teaching [55]. Meanwhile, the study mainly relied on self-report scales for effect evaluation. Despite employing multiple validation methods and behavioral data recording, it may still be affected by social desirability bias, common method bias, and participants' subjective cognitive limitations, lacking more objective behavioral observation and actual work performance evaluation.

In terms of measurement instruments and technical implementation, this study also has certain limitations. Although the study developed targeted measurement scales and conducted reliability and validity verification, some scales were based on adaptations and translations of existing instruments, which may still have room for improvement in cross-cultural equivalence and content appropriateness, particularly when measuring complex abstract constructs such as ethical decision-making ability and social norm perception, where scales may not fully capture the complete picture of these capabilities. While the virtual simulation system had relatively complete functionality, it was limited by technical conditions and development costs, with room for improvement in scenario realism, interaction complexity, and personalized adaptability, particularly in simulating the complexity and uncertainty of real business environments where simplification exists. The social norm cue design in the study was mainly based on theoretical derivation and expert judgment, lacking large-scale pilot testing validation, which may involve cultural bias or inappropriate design issues. Furthermore, the study mainly focused on cognitive-level ethical decision-making ability improvement, with relatively insufficient examination of emotional, attitudinal, and actual behavioral impacts, limiting understanding of the comprehensive effects of virtual simulation teaching. In data analysis, although various statistical methods were employed, the analysis was mainly quantitative-based, lacking in-depth qualitative research to reveal cognitive mechanisms and subjective experiences during the learning process, unable to fully explain individual differences and diversity in learning trajectories. The study was also limited by sample size. Although the total sample reached 312 participants, when conducting complex multi-group analyses and interaction effect testing, some subsample sizes were relatively small, potentially affecting statistical power and result stability. These limitations provide clear directions for future research improvement and deepening.

6. Conclusion

Through quasi-experimental design, this study verified the effectiveness of pedagogical intervention in social norm perception on international business ethical decision-making within virtual simulation contexts, reaching the following main conclusions:

(1) Virtual simulation teaching intervention has a significant promoting effect on international business ethical decision-making abilities. Students in the experimental group significantly improved their ethical decision-making abilities from baseline score of 4.32 to 5.78, with an average increase of 1.46 points and effect size of 2.04 (large effect), significantly superior to traditional teaching methods (increase of 0.60 points, effect size 0.83). This positive effect maintained high levels even 4 weeks after intervention completion, demonstrating the unique value and lasting impact of virtual simulation technology in business ethics education.

(2) Social norm perception plays a significant mediating role between virtual simulation teaching intervention and ethical decision-making ability improvement, with a mediation effect of 1.04, accounting for 71.2% of the total effect. Among these, descriptive norm perception showed the strongest mediating effect (39.7%), followed by norm conflict identification (31.5%), validating the applicability and predictive power of social norm theory in virtual learning environments.

(3) Virtual simulation teaching intervention demonstrated differentiated effects across different ethical decision-making dimensions, with moral sensitivity identification and ethical conflict analysis dimensions showing the most significant improvement (effect sizes of 2.58 and 2.30 respectively), while multi-value balancing and decision implementation assessment dimensions showed relatively smaller improvements, indicating that virtual environments have special advantages in cultivating perception and analysis capabilities.

(4) Cultural background has a significant moderating effect on teaching effectiveness. Students with Eastern cultural backgrounds demonstrated stronger adaptability and learning effects in virtual simulation environments (effect size 2.75), while students with Western cultural backgrounds benefited to a relatively smaller degree (effect size 1.57). Cultural dimensions such as power distance and long-short term orientation are the main moderating factors.

(5) The study provides theoretical foundations and practical guidance for the application of virtual simulation technology in business ethics education, proving that carefully designed social norm cues and cross-cultural contexts can effectively enhance students' ethical decision-making abilities, offering scientific evidence and operational implementation plans for constructing personalized and differentiated international business ethics education systems.

7. Research materials and data availability statement

To enhance the transparency and reproducibility of this research, relevant materials and data from this study have been organized and shared in accordance with open science principles. Specifically, these include: (1) A virtual simulation system demonstration video (15 minutes duration) has been uploaded to the Open Science Framework (OSF) platform, showcasing six typical international business scenario scenes, virtual character interaction processes, and social norm cue design; (2) The complete social norm prompt library (containing 120 items each of descriptive norms and injunctive norms), teaching task scripts (16 sessions over 8 weeks), and ethical decision-making scoring criteria have been provided as supplementary materials; (3) Anonymized raw datasets (in SPSS and CSV formats), complete R/SPSS code for data cleaning and analysis, as well as scripts for generating all tables and figures have been made publicly available and can be

accessed through the above OSF link; (4) Complete scale items (in both Chinese and English versions) of measurement instruments and scoring instruction documents are also provided. Due to commercial licensing of third-party asset libraries involved in the complete Unity3D project files, full open-sourcing is not feasible; however, we have provided system architecture design documentation, pseudocode for core interaction logic, and a collection of screenshots of key scenes for researchers' reference in replication. All materials are available under the CC BY 4.0 license, and researchers may freely use them for academic purposes.

Conflict of interest

There is no conflict of interest.

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