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Overview of the application of technology in acupuncture education

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Abstract

Objective: This study aims to provide an overview of advanced technologies (VR, AR, AI) and evaluate their effectiveness in improving spatial anatomical knowledge and safe acupuncture practice skills, addressing the limitations of traditional 2D training methods.

Methods: A narrative review of representative studies published between 2012 and 2025 was conducted using the Web of Science and PubMed databases. Eligible publications included original research articles, pilot technological development studies, and review papers addressing VR, AR, or AI in acupuncture education. Selected studies were analyzed qualitatively to identify technological approaches, reported educational outcomes, and limitations.

Results: Immersive VR systems integrating medical imaging data enable three-dimensional visualization of internal anatomical structures and simulated needle depth. Pilot evaluations reported improved spatial anatomical understanding and enhanced procedural accuracy. Mobile AR applications such as FaceAtlasAR support real-time facial acupoint localization with stable tracking performance. AI-based tools demonstrate educational potential; however, current evidence indicates limited clinical reliability. Most studies were preliminary and focused on feasibility and short-term outcomes.

Conclusion: Technology shows the potential to improve students' knowledge of spatial anatomy and safe practice skills. In particular, VR and AR may support anatomical visualization and safety awareness in training contexts, particularly in improving anatomical visualization and safety awareness. Gradual, context-appropriate implementation combined with strengthened foundational anatomy training may provide a sustainable integration pathway.

Keywords: Acupuncture education; virtual reality (VR); augmented reality (AR); artificial intelligence (AI); medical–engineering integration.

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1. INTRODUCTION

In traditional medicine, acupuncture is an important treatment method with a long history and is now recognized for its effectiveness in over 160 countries. However, current traditional acupuncture teaching methods rely primarily on textbooks, 2D illustrations, and peer practice, which reveals significant limitations. Students' difficulty in visually visualizing the anatomical structures beneath the skin leads to the risk of mistakenly inserting needles into dangerous areas, causing adverse events such as organ or tissue damage, especially in sensitive regions. Specifically, studies have warned of potential complications from improper needling, such as lung injury caused by

excessively deep insertion at the Jianjing (GB21) point, as well as ocular injury when acupuncture is performed near the orbital region. Evidence mapping studies have reported that adverse events related to acupuncture, although relatively uncommon, may occur when anatomical knowledge is insufficient, highlighting the importance of safe training approaches [1]

In the context of advancements in new medical science, the need to optimize acupuncture training is becoming increasingly urgent. Global research trends over the past 10 years show a significant increase in the use of technology-related keywords such as virtual reality, artificial intelligence, and big data in the field of acupuncture. Bibliometric data from Web of Science indicate a substantial increase in publications related to acupuncture and technology over the past decade [2]. This paper aims to provide an overview of advanced technological solutions and evaluate their effectiveness in modernizing acupuncture training processes.

2. REVIEWS

2.1. Research methodology

2.1.1. Study design

This study was conducted as a narrative review.

2.1.2. Study objects

The study objects were published scientific documents including:

- Original research articles.
- Pilot technological development studies.
- Review articles related to VR, AR, and AI applications in acupuncture education.

The timeframe was limited to 2012–2025, corresponding to the rapid development of immersive technologies.

2.1.3. Search strategy and selection criteria

Databases: Web of Science and PubMed

Keywords combined using Boolean operators: “acupuncture education”, “virtual reality”, “augmented reality”, “artificial intelligence”, “medical simulation”.

Inclusion criteria:

- Published between 2012–2025.
- Languages: English, Chinese.
- Focused on technological applications in acupuncture education.
- Reported system design or educational evaluation.

Exclusion criteria:

- Non-educational applications.
- Lack of accessible full text.
- Editorials or opinion-only articles.

The selected studies were analyzed qualitatively to identify major technological approaches, reported educational outcomes, and potential limitations.

2.1.4. System development methods in selected studies

Typical studies utilizing advanced technical platforms:

- Virtual reality (VR) development: Using Unity3D to build virtual environments and reconstruct anatomical models from medical image data. [3], [4].
- Augmented reality (AR) development: Utilizing the MediaPipe machine learning framework for real-time facial recognition and skin segmentation, supporting acupuncture point location identification on mobile devices. [5].
- Interactive design between developer and user: Utilizing an iterative design process with the participation of acupuncture experts to refine parameters and user interface. [4].

2.2. Results

Representative studies published between 2012 and 2025 addressing technological applications in acupuncture education were identified from Web of Science and PubMed databases. Most publications focused on virtual reality systems, followed

by augmented reality applications and exploratory artificial intelligence tools.

The majority of available studies were preliminary or pilot-scale investigations, primarily evaluating feasibility, usability, and perceived educational benefit rather than long-term clinical competency outcomes.

Most published research originated from China, and several Western countries. No internationally indexed studies specifically reporting immersive VR/AR applications in acupuncture education from Vietnam were identified in the searched databases.

2.2.1. Virtual reality (VR) and interactive simulation systems

a) Integrating personalized medical imaging.

The AcuVR system represents the trend of integrating medical imaging data, including MRI and CT scans, into a virtual environment using DICOM (Digital Imaging and Communications in Medicine) standards.

- Visualization of deep anatomical structures: Unlike static anatomical models, the system allows students to observe internal body structures and the depth of needle penetration. This helps students develop "X-ray vision" to understand the detailed spatial relationship between acupuncture points and adjacent anatomical structures.

- Training on clinical cases: The system allows data input from patients with specific pathologies, helping students create personalized acupuncture plans and avoid needling damaged areas.

- Safety: Warning functions help students avoid complications while practicing acupuncture in dangerous areas such as the Jianjing (GB21) point near the apex of the lung. [4].

b) Low-cost VR solution

Another approach is to use low-cost VR technology with smartphones and Google Cardboard glasses (costing under 5 euros). The application allows learners to interact and manually assemble structures in virtual space to better understand head and facial anatomy. This method makes smartphones a widely accessible training device without the need for expensive hardware investments. [3].

2.2.2. Augmented reality (AR) on mobile devices

The FaceAtlasAR system applies augmented reality (AR) technology to pinpoint acupuncture points on a real person's face in real time, at a speed of 60 frames per second (fps).

- Accurate Positioning: The system uses Bone proportional cun (B-cun) measurement to pinpoint acupuncture points based on each individual's unique characteristics.

- Stability: Thanks to advanced machine learning algorithms, the system works effectively even when the user's face is partially obscured by glasses or hair; providing strong support for self-learning [5].

2.2.3. Artificial intelligence (AI) and big data

In the context of the development of artificial intelligence technology, AI and big data are becoming important supporting tools. AI models like ChatGPT have potential applications in education. However, caution is needed because the accuracy in suggesting acupuncture points currently only achieves a low level of matching (below 50%) compared to clinical reports. [2].

Table 1. Related research studies

	Author, year	Technology/Model	Results & Key Finding
AcuVR System [4]	Zhang et al. (2024)	VR + Medical Imaging (Integrating MRI/CT into VR)	- Observe internal body structures and needle penetration depth. - Integrate real pathological images into training. - The authors reported that participants demonstrated improved spatial anatomical understanding after using the system.
VR, AI, Big Data [2]	Liu et al. (2024)	System Overview (Review: VR, AI, Big Data)	- AI has potential applications in education. However, caution is needed because the accuracy of the correlation is low (below 50%) compared to clinical reports. - Proposing an integrated medical-engineering training model.
FaceAtlasAR system [5]	Zhang et al. (2021)	Mobile AR + AI (Location of acupuncture points on the face)	- Easy to use, runs smoothly on phones (60 fps) - Accurately identifies acupuncture points even when the user is wearing glasses or has hair covering their face.
VR Educational Tool [3]	Izard et al. (2017)	Low-cost VR (Head and facial anatomy)	- Low-cost solution (< 5 Euro) using Google Cardboard. - The system allows smartphone-based interaction with 3D anatomical structures.

2.3. Discussion

2.3.1. Educational effectiveness

Available studies suggest that technology may enhance aspects of acupuncture training. The authors reported that participants demonstrated improved spatial anatomical understanding after using the system and approximately 75% of participants reported enhanced targeting accuracy. Low-cost VR systems are also considered to create a sense of control over the learning environment and enhance student engagement. [3], [4].

The comparative analysis is shown in Table 2.

Table 2. Comparative strengths and limitations of VR, AR, and AI in acupuncture education

Technology	Strength	Limitation
VR	immersive 3D visualization, depth simulation	cost, infrastructure requirement
AR	accessibility, mobile-based learning	accuracy dependent on algorithm
AI	knowledge support	limited clinical reliability

2.3.2. Trends in medical-engineering integration in training

The development of technology necessitates innovation in human resource training models, especially for healthcare professionals. In the context of rapid technological advancement, training talent through medical-engineering integration appears to be an emerging trend. Medical students should be encouraged to access technical and technological knowledge, or design cross-exchange training programs to develop smart devices in acupuncture and apply technology to clinical practice. [2].

2.3.3. Practical application in Vietnam

In the Vietnamese educational context, a phased and context-sensitive implementation strategy may be more appropriate. Low-cost virtual reality solutions could initially be integrated into anatomy-oriented acupuncture teaching to enhance spatial visualization without imposing substantial financial burden. More advanced VR systems may subsequently be utilized in small-group procedural simulation sessions to improve technical accuracy and safety awareness. Augmented reality mobile applications can support self-directed learning and reinforce acupoint localization skills outside formal classroom settings. Importantly, technological integration should be accompanied by strengthening foundational anatomical education and promoting interdisciplinary collaboration between medical and engineering faculties to ensure sustainable and context-appropriate development [2].

2.3.4. Limitations

Most of the reviewed studies were pilot-scale projects with limited sample sizes and short-term evaluation. Additionally, some systems are still under development or published as preliminary reports. Further large-scale controlled studies are needed to confirm the long-term educational effectiveness and cost-efficiency of these technologies.

3. CONCLUSIONS

The application of advanced technologies such as virtual reality, augmented reality, artificial intelligence, and big data in acupuncture education is a promising direction in the context of continuous technological development. These technologies help make abstract medical knowledge more visual and engaging; ensure safety during skill training; and expand the teaching and learning space for lecturers, students, and trainees.

However, current evidence is largely based on preliminary studies. Educational institutions should consider phased and context-sensitive implementation, integrating technological tools with foundational anatomical teaching and supervised clinical practice. Further controlled studies are needed to establish long-term educational effectiveness.

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