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Application of 3D digital orthopedic technology combined with PBL teaching model in traditional Zhuang medicine and orthopedics teaching

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Abstract

Objective: To explore the application effect of 3D digital orthopedic technology combined with PBL teaching mode in the teaching of traditional Zhuang medicine and orthopedics, and to explore possible efficient teaching methods for traditional Zhuang medicine and orthopedics. Method: 54 medical students who studied in the Zhuang Medicine and orthopedics major at Guangxi International Zhuang Hospital from January 2023 to December 2023 were selected as the research subjects and divided into a control group and an observation group, with 27 students in each group. Two groups were divided into an observation group (using 3D digital orthopedic technology combined with PBL teaching mode) and a control group (using traditional teaching mode) using different teaching methods. Statistical analysis was conducted on the exam scores, teaching effectiveness evaluation, and teaching satisfaction of the two groups to compare their teaching effectiveness. Result: The observation group had better exam scores, teaching effectiveness evaluation, and teaching satisfaction than the control group, and the differences were statistically significant ($P<0.05$). Conclusion: The combination of 3D digital orthopedic technology and PBL teaching mode can help improve overall teaching effectiveness and may be an efficient teaching method for Traditional Zhuang Medicine and Orthopedics.

Keywords

3D digital orthopedic technology;PBL teaching model
Zhuang medical science
teaching

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1. Introduction

The Zhuang Medicine Traumatology constitutes a vital component of Zhuang Medicine, being a discipline of profound practical application. Presently, instruction in Zhuang Medicine Traumatology primarily relies on textbooks and anatomical atlases, lacking the intuitive representation afforded by three-dimensional anatomical structures [1]. This deficiency may hinder students' accurate comprehension of key diagnostic and therapeutic principles for traumatological conditions, thereby impeding clinical practice within Zhuang Medicine Traumatology and potentially jeopardising its transmission and advancement.

Recent domestic and international pedagogical research indicates that problem-based learning (PBL) demonstrates excellent teaching efficacy in clinical medical education, effectively enhancing students' problem identification and analytical capabilities [2-4]. Digital orthopaedics, an emerging interdisciplinary field integrating computer science with orthopaedics, employs information technology to achieve the digitalisation, visualisation, virtualisation, operability, and intelligentisation of orthopaedic diagnostic and therapeutic procedures [5]. Research indicates that digital 3D orthopaedic technology fosters image-based cognition rather than textual comprehension, simplifying complex problems [6]. The organic integration of digital 3D orthopaedic technology with modern teaching methodologies significantly enhances clinical trainees' interest and practical skills [7]. Current literature offers limited reports on the application of these approaches in Zhuang medicine trauma science education. This study investigates the application of digital orthopaedic technology integrated with the PBL teaching model in Zhuang medicine traumatology education, contrasting it with traditional teaching approaches. Findings are reported below.

2. General Data

2.1. Case Grouping Information

The study cohort comprised 54 medical students enrolled in the Zhuang Medicine Traumatology programme at Guangxi International Zhuang Hospital between January and December 2023. The control group comprised 27 participants (12 males, 15 females) aged 21–24 years (mean age 22.5 ± 0.7 years). The observation group comprised 27 participants (13 males, 14 females) aged 21–24 years (mean age 22.3 ± 0.8 years).

2.2. Inclusion Criteria

① Medical students who actively participated in the entire course of Zhuang Medicine Traumatology instruction for this study; ② Voluntary participation with full knowledge of and consent to cooperate with this research.

2.3. Exclusion Criteria, Dropout, and Exclusion Standards

① Poor compliance; ② Individuals who had previously received training in Zhuang Medicine Traumatology; ③ Those who withdrew midway for any reason and could not continue participating in the study.

2.4. Methods

All subjects utilised the third edition of Zhuang Medicine Traumatology (People's Medical Publishing House) as the textbook. Instruction and clinical supervision were provided by faculty members with extensive clinical and teaching experience in Zhuang medicine traumatology. Assessment and evaluation were conducted upon completion of the learning programme.

2.4.1. Control Group

The control group employed traditional teaching methods. Specific implementation steps were as follows: ① Instructors delivered theoretical knowledge on Zhuang Medicine Traumatology via PowerPoint presentations. ② Students discussed relevant case studies presented by instructors, who posed questions to stimulate critical thinking and analysis. Students shared their insights before instructors provided concluding summaries.

2.4.2. Observation Group

The observation group utilised a combined 3D digital orthopaedic technology and PBL teaching model. The specific implementation steps were as follows: ① Problem-centred introduction: Utilising typical Zhuang orthopaedic trauma cases, the instructor guided students in collecting and compiling clinical case materials, summarising key disease aspects, and formulating critical questions. ② Guided group-based literature review and analysis: Each group member was required to gather and synthesise materials related to the actual teaching case questions, followed by literature analysis and summarisation. ③ Preparation of 3D-printed teaching aids: Prior to lectures, instructors distributed 3D-printed models of relevant teaching cases. Each group member prepared knowledge related to Zhuang orthopaedic trauma science. During lectures, groups presented and analysed findings using PowerPoint presentations alongside the 3D models to deepen understanding; ④

Inter-group discussion: Each group member shall present and summarise findings. The teaching instructor shall conduct a comprehensive assessment to guide trainees in identifying optimal evidence-based diagnostic and therapeutic approaches.

2.5. Assessment Criteria

2.5.1. Examination Results

A closed-book written examination, uniformly set by Associate Professors or above in Zhuang Medicine Traumatology, will be conducted. The content and duration of the examination will be identical for all participants, with a maximum score of 100 points.

2.5.2. Teaching Effectiveness Evaluation

Following the conclusion of both learning groups, evaluation forms and questionnaires will be distributed uniformly. Students' comprehensive abilities will be assessed by instructors based on professional competence, clinical analytical skills, clinical collaboration capabilities, and clinical practice proficiency, with each criterion scored out of 10 points.

Student questionnaires employed a Likert scale [8], comprising five response options: Very Satisfied, Satisfied, Fairly Satisfied, Dissatisfied, and Very Dissatisfied. Satisfaction rate = (Number Very Satisfied + Number Satisfied) / Total Group Participants × 100%. A total of 57 questionnaires were distributed, achieving a 100% valid response rate.

2.6. Statistical Methods

Data analysis was performed using SPSS 26.0 statistical software. Quantitative data are expressed as ($x \pm s$), with intergroup comparisons conducted via t-tests. Categorical data are denoted by n and analysed using χ^2 tests. Differences were considered statistically significant at $P < 0.05$.

3. Results

3.1. Comparison of General Characteristics and Examination Scores Between Groups

No statistically significant differences were observed in general characteristics between the two groups ($P > 0.05$), indicating comparability.

Following the training programme, the observation group achieved higher examination scores than the control group, with statistically significant differences ($P < 0.05$). Details are presented in **Table 1**.

Table 1. Theoretical and Practical Examination Scores for Both Groups (Mean ± SD, points)

Group	Examination Results
Observation group（n = 27）	85.04±7.30
Control group（n = 27）	80.15±9.02
t -value	1.657
P -value	＜ 0.05

3.2. Questionnaire Survey Comparison of Comprehensive Competencies Between Two Student Groups

The observation group demonstrated superior clinical analytical skills, clinical collaboration abilities, and clinical practice capabilities. Both self-reported competency enhancement and teaching effectiveness evaluations were higher than those of the control group,

Table 2. Questionnaire Survey Results Comparing Comprehensive Competencies Between Two Student Groups (Mean ± SD, points)

Group	Professional Competence	Clinical Analytical Skills	Clinical Collaboration Skills	Clinical Practice Skills
Observation group（n = 27）	8.26±0.66	7.96±0.50	7.74±0.46	7.15±0.57
Control group（n = 27）	8.03±0.29	7.33±0.54	7.00±0.30	6.70±0.57
t-value	1.295	4.132	5.405	2.371
P-value	＞ 0.05	＜ 0.05	＜ 0.05	＜ 0.05

Table 3. Teaching Satisfaction Outcomes for Both Groups (n, %)

Group	Very satisfied	Satisfied	Neutral	Dissatisfied	Very dissatisfied	Satisfaction level
Observation group（n = 27）	7（25.93）	16（59.26）	4（14.81）	0	0	85.19
Control group（n = 27）	3（11.11）	14（62.96）	8（29.63）	2（7.41）	0	62.96

with statistically significant differences ($P < 0.05$). See **Table 2** for details.

3.3. Comparison of Teaching Satisfaction Outcomes

Following the conclusion of both groups' placements, teaching satisfaction survey results indicated that students in the observation group, who utilised 3D digital orthopaedic technology and the PBL teaching model, demonstrated significantly higher satisfaction levels than their counterparts in the control group, as detailed in **Table 3**.

4. Discussion

Zhuang Medicine Traumatology constitutes a vital component of traditional Chinese medicine. It represents an indigenous traditional medical system developed by the Zhuang people through prolonged engagement in production, daily life practices, and the struggle against disease. Its therapeutic approach is characterised by simplicity, efficacy, and affordability [9]. Although Zhuang Medicine was formally incorporated into China's higher education curricula in 2011, transforming the traditional mode of transmission through oral tradition and apprenticeship, current teaching still predominantly relies on lecturers delivering theoretical instruction and demonstrations. with post-lecture student learning predominantly reliant on literature review. This approach lacks visual clarity and practical applicability, nor does it permit individualised guidance for student practice. Consequently, student engagement remains low, with insufficient initiative and proactivity. This results in suboptimal mastery of theoretical knowledge and clinical skills, failing to meet modern educational standardisation requirements or clinical demands.

Zhuang medicine has long recognised human anatomy as fundamental to understanding disease pathogenesis. During the Northern Song Dynasty, the Lingnan Zhuang ethnic group produced the Ouxifan Five Viscera Diagram, China's earliest documented illustrated anatomical chart. It depicts human visceral structures with remarkable accuracy and detail, incorporating medical observations on pathological mechanisms during dissection [10]. However, owing to the scarcity of human anatomical specimens, clinical teaching in Zhuang medicine's trauma science has predominantly relied on illustrated atlases or models. These substitutes fail to accurately reflect local anatomical features, leading to comprehension difficulties among students.

In recent years, advances in 3D digital orthopaedic technology have offered novel approaches to addressing clinical teaching challenges in orthopaedics. This technology enables the digitalisation, visualisation, virtualisation, operability, and intelligent application of clinical orthopaedic diagnostic and therapeutic procedures [11-12]. Compared to traditional human dissection, 3D-printed models are more cost-effective, readily available, and easier for medical novices to comprehend [13]. Addressing the current challenges of specimen scarcity and the inability of conventional organ models to intuitively and effectively demonstrate pathological features, 3D-printed models offer a solution for medical education [14]. Research indicates that 3D printing technology significantly enhances the quality of orthopaedic education [15-17]. Further studies reveal that the organic integration of 3D digital orthopaedic technology with modern teaching methodologies improves the quality of clinical practice instruction [18]. Therefore, fully leveraging the visualisation advantages of 3D digital orthopaedic technology and flexibly combining it with diverse modern teaching approaches can stimulate students' initiative and enthusiasm for learning, continuously improving their learning efficiency and thereby enhancing overall teaching effectiveness and quality.

The Problem-Based Learning (PBL) model is a contemporary, student-centred teaching approach centred on problem-oriented learning, emphasising active student engagement and collaborative problem-solving. Currently, PBL is widely applied across numerous clinical departments, particularly in orthopaedic clinical teaching. It enhances students' autonomous learning and collaborative abilities while facilitating pedagogical transformation and elevating teaching standards [19-20]. Wei Lei et al. [21] observed that applying PBL in sports medicine education not only improves students' assessment outcomes but also enhances their self-directed learning abilities, problem-solving skills, learning motivation, and literature retrieval capabilities, demonstrating clinical practical value. Therefore, fully leveraging the strengths of the PBL model and dynamically optimising its application during Zhuang medicine trauma science teaching can progressively standardise instructional practices, broaden pedagogical perspectives, and elevate teaching efficiency and quality.

Currently, the integration of 3D printing with PBL teaching has been extensively applied in orthopaedic clinical education, significantly enhancing teaching outcomes and quality [22]. This study compared the clinical teaching of Zhuang Medicine Traumatology using a combined 3D digital orthopaedic technology and PBL teaching model against traditional teaching methods. Results revealed that the organic integration of 3D digital orthopaedic technology with the PBL teaching model not only significantly improved students' examination scores but also markedly enhanced their clinical analytical skills, clinical collaboration abilities, and clinical practical competencies. It is evident that the organic integration of 3D digital orthopaedic technology with the PBL teaching model fully engages multiple sensory modalities in student learning, stimulates their enthusiasm for active participation, and contributes to enhanced teaching outcomes and overall teaching satisfaction.

In summary, the synergistic integration of 3D digital orthopaedic technology and the PBL teaching model achieves multi-level optimisation in Zhuang Medicine Traumatology instruction. This approach not only ignites students' interest and enthusiasm for self-directed learning but also enables more intuitive comprehension of local anatomical relationships and relevant theoretical knowledge in pathological conditions. Concurrently, it enhances peer-to-peer and teacher-student interactions, elevating students' clinical analytical skills, collaborative abilities, and practical competencies. This approach improves both the teaching quality and satisfaction levels in Zhuang Medicine Traumatology instruction. Furthermore, it assists educators in refining teaching methodologies, thereby elevating overall instructional efficacy. This approach warrants wider adoption.

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Disclosure statement

The author declares no conflict of interest.

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