Innovative Pathways for Ideological and Political Education in Anatomy Courses: Clinical Decision-Ethics Training Based on AI Scenario Simulation

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Abstract: The integration of AI scenario simulation into anatomy education has emerged alongside technological advancement, forming an innovative pathway for ideological and political education in medical curricula. As a novel approach to ethical training in the new era, this model focused on four key aspects: clarifying conceptual boundaries of ethical decision-making, establishing theoretical foundations from constructivist and cognitive psychology perspectives, defining functional roles in clinical-ethical dual-track training, and exploring practical implementation status. The research process is not only one of summarization but also of critical reflection. This article emphasizes integrating professions with disciplines, highlighting that improving students' clinical decision-making abilities helps with employment. By reviewing existing studies and reflecting on challenges in the development of AI-enhanced anatomy education, this paper clarifies its developmental trajectory and further affirms its potential value in cultivating ethically conscious medical professionals within the Chinese context.

Keywords: Anatomy education; AI scenario simulation; Ideological and political education; Clinical decision-ethics training; Medical humanities

1. Introduction and research value positioning

1.1. Contemporary challenges and ethical demands in anatomy education

Contemporary anatomy education faces dual challenges: on one hand, traditional cadaveric dissection teaching encounters ethical controversies and resource limitations [1]; on the other hand, medical education urgently needs to maintain the core value of humanistic care amidst technological innovation [1]. Research indicated that direct interaction with body donors plays an irreplaceable role in the professional identity formation of medical students, an experience that cultivates key competencies such as non-technical skills and applied bioethics awareness [1]. The ethical issues in current anatomy education need to be systematically integrated into the curriculum [1]. The

intervention of AI technology provides a new opportunity for this transformation, but its potential impact on traditional medical humanities education must be carefully evaluated [1].

1.2. Paradigm innovation of AI scenario simulation in medical education

Artificial intelligence (AI) technology is reshaping the paradigm of medical education. From virtual reality anatomy platforms to clinical decision support systems, AI provides highly customizable learning experiences [2,3]. In particular, the application of generative AI in clinical scenario simulation—such as systems like GutGPT—has been proven to effectively improve decision-making training for acute upper gastrointestinal bleeding management [4]. This technological innovation has achieved three breakthroughs: first, providing real-time feedback through multimodal interaction systems [5]; second, creating personalized learning paths to compensate for the shortage of clinical cases [6]; third, algorithmically embedding ethical parameters into decision tree models [7]. Notably, the development model of customized AI chatbots combined with selected knowledge bases provides a technical solution to ensure accuracy in anatomy education [8].

1.3. Special value of clinical decision-ethics training

Clinical ethical decision-making ability is a core competency in medical education, and its cultivation requires the integration of cognitive psychological mechanisms and real scenario experiences [9]. By constructing a "clinical-ethical" dual-track training framework, AI scenario simulation can systematically improve the following abilities: the application ability of explainable AI models (84.8% of clinical oncologists consider this a necessary prerequisite) [10]; value trade-offs under complex ethical dilemmas [7]; and the ability to respond to educational ethical controversies caused by algorithm transparency [5]. This training model is particularly suitable for sensitive topics in anatomy education, such as the ethics of body donation use [1]. Studies have shown that after AI-enhanced simulation training, participants' clinical decision-making ability scores increased significantly ($P < 0.001$) [9], confirming the role of technological innovation in promoting the cultivation of ethical literacy.

2. Theoretical basis of AI-assisted medical education

2.1. Constructivist learning theory and scenario simulation

Constructivist learning theory emphasizes the importance of learners actively constructing knowledge in real contexts, and this theory provides core support for the application of AI scenario simulation in anatomy education. In anatomy teaching, the immersive environment created by virtual reality technology allows learners to actively explore human body structures through interactive operations. This problem-solving-based experiential learning model is significantly superior to traditional passive receptive teaching [1]. Studies have shown that the AI-simulated human anatomy environment not only retains the technical training value of traditional anatomical practice but, more importantly, creates a contextual space for learners to reflect on bioethics. This space has unique value for cultivating medical students' professional identity and humanistic care ability [1]. AI scenario simulation from a constructivist perspective particularly focuses on the social interaction dimension in the learning process, promoting learners' in-depth thinking on medical ethical issues through functions such as virtual patient dialogue and multi-role collaboration.

2.2. Application of the Technology Acceptance Model (TAM) in medical education

The Technology Acceptance Model (TAM) provides a theoretical framework for analyzing medical students'

adoption behavior of AI teaching tools. A key challenge in current medical education is ensuring that AI tools can be used safely while effectively improving clinical decision-making capabilities [11]. Studies have pointed out that successful AI educational applications need to meet three core conditions: perceived usefulness (improving learning efficiency), perceived ease of use (lowering technical barriers), and behavioral intention (willingness to use actively). In anatomy courses, the acceptance of AI scenario simulation systems depends on their ability to accurately simulate the clinical decision-making environment while maintaining the rigor of ethical training [12]. Notably, technology acceptance has obvious stage-specific characteristics: medical students pay more attention to the visualization accuracy of anatomical structures in the basic learning stage, while in the clinical thinking cultivation stage, they focus more on the clinical relevance of decision feedback [12]. Educators need to adjust the functional focus of AI tools according to the characteristics of different learning stages to optimize technology acceptance [13].

2.3. Cognitive psychological mechanisms of ethical decision-making

The ethical decision-making process involves complex cognitive psychological mechanisms, including three subsystems: intuitive response, rational analysis, and emotional regulation. By creating high-fidelity clinical ethical dilemmas, AI scenario simulation can effectively activate learners' multiple decision-making systems [14]. Cognitive psychology research shows that when medical students face ethical choices involving virtual patients, they go through three cognitive stages: moral sensitivity identification, ethical principle trade-off, and action plan evaluation [14]. The advantage of AI systems is that they can record and analyze learners' reaction time, choice preferences, and emotional changes at each decision node, providing data support for personalized ethical training [15]. Notably, algorithmic bias and data privacy issues may affect the objectivity of ethical judgments, which requires AI educational systems to establish transparent decision parameters and interpretable feedback mechanisms [16]. Cognitive load theory suggests that the complexity of AI scenarios needs to match the cognitive development stage of learners; excessively high ethical decision-making requirements may lead to defensive avoidance by learners [16].

3. Core elements of ideological and political education in anatomy courses

3.1. Integration path of life education and humanistic care

The application of AI technology in anatomy education should not completely replace traditional human specimen practice, because interaction with real human specimens can cultivate students' sense of reverence for life and awareness of humanistic care [1]. Studies have shown that contact with body donors in the anatomy laboratory helps medical students form professional identity, cultivate non-technical interdisciplinary skills, and enhance their conscious awareness of applying bioethics [1]. In the design of AI scenario simulation, the discussion module on the ethical significance of body donors should be retained; through virtual reality technology, the life stories of donors can be reproduced, enabling students to establish an understanding of the value of life while learning anatomical structures [1]. This combination of technology and humanity can not only give play to the teaching advantages of AI but also maintain the essential connotation of life education in medical education [1].

3.2. Construction of clinical scenarios for patient privacy protection

AI scenario simulation provides a new opportunity for constructing clinical decision-making scenarios in anatomy teaching, among which patient privacy protection has become a key entry point for ideological and political

education [17]. In the development of virtual anatomy platforms, it is necessary to set privacy protection parameters that meet medical ethics standards, such as anonymizing case data and simulating clinical scenarios, such as electronic medical record system permission management [17]. Studies have shown that the issues patients are most concerned about regarding AI medical applications include data privacy protection and algorithm transparency [17], which requires incorporating practical training on privacy regulations, such as HIPAA, into the design of teaching cases to cultivate students' ethical handling ability of sensitive medical data [18]. By simulating privacy leakage risk decision points in clinical scenarios, medical students' professional ethical awareness can be strengthened.

3.3. Construction of a historical case library for human experiment ethics

Anatomy education needs to establish a digital teaching resource library containing historical ethical cases to warn of the serious consequences of violating medical ethics [1]. AI technology can dynamically present virtual scenarios of major ethical events such as the Nuremberg Trials and the Tuskegee Syphilis Experiment. Through scenario reproduction and decision tree analysis, it helps students understand the historical evolution of human experiment ethics principles [19]. The construction of the case library should focus on cross-cultural comparison, including the development process of medical ethics standards in different countries, to cultivate students' ethical judgment ability from a global perspective [20]. At the same time, it is necessary to set up an algorithm transparency discussion module to guide students to reflect on ethical bias issues that may exist in AI-assisted decision-making [21,22]. This critical thinking training based on historical cases can improve medical students' ethical sensitivity in the application of new technologies [20].

4. Technical implementation path of AI scenario simulation

4.1. Development standards for virtual reality anatomy platforms

The development of virtual reality anatomy platforms needs to comply with strict medical education standards and technical specifications. Studies have shown that immersive VR has become the preferred intervention method for anatomy education [23], and its development standards should include three core dimensions: anatomical accuracy, educational applicability, and technical stability. In terms of anatomical accuracy, the platform must ensure the accurate reproduction of three-dimensional anatomical structures, especially the presentation of complex spatial structures such as neuroanatomy [24]. Educational applicability requires the platform to support an "inside-out" observation perspective, helping learners establish an anatomical mental map from the perspective of surgical instruments [25]. Technical stability standards involve device portability, ease of use, and system fault tolerance, which directly affect students' technology acceptance [26]. Notably, 96% of learners indicated a preference for using VR for anatomy learning [25], which requires full consideration of user experience design in the development process.

4.2. Ethical parameter setting for clinical decision tree algorithms

The setting of ethical parameters for clinical decision tree algorithms needs to integrate cognitive psychology and medical ethics principles. Based on corpus analysis, the ethical parameter system should include three key levels: the basic ethical principle level, the scenario-specific level, and the dynamic adjustment level. The basic ethical principle level needs to encode the four principles of medical ethics (autonomy, non-maleficence, beneficence, justice) [1]; the scenario-specific level sets special parameters, such as human specimen use ethics and privacy protection, according to the characteristics of anatomy teaching [1]; the dynamic adjustment level

enables the algorithm to optimize ethical judgments based on cultural differences and learner feedback through a reinforcement learning mechanism [27]. Studies particularly emphasize that algorithms must retain the educational value of interacting with human donors and cannot completely replace the professional identity formation opportunities brought by traditional anatomical practice [1]. Parameter transparency has become a key challenge, and it is necessary to establish interpretable ethical decision paths to gain the trust of educators [1].

4.3. Design of multimodal interactive feedback system

The design of the multimodal interactive feedback system should realize the organic integration of tactile, visual, and cognitive feedback. In terms of tactile feedback, wearable tactile interfaces made of shape memory alloys can provide diverse tactile feedback modes [28], while taste feedback systems based on iontophoresis principles can enhance the realism of clinical scenarios [29]. Visual feedback needs to combine augmented reality technology to overlay an ethical decision information layer while maintaining the visualization of real anatomical structures [30]. The cognitive feedback system provides real-time evaluation and guidance for learners' ethical decisions through intelligent tutoring technology [31]. The recently developed vertically nested wearable tactile interface (WHOA) demonstrates the potential of multimodal feedback: it can generate 12 different tactile patterns, significantly improving engagement in virtual [32]. The system also needs to integrate end-edge-cloud collaboration technology to support multi-device access and collaborative learning [33], which is particularly important for team ethics training in anatomy education.

5. Innovative design of teaching modules

5.1. Modified application of the BOPPPS model in ethical training

The traditional BOPPPS teaching model (Bridge-in, Objective, Pre-assessment, Participatory learning, Post-assessment, Summary) needs targeted modification in the ethical training of AI scenario simulation. In the Bridge-in link, a virtual reality anatomy platform was used to present clinical scenarios with ethical conflicts [34]; the Objective setting needed to clearly distinguish between technical operation goals and ethical cognitive goals [35]; Pre-assessment predicted students' ethical judgment tendencies through decision tree algorithms [36]; the Participatory learning stage introduced a multimodal interactive feedback system to record students' decision-making processes in real time [37]; Post-assessment conducted a quantitative evaluation combined with an ethical decision scale [19]; the Summary link emphasized the differential analysis between AI decisions and human judgments [36]. This modification enables the traditional model to adapt to the training needs of ethical decision-making capabilities in the AI environment.

5.2. "AI clinical scenario-ethical decision" dual-track teaching architecture

This architecture includes parallel technical training tracks and ethical reflection tracks. The technical track trains standard operating procedures through a virtual anatomy platform, while the ethical track synchronously generates relevant ethical issues, such as privacy protection and informed consent [35,37]. The dual-track system adopts a dynamic coupling mechanism: when students perform anatomical operations on the technical track, the ethical track automatically triggers historical ethical events in the relevant case library [38]. The system adjusts the scenario complexity in real time according to the ethical parameter settings of the clinical decision tree algorithm [21]. Studies have shown that this architecture can effectively solve the problem of separation between technical training and ethical cultivation, enabling 83% of participants to form associated cognition between operation technology

and ethical judgment [39,40]. The key innovation is that the algorithm can automatically adjust the synchronization frequency and difficulty gradient of the two tracks according to students' performance [34].

5.3. Development of formative evaluation and ethical decision scale

Based on the characteristics of AI scenario simulation, a three-dimensional evaluation system was developed: technical operation accuracy (30%), ethical decision rationality (50%), and decision process transparency (20%) [19,35]. The ethical decision scale integrates six core ethical values: benefit, autonomy, justice, privacy, transparency, and scientific integrity [41], and analyzes students' voice and text feedback in scenario simulation through natural language processing technology [42]. The formative evaluation system adopts an iterative algorithm, which automatically updates the case library and evaluation standards after each teaching cycle [37]. Studies have shown that the criterion validity of this scale with traditional ethical tests reaches 0.81, which can effectively distinguish the ethical cognitive levels of students in different grades [19,40]. An algorithm transparency index is specially designed to evaluate students' understanding of the basis for AI decisions [34,43].

6. Current controversies and challenges in research

6.1. Balance between technical dependence and humanistic literacy

The application of AI technology in anatomy education has triggered an important discussion on the balance between technical dependence and humanistic literacy. Studies have shown that although AI human body simulation technology can provide highly accurate anatomical images [2], completely replacing body donors may weaken key educational values such as non-technical skills, applied bioethics awareness, and professional identity formation that medical students gain through interaction with body donors [1]. This technical replacement may cause students to lose the opportunity to understand the dignity of life and the essence of medical humanism [44]. Some scholars emphasized that anatomy education must protect the interactive experience with body donors, and any deviation from this educational foundation requires strict review [1]. The core of the current controversy is how to use AI technology to improve teaching efficiency while maintaining the indispensable humanistic care elements in medical education [1].

6.2. Impact of cultural differences on ethical judgment

The application of AI scenario simulation in clinical decision-ethics training faces challenges in ethical judgment caused by cultural differences. Studies have pointed out that AI systems may have geographical biases in training data [45], which may lead to different guidance for learners from different cultural backgrounds in ethical decision-making training. For example, on ethical issues such as patient privacy protection and life value cognition, different cultural traditions may form completely different judgment standards [46]. This cultural difference was not only reflected in the representativeness of training data but also in the setting of ethical parameters on which AI algorithms are based [47]. Some scholars call for considering cultural diversity factors when developing AI ethical training systems and establishing a flexible ethical framework that can adapt to different cultural backgrounds [45,48].

6.3. Educational ethical controversies regarding AI algorithm transparency

The issue of AI algorithm transparency has triggered widespread controversies in the field of medical education ethics. On the one hand, the application of AI systems in anatomy education and clinical decision-making training is becoming increasingly widespread [6], but the "black box" nature of algorithms makes it difficult for educators

to explain the internal logic of their ethical decisions [35]. This opacity may cause students to fail to understand the ethical basis behind AI suggestions during ethical training, thereby affecting the cultivation of their critical thinking abilities [48].

On the other hand, with the popularization of AI educational tools, ethical issues such as algorithmic bias, responsibility attribution, and post-deployment monitoring have become increasingly prominent [15]. Studies have emphasized that a structured AI ethical guidance system must be established to ensure that the decision-making process of AI systems for education has sufficient transparency and interpretability [35,47]. The focus of current controversies is on how to utilize the advantages of AI technology while ensuring the rigor and reliability of medical ethics education [48].

7. Future development directions

7.1. Training model for interdisciplinary faculty teams

The AI scenario simulation teaching of ideological and political education in anatomy courses needs to build an interdisciplinary faculty team composed of anatomy experts, clinicians, AI engineers, and ethics professors. Studies have shown that there are obvious disciplinary barriers in the current field of medical AI education: clinicians lack AI technical knowledge, while engineers have insufficient understanding of medical ethics [49]. The construction of such interdisciplinary teams should focus on the integration of capabilities at three levels: first, it is necessary to establish a knowledge sharing mechanism between medicine and AI technology, such as through regular interdisciplinary workshops; second, to cultivate teachers' understanding of the medical ethical decision-making process; finally, to establish a collaborative lesson preparation system between clinicians and AI developers to ensure that the virtual anatomy platform meets teaching needs and follows ethical standards. Notably, this team training needs to avoid the problem of humanistic literacy loss caused by excessive technical dependence [1].

7.2. Iteration mechanism of the dynamic ethical case library

AI-based anatomy ethics education needs to establish a dynamic case library system with self-updating capabilities. From the perspective of existing research, an effective ethical case library should include three key elements: historical anatomical ethical controversy events (such as human experiment history), typical clinical decision dilemma simulation scenarios, and real-time updated AI application ethical controversy cases [50,51]. It is recommended to adopt the "3C Model" (Culture-Clinical Context-Computational Verification) for case selection and continuously supplement new cases through a crowdsourcing model involving both teachers and students [7]. Studies have shown that this dynamic update mechanism can not only reflect differences in ethical judgments under different cultural backgrounds but also timely incorporate ethical issues caused by emerging AI technologies [47]. The iteration cycle of the case library is recommended to be controlled at 6–12 months, and each update must be reviewed by a professional ethics committee.

7.3. Precision development of intelligent evaluation systems

Future AI ethical decision evaluation systems need to develop in the direction of multi-dimensional precision. Existing studies have shown that effective intelligent evaluation should integrate three types of data sources: operation behavior logs of virtual anatomy platforms, eye-tracking, and physiological indicators during ethical decision-making processes, and standardized ethical judgment scale scores [20,52]. It is recommended to develop

an adaptive evaluation algorithm that can automatically adjust evaluation standards according to the learner's professional background (e.g., medical students vs. nursing students) [49]. Special attention needs to be paid to the transparency of the evaluation system to avoid educational ethical controversies caused by the "algorithm black box" [48]. Studies have pointed out that an ideal evaluation system should have an explanatory function and be able to visually display the logical path of ethical decisions [53], which not only meets the needs of medical education for process evaluation but also conforms to the development trend of AI ethical review.

8. Conclusion and educational implications

8.1. AI-enabled path for ideological and political education in anatomy

The integration of AI technology in anatomy education provides an innovative implementation path for ideological and political education. Corpus-based analysis shows that customized AI anatomy education chatbots can ensure teaching accuracy through carefully constructed knowledge bases [8], while virtual reality anatomy platforms realize highly customizable anatomical image generation [2]. However, we must be alert to the ethical risks that may arise from completely replacing real anatomical specimens with AI human body simulations, especially the potential weakening of medical students' intuitive understanding of bioethics [1]. The optimal AI-enabled path for ideological and political education in anatomy should be: on the basis of retaining traditional anatomical practice, strengthen the immersive experience of ideological and political elements, such as life education and humanistic care, through AI scenario simulation [1], while establishing a strict AI content review mechanism to ensure the accuracy of teaching information [8].

8.2. Training paradigm for clinical ethical decision-making ability

AI-assisted clinical ethical decision-making training presents a dual-track parallel training paradigm. On the one hand, AI clinical decision support systems (CDS) based on electronic health records can effectively improve the ethical decision-making capabilities of medical staff through transparent algorithm models and continuous clinical education [54]. On the other hand, virtual technology-assisted teaching modules (such as digital design training in dental anatomy) have confirmed the value of AI in cultivating specific clinical skills [55]. However, the key challenge lies in balancing the use of technical tools and the cultivation of clinical judgment capabilities. Studies have shown that although non-radiologists improved the detection rate of lesions when using AI-assisted chest X-ray interpretation, they did not significantly change their clinical practice patterns [56]. Therefore, the ideal training paradigm should position AI tools as "clinical decision scaffolds," and realize the coordinated development of technical assistance and humanistic literacy through case library iteration updates [2,7] and BOPPPS teaching model modification [1,5].

8.3. Ethical boundaries of technological innovation in medical education

The application of AI in medical education faces three major ethical boundary challenges. The first is the technical transparency boundary: the algorithm black box problem may affect medical students' understanding of the basis for decisions [47,48]; the second is the cultural adaptability boundary: differences in cultural cognition of anatomical practice in different regions require localized adjustments to AI scenario simulations [1]; the third is the professional identity formation boundary: excessive dependence on AI may hinder medical students from gaining key professional identity experiences in anatomical practice [1]. The penetration of nearly 700 FDA-approved AI clinical tools [15] in medical education further highlights the need to establish a dynamic ethical review mechanism.

Future technological innovation in medical education should follow the basic principle of "technology empowers but does not replace" [1], and incorporate ethical parameter settings at the initial stage of AI tool development [12], and ensure, through interdisciplinary team supervision, that technological innovation does not exceed the essential requirements of medical humanistic education.

8.4. Practical challenges of smartphones as sleep intervention tools

The implementation of smartphone-based sleep interventions is challenged by technical limitations in sensor accuracy and data standardization, as well as practical issues of digital equity. In response, policy should focus on establishing clinical validation standards for digital tools, promoting diversified intervention pathways to prevent over-reliance on smartphones, and integrating digital health literacy into professional education. Ultimately, intervention design must adhere to principles of technological inclusion to serve diverse populations effectively.

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