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Research on Problem-based Learning Teaching Mode in the Teaching of Introduction to Intelligent Medicine

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Abstract: The problem-based learning (PBL) has sparked widespread discussion and research in the field of education both domestically and internationally. This paper presents a case study of the implementation of PBL in the teaching of Introduction to Intelligent Medicine. Guided by the method of problem-based teaching and integrated with a project-driven approach, a blended learning mode was designed and implemented in the actual teaching process in Hainan Medical University. The students of new clinical medicine in the grade of 2020 and 2021 were selected as the control group and experimental group respectively. The former adopted traditional theoretical teaching mode, while the latter adopted PBL teaching mode. The statistical analysis of the experimental group's performance was better than that of the control group, which indicates the designed teaching model can significantly promote students to engage in self-directed learning, enhance their practical abilities, and achieve good learning outcomes.

1. Introduction

With the rise and promotion of computer technology in decades, medical informatics has penetrated into various aspects of the medical and health field: electronic medical records, biological signal analysis, medical image processing, clinical support systems, hospital information systems, health information resources [1]. In recent years, the application of artificial intelligence in medical research and diagnosis has become one of the hotspots of modern technology. The top five medical service institutions in the United States, such as Mayo Medical Center and Cleveland Medical Center, have begun to cooperate with artificial intelligence companies, aiming to better use artificial intelligence technology to predict, diagnose, treat, and manage diseases [2-3]. In terms of medical education, in order to adapt to the development of intelligent medicine, some universities have started teaching new medical courses to meet the needs of future medical personnel to apply intelligent medicine in clinical practice [4]. In the future, clinicians who can proficiently use artificial intelligence will rely on their clinical experience and digital expertise to better solve modern health problems, participate in the development of digital strategies for medical institutions, and manage intelligent medical devices. As a rapidly developing direction with broad application prospects in recent years , "Artificial intelligence + Medicine" plays a vital role in the development in the field of artificial intelligence[5,6]. Cultivating professional talents with medical knowledge and artificial intelligence technology in higher education can serve as the driving force for promoting the development and transformation of disciplines [7]. Therefore, conducting intelligent medical education for undergraduate students has significant and far-reaching significance for the establishment and improvement of a novel clinical professional education and training system [8,9].

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At present, the development of intelligent medicine in China is in its infancy. It not only requires the research and development of intelligent medical technology to meet clinical needs, but also focuses on higher education and talent cultivation that combines medical and industrial fields [10]. “Introduction to Intelligent Medicine” is an interdisciplinary course between medicine and computer science, mainly containing the contents of artificial intelligence technology in medicine. The goal of this course is to cultivate students to grasp the principles and core algorithms of artificial intelligence technology, understand examples of applying artificial intelligence technology to solve practical medical problems, know the application background and development trends of artificial intelligence in the medical field, and apply artificial intelligence technology to solve practical medical problems. Hainan Medical University has been offering an “Introduction to Intelligent Medicine” course since 2021. From the perspective of teaching practice, students generally show great interest in this course. However, it has also provided feedback on issues such as a single teaching mode and difficulty in applying what has been learned in the classroom to the analysis and mining of medical information resources. To solve the above issues, this paper proposed a blended learning mode combining PBL and project-driven approaches. The experimental results shows higher valuation scores and an improvement in teaching quality.

2. Objects

“Introduction to Intelligent Medicine” is a specialized course for students majoring in Clinical Medicine at Hainan Medical University. The control group containing 100 students was taught in 2021 by the traditional theoretical teaching model. The experimental group comprising 100 students was taught in 2022 using the proposed blended learning mode.

3. The Proposed Course Design Schem

3.1. Analzing course characteristics and teaching

The “Introduction to Intelligent Medicine” course encompasses a broad spectrum of knowledge. However, the traditional theoretical teaching approach employed in the instructional process reveals three primary issues. Firstly, students tend to rely on teacher explanations, avoiding critical thinking. Secondly, the limited scope of in-class questioning makes it challenging to address all students, resulting in a skewed assessment of their learning status through restricted interactions. Thirdly, students passively engage in classroom instruction, leading to suboptimal learning outcomes, particularly in achieving higher-order learning objectives such as application and evaluation. To encourage students to engage in classroom interaction effectively and strive towards achieving higher-order learning objectives, project-driven teaching and PBL have been introduced alongside traditional theoretical instruction. This integration includes group presentations, classroom discussions, and project demonstrations, aiming to improve teaching effectiveness by altering the teaching model.

3.2. The design of teaching model

Focusing on the course “Introduction to Intelligent Medicine”, this paper investigates how to build a comprehensive teaching system through PBL, aiming to optimize resource integration and enhance teaching efficiency. The specific PBL design is outlined as follows: PBL is a student-centered, outcome-oriented teaching approach where students engage in group discussions, under the guidance of the teacher, to explore, discuss, and learn about a specific topic based on real-world problems. This teaching model is designed to stimulate students’ interest in learning, foster their self-directed learning abilities, and enhance their overall critical thinking and innovation skills. The research contributes to the development of innovative and effective teaching strategies in the field of intelligent medicine. After the first round of implementation, the course has developed a well-rounded theoretical and practical integrated teaching system, as illustrated in Figure 1.

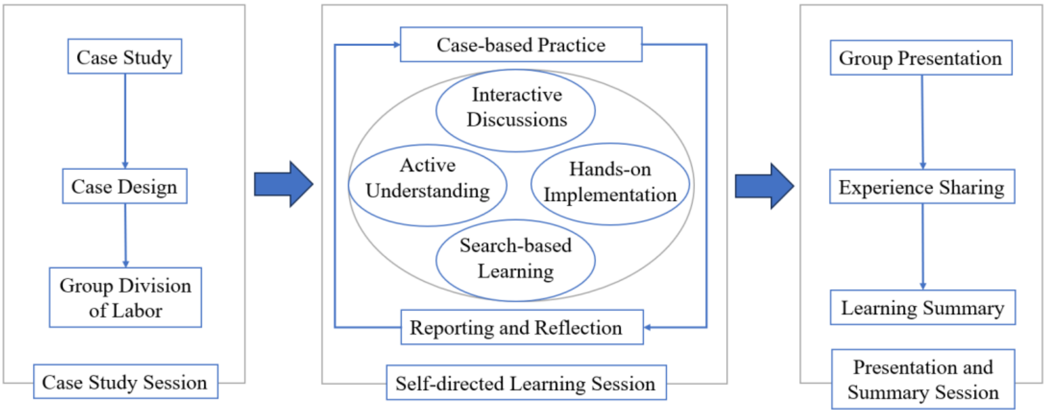

Figure 1: Theoretical and practical integrated teaching system.

Building upon the established teaching system for the “Introduction to Intelligent Medicine” course, this research explores the implementation of PBL in the design of basic confirmatory experiments and independent design experiments. Guided by project standardization management, the course design comprises several instructional steps:

1) Project Identification: Under the guidance of the teacher and following the experiment teaching guidelines, students select topics through data search and discussion. They identify intriguing, exploratory, academical and practical issues and topics. The suggested topics are aligned with medical research and strive to correspond with advancements in intelligent medicine.

2) Group Activities: Students complete the Solomon Learning Style Inventory questionnaire to determine their learning styles. Based on the surveying results, active learners are chosen as group leaders. They then autonomously form study groups comprising 2-3 classmates, coordinating task assignments within each group.

3) Planning: Each group discusses and determines the research questions and methods for their respective projects, formulating a research plan, outlining project requirements, and presenting their plans to teahcers. They receive feedback from teachers regarding the societal value and feasibility of the project, subsequently modifying and refining their research plans.

4) Implementation of Plans: Following the established project plans, students execute data collection, choose machine learning methods for data analysis, and engage in data preparation, processing, model construction, and model evaluation. The obtained conclusions are then thoroughly discussed.

5) Report Writing: Upon completion of the project design, each group individually begins writing the project design report following a specified format. Subsequently, one team member consolidates

the individual contributions, and the group engages in discussions to enhance and supplement the content while ensuring a unified writing style. According to the project design and report, teams create PowerPoint (PPT) presentation slides.

6) Presentation and Demonstration: Following an introduction to the background of their research projects, each group sequentially presents the outcomes and provides statements. They showcase project effects and respond to questions from other groups. Subsequently, teams collaborate to further refine their reports based on feedback received during the presentations.

7) Project Evaluation: Initial self-assessment and peer evaluations take place among groups. Finally, the teacher provides a comprehensive evaluation of each group's outcomes. The teacher engages in discussions with students about the research background, research advancement and challenges encountered during the study. This discussion aims to deepen students' understanding of data intelligence analysis related to the identified problem. Positive aspects are commended, shortcomings are highlighted, and future improvement directions are clearly outlined.

Table 1: Teaching Process Allocation

Chapter	Theory	Practice
Introduction	Introduction to Artificial Intelligence and Machine Learning	
Data reparation of clinical data	Data quality verification methods, data distribution statistical methods, methods for handling missing and outliers in data, and methods for data merging	Data preparation of diabetes data and completion of experimental report
Feature engineering of clinical medical data	Feature transformation and feature selection	Feature engineering of diabetes data, completion of experimental report
Establishment and evaluation of clinical medical models	The concept of supervised learning and common algorithms	
	Construction and evaluation of regression models	Practice of diabetes genetic risk analysis
	Construction and evaluation of classification models	Practice of diabetes category prediction
Independent case design and practice		Independent case design and practice
	Group presentation	

The allocation of theoretical and PBL components of the "Introduction to Intelligent Medicine" course is presented in Table 1, showcasing a concurrent deployment of theoretical and practical segments. The theoretical segments systematically expound upon the theoretical knowledge of the corresponding topics in the "Introduction to Intelligent Medicine", including fundamental concepts of machine learning, the disciplinary significance, and specific applications. Within the exposition of principles for data analysis, several case studies about clinical medicine are interspersed. Through practical analysis of these cases, students can obtain better grasp of theoretical knowledge. According to the content of theoretical lectures, the datasets relevant to medical themes are selected by students. They then design corresponding case objectives, progressively executing a series of data analysis processes, including data preparation, feature engineering, model construction, and model evaluation. Through this structured approach, students can acquire a fundamental understanding of methods employed in medical data mining.

3.3. The process of teaching model

The experimental group and the control group have an equal number of instructional hours. In comparison to the control group, the experimental group incorporates additional PBL segment. Specifically, within the "Case Discussion" theoretical instruction, group presentations and discussion sessions were introduced to the experimental group. Unlike traditional methods where theoretical and practical classes are taught separately, the theoretical and practical classes in the experimental group are integrated. Following the explanation of intelligent medicine theoretical methods, corresponding practical content is arranged, enabling students to apply widely used programming tools for processing and analyzing medical data. This approach is beneficial for students to further comprehend and reinforce theoretical concepts.

The content of theoretical instruction closely aligns with the learning topics designed for PBL. Classic discussion topics and project cases from years of teaching experience are analyzed, emphasizing both the role of artificial intelligence technology and the integration with medical research in PBL themes. Through group presentations, case studies, and discussions, the teaching model shifts from a "teacher transmitting knowledge unidirectionally to students" to a "bidirectional interaction between teachers and students." This approach emphasizes interaction with students, stimulates their thinking, encourages independent learning, questioning, debating, and reflection, promoting active thinking, communication, and deepening the understanding of knowledge points.

4. Results

4.1. The evaluation of the course

Both the experimental and control groups employ a formative assessment approach, with course grades comprising 70% for regular assessments and 30% for learning outcomes. Based on actual teaching activities, there are variations in the composition of regular assessments, as detailed in Table 2. In comparison to the control group, the course evaluation in the experimental group comprehensively covers the entire learning process, allowing for a more thorough and continuous tracking and reflection of student learning outcomes.

Table 2: The Composition of Testing Sore

Group	Composition of testing score
Control Group	Attendance (20%), Classroom discussion and communication (20%), Practice (30%), Learning report (30%)
Experimental Group	Attendance (10%), Classroom discussion and communication (15%), PBL and group presentation (25%), Practice (30%), Learning reports (20%)

4.2. The comparison of results

Table 3: The Comparison of Results

Group	Statistics			
	Number	Mean	S.D.	P-value
Control Group	100	80	6.625	0.028
Experimental Group	100	82.42	3.299	0.031

Using the mean ± standard deviation format, statistical descriptions were applied to the students' performance. The scores in both groups exhibited a normal distribution. An independent samples ttest with a significance level of 0.05 was conducted. The course grades of the experimental and control groups were analyzed using SPSS software. The average score and standard deviation for the experimental group were (80 ± 6.625), while for the control group, they were (82.42 ± 3.299). There was a significant improvement in the performance of the experimental group ($P < 0.05$), as shown in Table 3.

4.3. The comparison of feedbacks from students

The students in the experimental group universally provided feedback indicating that they completed the course learning in an active manner within the blended learning mode. Through discussions and exchanges in the theoretical and PBL (Problem-Based Learning) sessions, as well as practical activities, they formed a deeper understanding and appreciation of the knowledge covered in the course. In contrast, the majority of feedback from the control group indicated that they engaged in learning passively, and there was a relatively quick forgetting of the course content after its conclusion.

5. Discussion and Conclusion

5.1. Reforming the Traditional Theoretical Teaching Model

The teaching model of “Introduction to Intelligent Medicine” is relatively monotonous, typically composed of theoretical and practical teaching components, with a significantly greater emphasis on theoretical class hours compared to practical ones. Within the theoretical teaching process, the instructional approach tends to be unvaried and somewhat dull, often following a traditional classroom teaching model where teacher-led theoretical lectures take precedence, supplemented by passive listening from students. Furthermore, the course contains a substantial amount of conceptual and framework-oriented knowledge. The utilization of the mentioned teaching model often results in the awkward situation of teachers resorting to "cramming" and engaging in a monologue. This approach fails to stimulate students’ interest in learning, leading to challenges in retention, and a superficial understanding of the content even after attending the theoretical lectures.

In this educational reform, the teaching model in the theoretical component is initially altered. The instructional content is designed based on the characteristics of clinical professions, progressing from basic to advanced concepts. This approach aims to help students better understand the knowledge structure and application directions of the course.

5.2. The introduction of the PBL Teaching Model

The problem-based learning (PBL) [10], transforms the traditional role of lecturers into facilitators and guides, shifting the classroom focus from teachers to students. Consequently, the classroom becomes student-centered, where students autonomously learn by summarizing learning objectives based on presented problems. Due to variations in students’ knowledge accumulation, learning styles, and levels of understanding, the learning objectives they derive may deviate from the teacher’s anticipated objectives, but the two are not contradictory. The introduction of pre-class preparation aids students in acquiring fundamental knowledge, allowing them ample time during class to contemplate key issues. In the classroom, teachers assist students in thinking critically, summarizing, and refining common ideas into shared learning objectives, while addressing personalized questions raised by students. Once students establish learning objectives, they engage in independent learning activities, such as exchanging ideas, searching for information, and gaining insights from relevant materials. This approach effectively stimulates interest and initiative in learning, fostering critical thinking skills and a lifelong learning mentality.

5.3. The addition of project-driven practical cases

Due to the emphasis on informatization practice in “the Introduction to Intelligent Medicine” course, multiple project-driven practical cases corresponding to theoretical teachings have been designed. The purpose of these practical projects is to guide students in translating theoretical knowledge into practical applications, thus fostering a deeper understanding of the principles and significance of theoretical knowledge [11]. The practical project on genetic risk analysis for diabetes is specifically tailored to students with a clinical background. It aims to analyze the risk of diabetes using various machine learning models based on patient’s diagnostic information.

For students in the field of clinical medicine, who possess a rich knowledge base in medical expertise, their proficiency in information and computer technology is relatively limited. Therefore, it is essential to provide students with complete program codes and thoroughly explain the usage and meaning of the programming tools. This is done to alleviate the learning difficulty, allowing them to intuitively grasp the significant role of machine learning technology in medical data processing. The goal is to facilitate their understanding of the process of intelligent analysis of medical data and appreciate the crucial role played by machine learning in the field.

5.4. Limitations

Although both the experimental and control groups utilize formative assessment methods, the composition of grades is not entirely identical, which may have some impact on the final scores. The addition of group presentations, classroom discussions, PBL, and practical segments requires active student participation. In essence, this can reflect students’ attendance and demonstrate their learning outcomes. Therefore, a reasonable reduction in the “attendance” percentage is justified.

Furthermore, the implementation of the proposed hybrid teaching model will face certain challenges during its promotion. Typically, PBL is suitable for small class sizes, and practical sessions often require access to computer labs or simulation training rooms, both of which impose strict limitations on the number of students. Addressing how to effectively apply PBL and practical concepts to promote student learning in situations with a larger student population or in the context of large class sizes requires careful consideration.

5.5. Conclusion

The “Introduction to Intelligent Medicine” is a course at the intersection of information science and medicine, featuring an extensive knowledge base and a complex conceptual framework. In order to enhance students’ learning experiences in comprehending the course content, this study has devised a hybrid teaching model combining Problem-Based Learning (PBL) with a project-driven approach. The teaching results indicate that this model significantly promotes students’ independent learning. Through discussions and exchanges in theoretical, practical, and PBL segments, along with hands-on activities, students develop a profound understanding and appreciation of the course material, leading to notable academic achievements.

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