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Integrating artificial intelligence into interdisciplinary technology courses to explore sophomores' effectiveness of problem-based learning

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ABSTRACT

Artificial intelligence (AI) is integrated into the interdisciplinary technology course to explore sophomores' effectiveness of problem-based learning (PBL). This study aims to evaluate their performance in subject learning and understand their problem-solving abilities so that teaching becomes more diverse and learning becomes more meaningful. Based on this, this study designs teaching materials for applying AI in interdisciplinary technology and PBL as a teaching method to explore their performance in integrating AI into PBL (AI-PBL). The research results show the following three points: (1) teaching material construction is conducive to the formation of conceptualization, training reasoning ability, knowledge development and accumulation of subject knowledge, (2) effective auxiliary tools can help students explore problems, demonstrate problem-solving skills and cultivate reasoning ability, and (3) students can participate in and practice this immersive activity more meaningfully, enriching their learning content and broadening learning horizons. In summary, this study found that the AI-PBL immersive teaching method has positive learning effectiveness in supporting the practical solution of AI situational problems.

Keywords: artificial intelligence, interdisciplinary technology, problem-based learning, effectiveness

INTRODUCTION

As we all know, the 21st century is an era of emerging technologies and technologies. Creativity and new industries are rising rapidly. Artificial intelligence (AI), the Internet of things, and 5G are quietly entering everyone's life circle. In tandem with the development of AI technology, the social field's applications are expanding in diversity and possessing human-like skills such as self-correction, learning, adapting, and solving complex problems (Chen et al., 2023). AI seems to have become a contemporary emerging technology and continues to shine, and upgrade students' interest in AI social applications. However, when AI becomes the core weapon of the fourth technological revolution in the new century, talent training has become a positive issue in today's education (Su, 2021). Education plays a critical role in shaping individuals who can cope with future challenges of life. As the foundation of human development, education transmits and develops skills, values, and character, thereby supporting the progress of individuals and society (Brighouse, 2024).

To use AI in various environments, such as education, business, and industry. AI has shown steady development in diverse fields, such as text, images, audio, video, and other forms of media (Law, 2024; Lim et al., 2023; Pasick, 2023; Toner, 2023). Accordingly, integrating AI technologies into interdisciplinary knowledge and activating course learning strategies will help improve students' behaviour engagement (Huan, 2018; Yan, 2023). Instructional design and methods is a multidisciplinary field that integrates many interrelated knowledge fields, such as education, psychology, technology, and design. Instructional design is dynamic and constantly evolving (Sharif & Cho, 2015; Wang et al., 2021). Due to the constant changes in modern technology, teachers in various fields are responsible for creating effective and efficient learning experiences, such as designing, developing, evaluating and managing teaching materials and methods for learning environments (West, 2018). However, some scholars (Fan et al., 2024) hold another view, pointing out that AI may reduce students' cognitive engagement with learning materials, thereby reducing cognitive effort and inducing meta-cognitive inertia. Therefore, it is more important to find effective teaching methods.

Integrating AI technologies into appropriate teaching methods is a positive learning strategy that will help improve their learning performance (Huan, 2018). Problem-based

learning (PBL) is a student-centered teaching method where students learn from relevant and interesting problem structures, enhance their learning motivation, and promote the practice of teaching and learning skills, thereby improving their academic performance (Mundilarto, 2018). This teaching method has received widespread attention from educational scholars (Sakir & Kim, 2020). Syadiyah et al. (2017) pointed out that PBL can enhance their learning motivation and cultivate a teaching model that focuses on skill practice (such as problem-solving skills), thereby improving their academic performance.

In summary, this study will design teaching materials for AI interdisciplinary technology and use PBL as a teaching method to explore students' performance in integrating AI into PBL (AI-PBL).

Research Purpose and Question

AI is integrated into the interdisciplinary technology course to explore the teaching effectiveness of PBL. It aims to evaluate students' performance in subject learning and solve the focus of teaching problems, making teaching more diverse and their learning meaningful. Based on this research purpose, this study attempts to solve the following questions:

1. How to construct AI-PBL teaching materials for life situation experience in the interdisciplinary technology course?
2. What is students' learning performance in integrating AI-PBL teaching materials into the interdisciplinary technology course?
3. What is the feedback analysis of students after AI-PBL interdisciplinary teaching?

LITERATURE REVIEW

Artificial Intelligence

The definition of AI, scholar Lai (2016) pointed out that human intelligence (HI) (such as perception, learning, memory, knowledge, semantics, reasoning, language and thinking) is realized on computers, and through machine learning, it effectively transformed so that computers can practice HI. After some twists and turns, AI has made breakthrough progress in face recognition, autonomous driving, language learning, etc. (Su, 2022). With the development of AI around the world, AI seems to have become a contemporary prominent subject, and the topic continues to stimulate students' interest in the social application of AI. The application of AI in education is becoming increasingly diverse, including scientific research, health and safety, public domain, marketing, advertising, criminal justice, financial services, transportation, agriculture, etc. (Rihtaršič et al., 2016).

University teaching practice is an important activity that educational researchers focus on maximizing student engagement (Harbour et al., 2015). Smith and Baik (2021) identified nine categories of instructional strategies for high-impact teaching practices in higher education, including self-regulation, interaction and relationships, research, application, experience, obstacles, relevance, and clarification. Teaching techniques are critical in increasing students' attention, involvement, learning, and academic accomplishment (Vercellotti, 2018). However, AI education makes it difficult for most students to learn knowledge (Benetti, 2012). These problems are closely related to students' learning literacy and social science cognition. The impact of AI technology issues has become a new trend. Based on this, generative AI practice combined with PBL (Su, 2022) has become a guideline for students to learn AI technology.

Problem-Based Learning

PBL is a problem-based collaborative learning method that is learner-centred and attempts to guide students to solve problems in simulated situations to acquire new knowledge (Syadiyah et al., 2017). In the mid-1960s, Canadian medical educator Howard Barrows (Torp & Sage, 2002) devised this strategy and proposed a student-centred teaching model to guide students. Lapuz and Fulgencio (2020) found that PBL originated from constructivist theory and constructs new knowledge in expertise's initiative and critical nature.

PBL differs from other methodologies by using poorly organized issues as settings to help elucidate difficulties, plan independent learning, propose solutions to the problem, review the solution to the problem, and submit final reflection feedback in six steps (Lee & Bae, 2008; Su, 2022), which stimulates learning motivation and activates learning problems to start their learning, thereby improving knowledge cognition. Therefore, in the PBL learning process, students play the role of problem holders, learn collaboratively and discuss topics, resource utilization, information collection and new knowledge application in groups, conceive solutions to problems and evaluate solutions. The teacher plays the cognitive coach, promoter, assistant and consultant to help complete the task.

The application of the PBL teaching method in participants' learning helps to assist in problem-solving and evaluation skills and deepens their understanding of science courses (Jansson et al., 2015; Yoon et al., 2014), significantly promotes their subject learning process and learning outcomes (Gunter & Alpat, 2017), combines different course topics to obtain meaningful learning experience (Rillero & Chen, 2019), and has learning potential in solving practical environmental problems (Hernández-Ramos et al., 2021).

In summary, this study uses the PBL teaching method to design AI life-oriented hospitality technology teaching scenario teaching materials as a topic for classroom group discussion to understand learners' learning effectiveness after practice.

METHODOLOGY

Participants

Forty-four second-year students enrolled in the interdisciplinary technology course, aged 21-22, from a university of science and technology in northern Taiwan, 31.8% of whom were male and 68.2% were female. Five students volunteered to participate in the interview, including three females and two males.

Research Design

Our AI teaching strategy incorporates science, technology, engineering, mathematics, and design into interdisciplinary learning. Participants in interdisciplinary learning must use PBL group discussions before allowing Chat GPT to build its own rules and make conclusions based on enormous amounts of scientific data. Encourage participants to create models for controlling robots and how to make robots correctly execute human thought. Encourage engineering students to design concepts such as AI trip planning services, accurate travel navigation, self-service automatic billing vending machines, unmanned stores, etc. These activities combine to achieve the purpose of AI-PBL learning.

A 7-week university interdisciplinary technology course on AI-PBL consists of two 50-minute courses each week. For the first three weeks, we taught students about basic AI principles, identified learning difficulties in AI education, and laid the framework for their use in interdisciplinary technology course implementations. All students were divided into eight groups and began working on their AI design projects over the next four weeks. To encourage students to look for AI content (such as Chat GPT) from the fourth to the sixth week to fulfil their curiosity and to explore and learn from group questions to create basic AI knowledge (Chan, 2022).

Throughout the five weeks, encourage PBL, active learning, and teamwork. Students apply their prior knowledge to assess the facts regarding the AI process. They gather huge groupings and search for AI information to solve problems. They might begin researching and thinking about AI for themselves. Use AI-PBL exercises to promote interdisciplinary learning and the development of higher-level talents and attitudes, allowing students to successfully traverse any potential learning challenges and complicated concerns in interdisciplinary technology courses.

In the final week, students integrated their generative AI application and scientific principles learned through ChatGPT with their AI-PBL learning outcomes. By applying the AI-PBL learning framework to solve interdisciplinary real-life problems, while also addressing logical deficiencies and fostering team dynamics, ChatGPT is a valuable tool for enhancing students' learning experience (Kasneci et al., 2023). Using ChatGPT can provide personalised support and leverage the interactive learning advantages of AI applications (Huallpa et al., 2023). During the seventh week, each group presented their final work and provided "give back and reflect".

Research Procedure

The research steps of this study are in **Figure 1**. In **Figure 1**, first, students are informed of the research objectives and understand the research risks. By combining and evaluating the literature on AI-PBL topics, the second step is to determine the study topic. The third is the design of PBL generative AI life scenario experience teaching resources. The fourth is the development of AI-PBL learning performance evaluation tools. Following their integration into the AI-PBL learning environment, students are requested to fill out the AI-PBL learning performance questionnaire as part of the preparation for the interdisciplinary technology course, followed by random sampling interviews, data statistical analysis, and data processing by ethical standards and following the university academic research guidelines, which stipulate confidentiality and objectivity (Su, 2024; Taber, 2014).

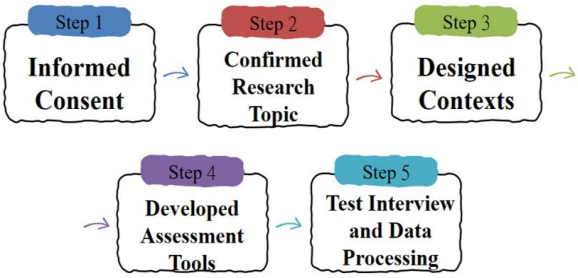

Figure 1. Research procedures flow (Source: Author's own elaboration)

Development of Assessment Tools

Learning performance questionnaire of AI-PBL, this study presents quantitative and qualitative information and explores students' creativity in learning interdisciplinary technology courses. The evaluation tools include the learning performance questionnaire and semi-structured interviews of AI-PBL in interdisciplinary technology courses. This study developed a learning attitude questionnaire to evaluate students' learning performance. The PBL attitude questionnaire created by the author serves as the foundation for the research questionnaire (Su, 2022). This structured learning attitude questionnaire uses a Likert five-point scale, with options including strongly agree, agree, average, disagree, and strongly disagree, from five points to one point.

The questionnaire extracts three aspects, namely, course materials, teachers, and learning, from six subscales to provide dependent variables of the learning attitude questionnaire. Bartlett's sphericity test is significant, showing that factor analysis is appropriate for the attitude questionnaire for structural validity. The three subscales of learning attitude include: Qa, attitude towards AI-PBL courses; Qb, attitude towards AI-PBL teachers; Qc, attitude towards AI-PBL learning environment; the overall mean (M) of the questionnaire is 4.542, the standard deviation (SD) is .039, and the Cronbach's α value is .957. The reliability coefficients of all scales are over .900, and the internal consistency of the table is excellent (Salta & Tzougraki, 2004). The final questionnaire of this study contains 13 Likert five-point scale test items. Extracted item 1, this immersive course material will help me improve in the future.

Semi-Structured Interview Questionnaire

This study refers to the semi-structured thematic questionnaire of the author (Su, 2024) and designs three interview topics. For example, in topic 1, using the PBL method to teach AI situational problems, is the course material design helpful to you? Can you give a specific example to illustrate your feedback? Topic 2: Does PBL's problem-solving method help you apply AI to daily life? Why? Please provide an example. Topic 3: What is your overall aspiration about using PBL for AI teaching? Why? Can you give an example to describe your thoughts? This study adopted these three topics

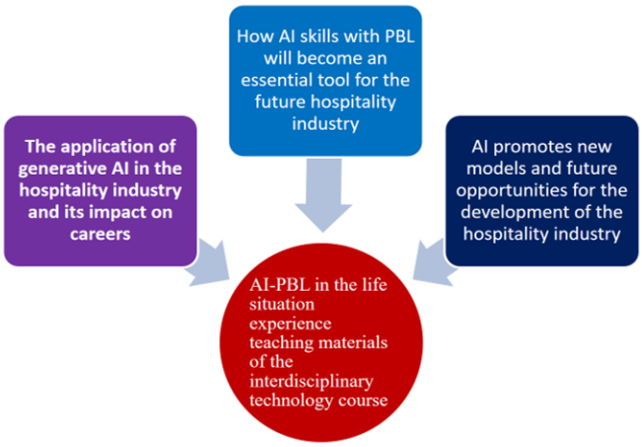

Figure 2. AI-PBL course experience teaching material architecture (Source: Author's own elaboration)

to make up for the shortcomings of the structured attitude questionnaire and try to understand the feedback and reflections of participating students. After completing integrated instruction and administering the questionnaire, five students (three girls and two boys) conducted semi-structured thematic interviews. Interview participants were randomly and willingly coded, with males assigned SM01-SM02 and females assigned SF01-SF03.

Data Analysis and Ethical Considerations

The questionnaire for this study, the AI-PBL learning performance questionnaire in the practice of interdisciplinary technology course, finished after the participants provided informed consent. After the AI-PBL integrated learning, the participants filled out the questionnaire anonymously and accepted the interview. Applied Arabic and English codes to the gathered questions and complied with ethical considerations. The statistical methods used included descriptive statistics, Cronbach's α statistical analysis and SPSS for MS Windows 25.0 software for statistics.

RESULTS AND DISCUSSION

AI-PBL Experience Teaching Materials

Figure 2 reveals the AI-PBL life scenario experience teaching material framework diagram in the interdisciplinary technology course. The construction of AI-PBL teaching materials in the life situation experience of the interdisciplinary technology course aims to help students actively conceptualize (Shemwell et al., 2010) and improve their reasoning ability (Sonnleitner et al., 2013). According to the research of Lopez et al. (2014), the construction of interdisciplinary teaching materials in AI-PBL situation experience is the basic cultivation of participants' knowledge development and accumulation of subject knowledge. The teaching material design goals of **Figure 2** are three:

(a) to let students understand the application of generative AI in the interdisciplinary field and its impact on careers,

(b) to discuss how AI skills will become a necessary ability in the future interdisciplinary technology industry, and

Table 1. Learning performance of AI-PBL teaching materials integrated into course practice

Aspect	Content	M	SD
Qa	From context	4.565	.015
Qb	From teacher	4.545	.075
Qc	From learning	4.516	.088
Overall		4.542	.039

(c) to explore how AI can promote the development of new models and future opportunities in the interdisciplinary technology industry.

Based on this framework, the AI-PBL experience teaching material content is designed and shown in **Figure 2**.

Teaching material of textbook (I) lets each group of hospitality students discuss the difference between AI and HI. Types and development history of AI? The application of generative AI in the interdisciplinary technology field? How do each group of students plan their future careers to link with AI?

Textbook (II) allows each group of students to discuss the AI skills necessary for the hospitality industry, such as big data analysis, data integration, text mining and natural language processing, etc.; textbook (III) hospitality students are divided into groups to discuss how AI can develop new models to enhance the development of the interdisciplinary technology industry and future opportunities. Robots provide new models such as hotel reception, customer service, tourist outlets, tourist navigation, tourist services, cooking and smart restaurants.

Learning Performance

Table 1 will display the learning results and performance of the AI-PBL instructional materials included in the interdisciplinary technology course practice. There are three aspects to investigate their learning performance. In aspects Qa, attitude towards AI-PBL courses; Qb, attitude towards AI-PBL teachers; and Qc, attitude towards AI-PBL learning environment, are assessed using ideas and descriptive statistical analysis. **Table 1** revealed that within the questionnaire's first aspect (Qa), from the Likert five-point scale statistical analysis, the average value (M) of the overall dimension Qa was 4.565 (SD, .015), which is higher than the literature value of 3.500 (Su, 2018). In other words, 91.3% of the participants believed that the depth of the teaching material content was moderate. This AI-PBL integration course is an interdisciplinary technology course that meets the research objectives of this study; in the second dimension (Qb), 90.9% of the participants thought that the teacher was competent for this integrated course; in the third dimension (Qc), 90.3% of the participants believed that the integration of teaching materials was conducive to learning.

Su (2018) pointed out that auxiliary tools can help students explore problems, demonstrate problem-solving and develop reasoning skills. Sonnleitner et al. (2013) emphasized that students' problem-solving ability is related to reasoning ability. Sadler et al. (2016) also found the importance of contextual problems in PBL teaching methods. The basic cultivation of knowledge development and accumulated subject knowledge can improve their thinking and decision-

making abilities, generate new insights driven by AI-PBL technology, and help improve learning performance in course practice.

Students' Learning Feedback

Using thematic interviews to assess students' feedback. In this research, students were randomly selected for interviews. After completing the post-test, the teacher randomly selected five students from the students and interviewed them with their consent. The teacher plays a guiding role in the interview process, enabling the interviewee to articulate their ideas clearly and smoothly. The findings from the interviews with five students are as follows:

Theme 1. Using the PBL method to teach AI situational problems, is the course material design helpful to you? Can you give a specific example to illustrate your feedback?

> Students SF01 and SM01 believe that the textbook guides them to think and learn about AI, from listening to the opinions of their peers and encouraging each other to communicate and to learn, which helps to solve problems in a modular way and stimulates their interest in learning artificial intelligence. Students SF02, SF03, and SM02 believe that using the PBL method to teach AI situational problems allows us to understand the development, origin and importance of artificial intelligence and helps collect information related to artificial intelligence. For example, robot applications in hotels, medical treatment and food production enrich the content and expand the learning horizon.

Theme 2. Does PBL's problem-solving approach help you apply AI to your daily life? Why? Please give examples.

> The five interviewed students concurred that group discussions and questioning facilitate individual thought, clarify problems, and transition responses from divergent to convergent. For example, applying ChartGPT questioning techniques and employing the PBL approach to problem-solving in group discussions can help improve logical thinking skills, generate content that allows the AI to accurately respond to questions, and complete the course learning process, fostering problem-based learning.

Theme 3: What are your thoughts and feelings on the use of PBL in AI education? Why? Can you give an example to describe your thoughts?

> Three interviewed students (SF01, SF03, and SM01) pointed out that the application of AI in hotels has helped students find a PBL learning model. They are curious about how to learn to get along with emerging technologies as they progress. As a result, they are shocked and concerned about the increased employment pressure that artificial intelligence would put on upcoming hotel management. SF02 and SM02 found that we cannot underestimate the contribution of PBL collaborative learning. This teaching method allows us to appreciate new things like facial recognition systems, self-driving cars, and robots. Despite getting more multidisciplinary information, it also lets us see how learning differs from previous lecture-based courses.

This immersive learning, using AI-PBL technology to find solutions to problems, helps improve logical thinking skills, enrich learning content and expand learning horizons, and enables students to participate and practice more meaningfully to achieve the purpose of problem-solving (Mayer, 2011; Mundilarto, 2018). The application of semi-structured interviews can indeed make up for the shortcomings of structured questionnaires. Based on this, this study found that the PBL teaching method has great potential to support the practical solution of AI situational problems (Hernández-Ramos et al., 2021).

CONCLUSIONS

In response to research question 1, How to construct AI-PBL teaching materials for life situation experience in interdisciplinary technology courses? The teaching materials are conducive to the formation of conceptualization, training of reasoning ability, knowledge development and accumulation of subject knowledge in this study. As a response to research question 2, how well do students learn when interdisciplinary technology courses use AI-PBL teaching materials? The auxiliary tools can help students explore problems, demonstrate problem-solving and cultivate reasoning skills. Participants generate new insights driven by AI-PBL technology, which helps to improve their learning performance in course practice. In response to research question 3, What is the feedback analysis of students after AI-PBL teaching? Students can participate in and practice this immersive activity more meaningfully, enriching learning content and expanding their learning horizons.

Suggestions

In conclusion, this study found that the AI-PBL developed in the construction of life situation experience teaching materials in the interdisciplinary technology course is helpful to improve the course practice and their learning performance. However, there are still some limitations to the inference. Recommendations will be given on instructional strategies and future study designs to make the conclusion more thorough:

1. Suggestions on AI-PBL teaching practice: In the teaching practice suggestions, integrating AI-PBL into the field of interdisciplinary technology should increase its practicality so that participants can fully understand AI and PBL teaching methods and effectively improve the learning efficiency of the experiencers.
2. Suggestions for the design of subsequent AI-PBL research: Future research design recommendations: Given the small number of samples examined in this study, caution is necessary to draw more general conclusions. Future studies should be able to successfully expand the number of samples, improve the research's depth, and boost learners' efficacy.

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Ethical statement: The author stated that the study does not require any ethical approval. This study complied with the strictest ethical guidelines for scientific investigations. Additionally, the author noted that the participants were fully informed about the project's objectives and methodology. They could refuse data collection at any time without giving a justification.

AI statement: The author stated that no generative AI was used in any part of this study.

Declaration of interest: No conflict of interest is declared by the author.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the author.

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