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Review Article

Effective Methods and Strategies for Teaching Anatomical Sciences Without Using Modern Technology

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Abstract

Introduction: Traditional lecture-based approaches in anatomy education often promote passive learning, limiting deep understanding and long-term knowledge application. To address this, our review critically evaluates innovative, evidence-based strategies that employ straightforward and impactful methods to enhance anatomical teaching and learning.

Methods: Google Scholar, PubMed, and Scopus databases were searched for articles published since 2010, with a focus on studies examining active learning methodologies in anatomical sciences education.

Results: An analysis of research comparing the effectiveness of empowering teaching methods with traditional lecture-based approaches revealed that various interactive formats can greatly enhance focus and understanding of anatomical sciences, without relying on technology or incurring financial expenses.

Conclusion: Anatomical education can easily transition from teacher-based lectures to contextually adaptable, multimodal strategies.

Keywords: Anatomical Sciences Education, Low-Tech Approaches, Active Learning Strategies, Non-Technological Approaches

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Introduction

Anatomical sciences present significant pedagogical challenges owing to their inherent complexity and the advanced spatial cognition they demand. Moreover, traditional didactic lecture-based approaches frequently engender passive student involvement and rote memorization, thereby impeding meaningful conceptualization and eroding learner engagement (1, 2). As the demand for highly skilled healthcare professionals intensifies, educators face the imperative to adopt strategies that foster the genuine mastery of intricate anatomical structures.

Educational psychology underscores the efficacy of active learning, collaboration, and thoughtful pedagogical design in enhancing outcomes. Moving beyond passive reception, innovative methods such as experiential learning and inquiry-based activities bridge theoretical knowledge with practical application. These approaches cultivate not only deeper anatomical understanding but also critical thinking, problem-solving, and collaborative skills essential for future clinicians (3, 4). Consequently, anatomical education must embrace evidence-based, psychologically grounded approaches in order to promote durable, active learning suited to evolving needs (5).

It is noteworthy that these effective strategies are underpinned by robust theoretical frameworks. Cognitive theory highlights mental processes (thinking, memory, and problem-solving), explaining how active methods enhance engagement and critical thinking (6). Likewise, behavioral theory, focusing on observable actions and modification, informs the use of reinforcement and consistent assessment (7). Moreover, constructivism views learning as an active process of knowledge construction through experience, exemplified by collaborative project-based learning (8). Furthermore, humanistic theory emphasizes personal growth, aligning with student-directed learning and goal-setting (9). Finally, the theory of multiple intelligences advocates for diverse instructional strategies (e.g., kinesthetic and linguistic) to cater to varied student strengths (10).

Mastering anatomy uniquely demands advanced spatial reasoning for visualizing complex three-dimensional structures, distinct from disciplines emphasizing critical analysis alone. It heavily relies on visual and tactile modalities. Essential non-technological techniques, therefore, include physical modeling, detailed drawing, and targeted simulations to decode intricate bodily systems (11). These approaches necessitate a shift from rote memorization fostered by outdated methods toward innovative, non-digital approaches that cultivate genuine

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comprehension, structural visualization, and practical skill development for real-world medical practices.

Therefore, this systematic review aims to synthesize the literature (2010–present) from Google Scholar, PubMed, and Scopus to identify and evaluate proven, effective methods and strategies for teaching anatomical sciences that do not depend on modern technology.

Effective Low-Tech Educational Methods in Anatomical Sciences

Living Anatomy and Body Painting

The origin of body painting (BP) can be traced to tribal cultures, where it was used for ceremonial purposes. It was considered an ancient form of art in primitive tribes (12, 13). Living anatomy as a branch of learning anatomy refers to work on the body of living people, which has attracted extensive attention in the field of anatomy education today (14). Moreover, BP is regarded as a valuable and practical complementary method to living anatomy that improves surface anatomy and clinical skills courses (15, 16). Op Den Akker et al were the first team to employ BP as an innovative approach to facilitating and improving anatomy learning. In addition, BP is an art form defined as drawing and painting internal structures, such as muscles, veins, bones, nerves, and many internal organs, on the surface of the body or skin in detail for teaching anatomy (17). In a scientific study, Nanjundaiah and Chowdapurkar concluded that the BP method was well accepted by the students as an effective and practical method to learn the surface and clinical anatomy. They further mentioned that visual images on the bodies increased their memory of the landmarks (18). This form of art-based educational method serves as an excellent method to promote students' cognitive and psychomotor skills and has many advantages. According to some studies (13, 19), these benefits are as follows:

Promotes Appreciation of Surface and Clinical Applied Anatomy: This method allows students to have a vivid experience on a living body to find body landmarks (19).

Cost-Effective Teaching Method: BP is a highly cost-effective method because it requires only colorful marker pens or body paints, which can be easily purchased at a low cost [15].

Promotes Understanding and Retention of Knowledge: BP permits easy visualization of anatomical structures and landmarks through powerful and highly memorable visual impressions (18). Azer indicated that BP promoted lateral thinking by 31%, enhanced knowledge transfer into painting by 63%, and finally improved consolidated students' understanding by 92% (20).

Promotes Active and Collaborative Learning: In the field of educational topics, BP activity is known as active learning (21). While students perform palpation and identify surface landmarks, they need to construct mental imagery of the internal structures and reflect on the skin (22).

Other Benefits of Body Painting: It stimulates interest, engagement, and motivation (23) and is considered an alternative teaching method to cadaveric-based pedagogies (24).

Flipped Classroom

The flipped classroom is an innovative teaching method in which students engage with learning materials at home before participating in discussions and problem-solving activities in class. Teachers create accessible instructional content (e.g., videos or articles) for students to review beforehand. To deepen understanding, educators facilitate discussions and group activities in class. Continuous assessment and feedback are vital for tracking progress. While this method requires internet access and digital devices, it can be implemented in developing countries. Challenges include students' responsibility for their learning; for instance, students may struggle in class if they do not review materials. Additionally, educators face increased workloads in content creation, and not all students may adapt well to online learning (25). Given that this approach does not require specialized technological infrastructure, applying the flipped classroom model in anatomy education in developing countries has significant potential for effectiveness and benefit. Vertemati et al, focusing on enhancing anatomy education through flipped classroom and adaptive learning, concluded that the flipped classroom method, by providing valuable and precious insights into the potential of artificial intelligent-based adaptive learning systems in anatomy education and learning, can address the challenges of limited teaching hours, a shortage of specialist anatomists, and the need for individualized training (26).

Blended Learning

Blended learning combines traditional and digital teaching methods, providing flexibility for students to choose their study times and locations. In addition, it promotes interaction between peers and educators in online and in-person settings, accommodating various learning styles. However, challenges include technology access and the need for proper training for educators. Effective time management is crucial for students balancing both formats. When well implemented, blended learning enhances educational quality and boosts student motivation and engagement, requiring careful planning and support for teachers and students (27). In this setup, both students and instructors make use of devices such as laptops, tablets, or smartphones, alongside video conferencing tools (e.g., Zoom, Microsoft Teams, or Google Meet) to interact with online materials and courses. Further, this model can be applied in areas with limited technological resources (28). In the realm of anatomy education, blended learning can be adapted even with restricted technological infrastructure through various methods, such as combining printed materials, utilizing basic technologies, and using mobile applications.

Combining Printed Materials: Integrating digital resources with physical texts and handouts can enhance the learning experience (29).

Utilizing Basic Technologies: Educational videos saved on DVDs or USB drives can be effectively used in classroom environments (30).

Mobile Applications: Capitalizing on mobile phones and simple messaging apps for sharing information can be advantageous.

By employing blended learning method for teaching and learning human anatomy (traditional teaching plus online study material), Pereira et al found that students supplemented with additional online resources performed significantly better than those receiving traditional teaching method alone (31). In a systematic review, Karbasi et al reported that students who used blended learning method to learn anatomy demonstrated improved performance and increased satisfaction and motivation. Many of the studies reviewed by the above-mentioned study confirmed the effectiveness of the blended learning method (32).

Problem-Based Learning

Problem-Based Learning (PBL) is an active educational strategy in which students address authentic, complex problems to construct knowledge. Moreover, learners engage by researching, hypothesizing, and collaboratively developing solutions in small groups, enhancing critical thinking, logical reasoning, and argumentation skills. This method boosts motivation through real-world challenges and fosters teamwork and communication. However, PBL requires significant time investment and skilled facilitation, and its assessment focuses on the learning process rather than just outcomes, adding complexity (33). Nonetheless, this technology-independent method can be effectively incorporated into anatomy education within resource-limited settings through several strategies, including selecting pertinent real-world anatomical problems (e.g., clinical cases, injuries, and diseases) and prompting independent research using diverse non-digital sources (textbooks and academic journals). Other strategies are facilitating structured discussion sessions to evaluate solutions and stimulate critical analysis and providing ongoing feedback on problem-solving approaches and learning progress. Where basic digital access exists, simple tools such as educational videos or software can supplement the core experience (34). By applying these strategies, PBL can be effectively incorporated into anatomy education in less developed nations, thereby enhancing students' critical thinking and problem-solving abilities.

The findings of the study by Zuccaro et al affirming the efficacy of the PBL method as an augmentative approach marked enhancements in student engagement and interactions in medical anatomy education (35).

Nyemb et al, investigating the PBL approach, found that students demonstrated very positive behavior (Response) in anatomy learning when using this method. They further indicated that for 92% of students, the PBL approach is a stimulating and intuitive approach in anatomy learning, even with the current conventional (lecture) teaching methods (36).

Inquiry-Based Learning

Inquiry-based learning (IBL) promotes active participation through hands-on activities, fostering a deeper understanding of concepts. This method is vital for developing critical and analytical thinking skills. Guided by instructors, students independently seek information and solve problems. The key stages include question formulation (1), research and exploration (2), presentation of findings (3), and feedback and evaluation (4).

Question Formulation: Students generate questions for investigation.

Research and Exploration: They gather information from various resources.

Analysis of Information: Collected data are examined for logical conclusions.

Presentation of Findings: Students share their discoveries.

Feedback and Evaluation: Constructive criticism is provided by teachers and peers.

This approach not only enhances problem-solving skills but also boosts motivation, as students actively engage in their learning and tackle challenges in order to improve their abilities (37).

IBL enhances understanding and fosters lasting educational outcomes, while teamwork develops social skills. In less developed countries, integrating this approach into anatomy education can be achieved by encouraging students to formulate questions through group discussions, designing small research projects to explore anatomical features or compare human and animal anatomy, and utilizing community resources, such as museums and health clinics, for practical engagement. Collectively, such strategies improve student learning and collaboration in anatomy education (38, 39). By implementing these strategies, IBL can be effectively integrated into anatomy education in less developed countries, thereby fostering the enhancement of students' critical thinking and research skills.

Fating et al investigated the performance and effectiveness of IBL method and concluded that students liked this method because it improved the confidence of teachers and students, simplified and clarified concepts and topics, helped develop thinking skill, increased interest and attention in students, strengthened the quality of teaching and learning and increased interaction between teachers and students (40).

Small Group Methods

The small group method or team-based learning emphasizes collaboration and active participation among learners. The students are divided into several small teams or groups and members engage in discussions. In addition, members of the group solve problems together and share personal experiences, motivating them to take an active role in their education through hands-on experiences and collaborative projects. This approach allows students to learn from diverse perspectives, fostering a deeper understanding of the topics. Further, each member assumes specific roles, enhancing accountability and commitment to the learning process (41). Through conversation and interaction, students can also improve their critical thinking skills and engage in deeper analysis of various topics. In small groups,

participants can quickly provide feedback to one another, allowing for learning through shared mistakes. Likewise, the small group approach promotes more effective and meaningful learning experiences, encouraging students to take a more proactive role in their studies (42). This method is particularly advantageous in environments with limited resources. Team-based learning, which promotes collaborative problem-solving, provides an active learning and structured form of the small group learning method that can be employed in classes with many students (40).

Small groups that come together to learn a specific subject or solve a problem create golden educational opportunities that, if used correctly, can bring extraordinary results. This issue is important because small group teaching is one of the effective teaching methods that can achieve very high efficiency in learning. Small groups, consisting of at least two people and possibly including up to 30 people, have very strong potential that can facilitate the flow of teaching and learning (43, 44). In a study, Lopez et al referred to small group method as a unique and effective method for teaching anatomy, stating that all students agree with instructor assessments and believe that this method helps them prepare for clinical courses, especially in anatomy learning. Moreover, students who used this learning method achieved first-time pass rate of 98.6% in the anatomy course (45). In a cross-sectional study by Jaiswal, the small group discussion method was compared with traditional lecture in anatomy teaching. It was revealed that it was a useful method for the improvement of communication skills among students and helped in retaining knowledge. This method had other advantages over the lecture method, including less stress, more interactive, active participation, and increased interest (46).

Gamification

Gamification is a newer teaching method that enhances student motivation and engagement through the appeal of games. By participating in challenges, students experience lively learning that fosters critical thinking and problem-solving skills. Multiplayer games promote social skills, collaboration, and communication while also providing hands-on learning in a safe environment (47). However, adopting gamification can be costly and frequently requires advanced technology and infrastructure. Educational free tools, such as Kahoot, Quizizz, and Classcraft, empower teachers to craft interactive learning experiences (48). Likewise, other online platforms, such as Edmodo and Google Classroom, can facilitate the sharing of games and learning activities (49) and can be successfully utilized in developing nations with a low cost for learning anatomy. Based on the findings of Castellano et al, the gamification method improved and supported students' anatomy learning. The scores of students who used the applications were better than those of the control group (50). Moreover, Geetha et al compared two educational methods in anatomy education, including kaizen strategies and game-based education or gamification, and concluded that students who employed game-based learning approaches, were far better than those who utilized conventional learning (51).

Social Learning

This type of learning involves acquiring knowledge by observing and interacting with others, allowing individuals to learn from peers' experiences without direct involvement. This method enhances motivation through inspiration from others' successes and fosters communication and teamwork. However, it may neglect individual learning and can lead to imitating negative behaviors if role models are poor. Accordingly, effective social learning requires an engaging environment; otherwise, learning opportunities are significantly diminished (52). To effectively apply this approach, various platforms, such as Google Classroom, Moodle, and Edmodo, can encourage interaction and teamwork (53). In addition, social media sites, including Facebook, LinkedIn, and Twitter, can aid in the sharing of knowledge and experiences. Online webinars and discussions using tools such as Zoom and Microsoft Teams can further enhance educational exchanges. Furthermore, applications like Slack and Trello can facilitate better group collaboration and communication (54). Similarly, utilizing multimedia resources (e.g., videos, podcasts, and articles) can enrich social learning and facilitate the dissemination of information. In addition, freely available resources can be used in less developed countries. Regarding this method, Chytas indicated that although there are limited studies about the use of social media in anatomy education, generally, the social could positively affect anatomy education (55). Ortadeveci and Ozden also examined the effect of social media as a learning tool on anatomy education and found that medical and dental students were eager to use social media to learn anatomy, and 96.5% of them preferred to follow anatomical content on social media (56).

Self-Directed Learning

Self-directed learning (SDL) empowers individuals to control their education by setting goals, finding resources, and personalizing learning. It is vital in higher education and professional development, enhancing skills and career advancement. Moreover, SDL promotes flexibility and self-management but requires self-discipline and motivation, with challenges in resource access for those in underdeveloped areas (57). Websites such as Coursera and Udemy offer accessible means for individuals to engage with educational content (58). Several strategies, including providing a diverse range of learning materials (e.g., textbooks, videos, and scientific articles), can be implemented to effectively promote SDL in anatomy education in less developed countries.

Biswas et al compared SDL versus traditional teaching in learning gross anatomy and reported that SDL under the supervision of teachers was as good as the traditional methods (59). However, Sachdeva and Mahajan (2022) evaluated the effects of SDL in the department of anatomy on 126 Bachelor of Medicine, Bachelor of Surgery students

of the first semester. Based on their results, most students scored more than the mean score of anatomy course after this method. The SDL teaching method motivates students and can be effectively implemented in anatomy education and teaching (60).

Experiential Learning Theory

Experiential learning theory (ELT) emphasizes active participation through hands-on experiences, consisting of four phases: Direct experience, reflection, generalization, and application. This approach connects emotional and cognitive processes, enhancing problem-solving skills, self-confidence, and self-awareness. Additionally, it promotes communication and teamwork by encouraging the sharing of experiences among peers (61). This teaching approach is also vital in anatomy education as it fosters lasting learning, boosts motivation, and develops practical skills. Some strategies for integrating experiential learning in developing countries include conducting practical laboratory sessions with real specimens, organizing hands-on workshops for collaboration, facilitating the observation of healthcare professionals in clinical settings, using anatomical simulators, encouraging research projects, and providing ongoing feedback to enhance the learning experience. By implementing these strategies, experiential learning can be effectively woven into anatomy education in developing countries, thus helping students obtain a deeper understanding of anatomical concepts.

Sarkar et al applied ELT-based sessions to anatomical sciences education and found that the satisfaction index in ELT-based sessions was 96.1%. They concluded that the ELT-based method can effectively foster positive engagement and improve learning experience in students (62).

Personalized Learning

This type of learning tailors teaching methods and materials to meet each student's unique needs and abilities, thereby enhancing learning effectiveness. Further, this model relies on understanding learners, promoting meaningful connections, and utilizing data. It also requires diagnostic assessments and advanced technologies, with artificial intelligence playing a key role, particularly in countries with modern infrastructure (63). A number of strategies can be considered for implementing personalized learning in anatomy education in less developed nations, including using diverse instructional methods (e.g., workshops and hands-on activities), providing varied learning resources, arranging counseling sessions for educational planning, utilizing basic tools (e.g., mobile phones) for access, and designing practical experiences with continuous assessment and feedback (63, 64). By employing such strategies, personalized learning can be successfully incorporated into anatomy education in less developed countries, thereby enhancing the overall quality of education. The results of a recent study by Stambuk-Castellano et al confirmed the effectiveness of personalized learning strategies in improving academic performance in learning anatomy (65).

Multisensory Learning

It is a teaching method that simultaneously engages multiple senses of students, such as vision, hearing, and touch. Moreover, this approach enhances information processing and improves understanding and retention by capturing learners' attention and promoting deeper involvement. It also accommodates various learning preferences and requires no advanced technology, making it suitable for underdeveloped areas (66). To successfully integrate multisensory learning into anatomy education in these regions, several strategies can be used, including organizing interactive workshops where students can investigate anatomical structures using anatomical models or real specimens and incorporating diverse media forms (e.g., text, images, videos, and audio) to present anatomical information. For example, educational videos can be supplemented with corresponding audio narratives. Other strategies are encouraging teamwork among students on projects or research focused on anatomical structures, which may include the analysis of real specimens or models, and designing activities that stimulate multiple senses, including tactile exploration, visual observation, and auditory experiences related to anatomy (e.g., the sounds associated with heartbeats). Even with potential infrastructure challenges, accessible technologies such as tablets or smartphones can provide access to multimedia educational resources. Another strategy is organizing visits to local hospitals or medical centers in order to observe anatomical practices and learn from healthcare professionals (3). This approach recognizes that learners may have different sensory preferences and can benefit from a variety of instructional techniques.

Role Play

Role play is recognized as an effective teaching method in medical education, particularly for anatomy and clinical skills. Research has shown that role play improves understanding of complex concepts, increases learning motivation, and enhances clinical and communication skills (67).

In anatomy education, role play allows students to explore realistic clinical scenarios in a controlled environment, thereby facilitating greater interaction between students and instructors. The technique involves dividing students into small groups to plan and perform clinical situations, followed by debriefing sessions (67-69). Furthermore, role play has been found to promote active learning, critical thinking, and teamwork (69). One study investigated the use of role play as an educational strategy in clinical anatomy, involving 61 students. The role play technique was structured into planning, application, and debriefing phases, and the results demonstrated that 98.1% of students approved of the method, and 95.1% found it effective for achieving learning goals. Additionally, 86.9% would recommend it for future use. Overall, this method was deemed practical and engaging, enhancing the learning experience in clinical anatomy (70).

Conclusion

By embracing these simple and low-tech educational techniques, educators can foster deeper understanding and encourage more active involvement from students. By using these methods, teachers can transform anatomy education into a more meaningful, engaging, and sustainable pursuit. Finally, anatomical education can easily transition from teacher-based lectures to contextually adaptable, multimodal strategies.

Authors' Contribution

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The authors have no competing interests to declare.

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