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IMPLEMENTATION OF INNOVATIVE ARTIFICIAL INTELLIGENCE COGNITIONS WITH PROBLEM-BASED LEARNING GUIDED TASKS TO ENHANCE STUDENTS' PERFORMANCE IN SCIENCE

King-Dow Su

Abstract. *This research conceived multi-variate learning concepts and aimed at the implementation of integrating artificial intelligence (AI) life learning of face recognition, self-driving, and robots' situational issues into problem-based learning (PBL) in natural science. This research put forward problem-solving and group cooperation in which students worked together to complete learning tasks from encountering problems to planning problem-solving. All 127 participants engaged in this research from the Hungkuo Delin University of Technology in Taiwan. 7 experts helped construct the content validity, construct validity, and reliability through instrument developments of 5 open-ended test questions and 31 learning attitude items. The statistical analyses revealed that those students improved their scientific cognitive skills of problem-solving by quantitative analyzes and presented their logical reasoning and activation ability by qualitative ones. In addition, the descriptive statistical analysis of learning attitude revealed that students had positive thinking attributes for the application of cross-disciplinary PBL and AI new knowledge. These findings had implications for the AI cognitions with PBL educational environment to increase innovation in the classroom. Pedagogical suggestions presented that students' learning growth in the environment requires long-term cultivation to exhibit significant learning outcomes in the future.*

Keywords: *artificial intelligence, cross-disciplinary, problem-based learning, situational issues*

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Introduction

As we all know, the 21st century is an era of emerging technologies and creativity, and new industries are rapidly emerging. Artificial Intelligence (AI), the internet of things (IoT), and 5G are quietly entering everybody's circle of life. The application of AI in the social field is becoming more diversified, such as transportation, agriculture, scientific research, health and safety, public domain, virtual reality and augmented reality, marketing, advertising, criminal justice, financial services, etc. With the development of global AI, AI seems to have become a contemporary science and continues to light up students' interest in the AI social application. Therefore, AI acts as an evaluation tool for an application not only in the own field but also in cross-disciplinary (Rihtaršič et al., 2016). However, when AI has become the core tool of the fourth technological revolution in the new century, talent training has become a positive issue of discussion today (Su, 2021).

Furthermore, AI education research still has more limitations and challenges for the knowledge construction of most students in the field of integrating natural science teaching (Benitti, 2012). Therefore, some researchers (Altin & Pedaste, 2013; Sullivan & Heffernan, 2016) pointed out that a new pedagogy still needs to integrate more research and development, active AI learning strategies, and effectiveness in natural science. Accordingly, some advanced countries get involved actively in AI educational integration and positive research (Alimisis, 2013). Integrating AI emerging technologies into natural science learning is an activating learning strategy that will help improve their learning performance (Huan, 2018). The learning strategy is in proportion to their interests and has substantive needs to be selected. For example, problem-based learning (PBL) is a student-centered teaching method, which students learn from their relevant and interesting problem structure. PBL enhances their learning motivation and fosters a teaching and learning model of practical skills such as teamwork, problem-solving, self-discipline, and promoting their learning performance (Mundilarto, 2018; Syadiyah et al., 2017). This method has been paid much attention by educational scholars in various subjects of teaching and learning (Sakir & Kim, 2020).

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PBL is derived from the theory of constructivism and stresses the active and critical construction of knowledge based on prior knowledge (Lapuz & Fulgencio, 2020). It was developed in the mid-1960s by Howard Barrows, a Canadian medical educator (Torp & Sage, 2002), who proposed student-centered teaching to guide students. Mundilarto pointed out that the method prevails in domestic and international higher education and many subject areas. PBL allows students to develop a viable problem-solving plan, and then integrate theory and practice, apply knowledge and skills to explore the process of problem-solving, and learn how to learn (Sockalingam et al., 2011). Students play the role of problem holders in PBL processes. The educator acts as the cognitive coach or promoter to organize learning content and situational teaching by the ill-structured problem. Students discuss learning topics, use resources, collect information to learn and apply new knowledge, conceive problem-solving, and evaluate programs with the group cooperative learning.

Therefore, this research focuses on the effective integration of AI life learning of face recognition, self-driving, and robot situational issues into PBL in natural science. Three life situation issues of the social application provide the experience of authenticity problems, strengthen students' narrative ability, and problem-solving skills. Students' scientific knowledge experience is activated to enhance their cognitive understanding of learning effectiveness, evaluate their attitude, and conduct feedback analysis in an interview.

Application of PBL

PBL was a problem-based, student-centered approach to collaborative learning, which was also the principle of problem-based acquisition of new knowledge (Jansson et al., 2015; Syadiyah et al., 2017). What differentiates the PBL approach from other approaches were ill-structured problems as learning contexts in which students initiate learning by solving life problems, linking learning experiences, motivating learning, and activating learning problems to improve their knowledge. Yoon et al. (2014) and Jansson et al. (2015) proposed that PBL teaching methods could help students enhance their problem-solving and assessment skills and deepen their understanding of the science curriculum. Gunter and Alpat (2017) revealed that PBL had notable results for their scientific learning processes and achievements. Rillero and Chen (2019) also found that PBL could combine different curriculum themes with meaningful experiences. In addition, Hernández-Ramos et al. (2021) emphasized that the PBL approach offered learning potential in addressing real environmental problems in natural science education. Accordingly, this research used the PBL teaching method and designed the life teaching situation of AI application in society as the issue of classroom discussion.

Social Applications of AI

Lai (2016) defined AI as the effective transformation and realization of human intelligence, such as perception, learning, memory, knowledge, semantics, reasoning, language, and thinking, implemented on computers through machine learning. Ng (2016), Ricoy and Feliz (2016) revealed that AI could provide students with possible one-to-one teaching support to help problem-solving, learning judgment, and thinking of decisions. AI topics were cross-disciplinary integration and experience practice of emerging technologies. The generation and development of technological concepts were closely related to human life experience and social survival (Topcu et al., 2010).

The social applications of AI in life were becoming more and more diverse, such as face recognition, self-driving, robot, virtual reality, augmented reality, etc. In this era, how to enrich the social connotation of students' AI background knowledge and generate new insights from cross-disciplinary learning. However, emerging technological issues related to AI are gradually appearing in everyone's life. For example, discussions on the learning benefits of cloud technology education courses have received more attention from academics (Kaur & Rampersad, 2018; Rahman et al., 2017). Traveling long distances in driverless cars or buses would allow passengers to focus on business and increase productivity (Bansal et al., 2016; Nordhoff et al., 2017).

In addition, the face recognition systems were almost indistinguishable due to the technologies of generative adversarial networks (Hsu et al., 2020), and these problems were related to students' learning literacy and social science cognition. The impact of AI technology issues has become a new trend. Therefore, this research offered authentic insights into the PBL teaching method to construct AI teaching materials and develop an AI learning effectiveness questionnaire. All strategies were to evaluate their learning effect and attitude towards AI.

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Research Purpose and Questions

This research focused on evaluating students' science learning effectiveness and completing the teaching site focus of issues. They would make teaching more diverse, and learning becomes more meaningful. Based on the purpose, the responses to the following research questions:

1. How to construct AI-PBL experience teaching materials of life situations?
2. How to develop the validity and reliability of pre-test and post-test items and attitude questionnaires for assessment tools of learning effectiveness?
3. What were the influencing factors of students' learning attitude of cross-disciplinary experience through one-way ANOVA?
4. What were the feedback analyses after random interviews after AI-PBL teaching?

Research Methodology

General Background

In this research, the background included students' problem-solving guidance, data collection of learning effects, influencing factors of learning attitudes, feedback analysis, and presentation of AI-PBL textbooks. The contribution of this research came not only from group discussion, preparation, and response but also from the evaluation of teaching with more possible AI questions to suggest future research needs. The program lasted two hours of AI-PBL instruction per week, nine weeks in two semesters, for a total of 36 hours. Therefore, there was a limit to the impact on their scientific questions and learning attitudes. Research topics covered life science contextual issues such as face recognition, self-driving, and robots. All research results are needed to reveal AI-PBL research questions, teaching methods, group discussions, and learning assessments to build a positive learning environment and improve their scientific cognition. During the 2020 academic year, the students demonstrated the AI learning effect that followed the natural science learning objectives. Their experience learning from AI-PBL social application life situations enhanced their scientific learning effectiveness.

Participants

This research comprised 127 participating students who attended the author's course, screened in two stages of qualification tests, as a total study sample of university students in Taiwan. The participants included 70 males and 57 females, ranging in age from 20 to 22. The pilot test guided 44 Second-year students to engage in the research for the AI-PBL developments with the pre-knowledge at the first stage. Other 83 participants with high cognitive skills had attended this research with AI-PBL strategy at the second stage as the research sample. All 127 participants based on volunteering with suggestive results and the anonymous findings might publish in this research. All ethical considerations met with students' approval of experimental processes (Su, 2018) in this research. In terms of experts, seven professors engaged in this research, consisting of three science education scholars, two information education communication scholars, one humanities education scholar, and one AI education scholar. They logically revised and reviewed the intelligibility of the questionnaire draft and their suitability to the participant level to form experts' content validity.

AI-PBL Teaching Design

This research implements teaching innovation from student roles, teachers' vision, AI-PBL natural science teaching goals, and AI-PBL teaching materials design. The design of this research was based on the learning objective so that students can gain a profound understanding of the practical value of AI fundamentals and scientific knowledge, understand the new functions of AI in social applications, and the need for cross-disciplinary talents. They got hands-on and experienced new AI knowledge to enhance understanding, make decisions, and solve scientific problems facing around life. The PBL pedagogy was a student-centered collaborative learning method that creates an experiential learning situation step-by-step in the science classroom, allowing students to find learning opportunities and build self-competence. Teachers were the facilitators of their learning to facilitate and guide the experience of designing authentic AI social contextual life issues. In addition, the goals of the natural

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sciences could combine experiential texts and assessment questions to stimulate science learning and to judge right and wrong in the process. The AI-PBL teaching focus showed that students could use the PBL method to complete problem-solving tasks, strengthen the absorption and application of AI life science knowledge, and draw meaningful conclusions through AI-PBL teaching and group discussions.

It was more important to clarify the new knowledge they build on existing infrastructure and connect it to the prior knowledge to enhance their learning effectiveness. And the way of student achievement assessment included their self-assessment checklist and paper-and-pencil tests. In the grading checklist, 60% of the scales attempted to help group students to plan problem-solving and discussion, and paper-delivered examined to account for 40%. All scales included group self-assessment form, problem-solving plan form, member mutual evaluation form, work record form, resource record form, and learning outcome evaluation form. However, three PBL life situational issues of AI social application tried to integrate into the course, namely face recognition system, the social issue of self-driving, and AI robot functionality. The three situations activated the group discussion at the teaching site, and students could further put forward their needs for the course. The study took 18 hours (nine weeks) of AI-PBL instruction in the first and second semesters. In addition, this research used five open-ended questions to evaluate their learning effectiveness at the life-like level of AI social applications.

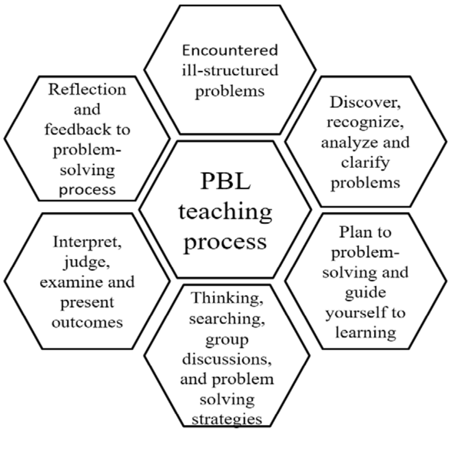
Research Design

In the PBL method, this research applied AI in the real-life social application context to conduct experimental teaching of natural science courses for general education. Students divided into six groups and discussed their learning process, problem-solving abilities, learning attitude, and feedback analysis. Table 1 reveals a PBL method design. The PBL teaching experimental process included an introduction, problem confirmation, data collection, group discussion and problem-solving demonstration, group results publication, and learning contribution evaluation. Figure 1 shows the PBL teaching process model (modified from Lee & Bae, 2008). There are six procedures in the flowchart. All steps include ill-structured questions, clarifying problems, planning self-directed learning, putting forward problem-solving, reviewing problem-solving, and presenting their final reflection feedback. Students immediately conduct the open-ended posttest and learning attitude questionnaire after the teaching experiment. Subsequently, 3-4 students are randomly selected for each group to make their perception and feedback analysis of the AI-PBL teaching.

Table 1
The Experimental Research Processes of the PBL Method

Group	Pre-test	Process	Post-test	Feedback
$E_1 \sim E_6$	Open-ended questions	PBL method	Open-ended questions	Attitude questionnaire and interview

Figure 1
The PBL Teaching Process Model



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Research Instrument

Through the development of surveying instruments and data collecting, the findings presented quantitative and qualitative data and discussed students' creativity in their learning in this research. The assessment tools included open-ended test questions, PBL attitude questionnaires, and semi-structured questionnaire interviews. This research designed five open-ended questions for their AI test items with the content validity of experts. Based on the opinion of experts, they suggested revising the readability, accuracy, and applicability of the instrument content to form the appropriate content validity. This research used these questions to evaluate their cognitive responses to the social application of AI in life and try to understand learning effectiveness. The open-ended test item scoring was modified from the criteria of Gunter and Alpat (2017), as shown in Table 2, and applies to this research according to the scoring criteria.

Table 2
The Scoring Criteria of Students' Responses for Open-ended Questions

Categories (Abbreviation)	Score	Content Description
Incomprehension (**I**)	0	This response is not related to the question.
Specific Misconception (**SM**)	1	This response is not true scientifically but is considered true by the student.
Partial Understanding with Specific Misconception **PUSM**)	2	The response is correct, but its explanation is wrong or inverse.
Partial Understanding (**PU**)	3	The response contains only some aspects, but not all aspects of the desired response.
Clear Understanding (**CU**)	4	The response to the question is accurate.

In the **PBL attitude questionnaire**, this research developed the learning attitude questionnaire to assess their perceptions, which included two parts: the first was about their basic background information, and the second was the structured learning attitude questionnaire of 5-point Likert scale, with options such as strongly agree, agree, neutral, disagree, and strongly disagree. Students' background information provided independent variables in the research. Besides, six subscales of the questionnaire offered dependent variables from the composition of the learning attitude questionnaire. The first draft test items were modified and revised from Su's (2016) questionnaire. All seven experts conducted the substantive review, revision, and deleted test items to confirm the validity of the content and surface of the questionnaire. A pilot test responded according to 44 students who took the science course and performed after the mid-term examination between November and December 2020.

However, in terms of the construct validity, Bartlett's test for Sphericity proved significant, indicating that the factor analysis was suitable for the attitude questionnaire. All six Eigenvalues were above 1.0 with an accumulative explained variation of 72% in the principal component analysis. Six subscales of learning attitude included: Q1, attitude towards AI situational problem-based learning (AI-PBL) courses; Q2, attitude towards teachers; Q3, attitude towards AI-PBL learning environment; Q4, attitude towards AI-PBL situational contexts; Q5, attitude towards self-learning of AI-PBL situational contexts, and Q6, attitude towards learning results of the AI-PBL situational contexts. Table 3 reveals the results of the pilot test. In Table 3, the overall questionnaire average (*M*) is 4.00, the standard deviation (*SD*) is .69, and the Cronbach's α value is .95. The coefficient reliability of any scale is over .90, and the internal consistency is excellent (Salta & Tzougraki, 2004). The final questionnaire, AIPBLQ, consisted of 31 test items in this research which were summarized as follows: Item 1, AI-PBL content, is justly the type of learning I want.

Aspect	*M*	*SD*	Cronbach's α
Q1	3.95	.67	.96
Q2	4.17	.58	.96
Q3	4.02	.74	.95
Q4	4.00	.86	.96
Q5	3.91	1.00	.94

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Aspect	*M*	*SD*	Cronbach's α
Q6	3.94	1.01	.96
Total	4.00	.69	.95

Students' Feedback

This research referred to the author's semi-structured questionnaire (Su, 2018) and designed three open-ended interview reference items. After the logical review and fluency modification of the above seven experts, they became three interview questions with content validity. Three interview questions, such as Q1: Using the PBL method to teach AI situational issues, does the textbook design help you? Can you give a concrete example of your feedback? Q2: Does the problem-solving method of PBL help you apply it in daily life? Why? Please provide an example. Q3: What is your overall evaluation and feelings about the use of PBL for AI teaching issues?

Why? Can you give an example to describe your thinking? Accordingly, this research used three questions to make up for the deficiency of the structural attitude questionnaires and attempts to understand students' feedback and reflection. After the post-test and structured questionnaire, 38 students engaged in semi-structural interviews randomly.

Data Analysis and Ethics

AI-PBL teaching pre-test and post-test management, the collected experimental data would be tested by computer code and Arabic numerals. Statistical methods contained Cronbach's α internal consistency of test questionnaires, descriptive statistical analysis, and one-way ANOVA. All statistical analysis came from SPSS for MS Windows 22.0 software. The consent of the students conducted data collection and analysis. The interview of students was represented by English letters, such as the first interview student code of the S1 form, to meet the requirements of academic ethics. All students volunteered and actively participated in this research. Students went to this research with their approval.

Research Results

Based on the constructive learning theory of Ausubel (2000), this research designed three topics for students to experience the social application context of the scientific content in the life of AI-PBL, to enhance their broader basic knowledge, understand social implications, and need AI cross-disciplinary, with AI life issues, designing face recognition systems, self-driving cars, and robots, guiding PBL multivariate learning environment. In face recognition systems, the contexts consisted of the generative adversarial network, visitor control, clothing design, interior design, solar car model design, and financial consumer payment. In self-driving cars, the contexts included the introduction of sensors, autonomous driving levels, technology development, the internet of vehicles, cloud computing, and other application fields. Furthermore, in robots, the contexts embodied applications in education, tourism, finance, retail, transportation, and healthcare. In summary, students could generate innovative thinking by cross-disciplinary to solve the problems encountered in life around.

This research attempted to develop a three-unit AI-PBL science experience textbook and to provide a profound understanding of AI in life. The instructor was both a facilitator and a mentor to achieve their authentic conceptual acquisition in class. Teachers used AI-PBL science experience materials to guide students in interactive learning and acquire scientific concepts. The students thought deeply about this three-unit AI-PBL scientific experience textbook to enhance the scientific concepts. Students practiced the problems encountered, the problem-solving plan, self-learning, and data collection. Their group discussion established a consensus on solving and proposing solutions to complete the problem-solving task. Appendix 1 summarizes group students' learning processes in AI life issues. In Appendix 1, their practiced presentations and

online discussions present the learning outcomes of the natural sciences classroom. Due to the impact of the Covid-19, part of the experimental teaching would conduct online simultaneously. The students were very interested in AI applications in life and actively presented the results of their discussions.

In terms of learning effect, students' learning in AI-PBL course, this research used open-ended test questions

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before and after to examine their learning effect and differences. They checked their answers to the open-ended test questions and accorded to the scoring criteria proposed by Gunter and Alpat (2017) and shown in Table 4. In Table 4, the statistical analysis describes the percentage of their responses. The results were as follows. The mean 0 points for the pre-test and post-test were 3.7% and 0%, respectively. Statistical results for students' answers showed that they had nothing to do with the questions, blanks, or incomprehensible (I) were all scored as 0 points. The average percentage of pre-test and post-test averages of 1 point was 29.2% and 15.7%, respectively. If the question response confirmed an incorrect scientific answer and presented the student as a specific misconception (SM), then awarded 1 point. The results showed that students decreased by 13.5% after the PBL instruction misconception. The average percentage of pre-test and post-test scores with a mean of 2 points was 58.2% and 67.8%, respectively. It indicated that the answer was correct but wrong interpretation, or wrong answer but correct explanations. These all showed partial understanding and a specific misconception (PUSM), awarded 2 points. The results showed PBL-guided teaching provided a partial answer with significant misconceptions that increased by 9.6%. The average percentage of pre-test and post-test averages of 3 points was 8.1% and 14.8%, respectively. If the answer to the question was only partially correct, indicating that the student has partial understanding (PU), get 3 points. The results showed that after PBL guided teaching, the number of students who answered partially increased by 6.7%. The average percentage of pre-test and post-test scores of 4 was 0.8% and 1.7%, respectively. If the question response showed accurate answers to the questions and showed that students clear understand (CU), get 4 points. The results revealed that after PBL guided teaching, students with a clear understanding increased by 0.9%, and the overall level of conceptual cognition improved.

Table 4

Students' Learning Effectiveness Response Percentage (%) for Five Open-ended Test Questions

Response	Test Item 1	Test Item 2	Test Item 3	Test Item 4	Test Item 5	Average
Level	post-test/pre-test	post-test/pre-test	post-test/pre-test	post-test/pre-test	post-test/pre-test	post-test/pre-test
I	0/7.4	0/5.6	0/3.7	0/1.9	0/0	0/3.7
SM	17.4/31.4	17.4/35.2	13.0/31.4	19.6/31.4	10.9/16.7	15.7/29.2
PUSM	65.3/55.6	58.7/50.0	67.4/55.6	67.4/63.0	80.4/66.6	67.8/58.2
PUSM	10.9/3.7	23.9/9.2	19.6/9.2	13.0/3.7	6.5/14.8	14.8/8.1
CU	6.5/1.9	0/0	0/0	0/0	2.2/1.9	1.7/0.8

The descriptive statistical analysis of their AI-PBL situational issues learning attitude questionnaire (AIPBLQ, effective recovery rate 82%) showed that the overall average of each subscale was 3.71, the standard deviation was .60, and the overall questionnaire reliability was .96. After the experimental teaching, all students participated in the test of the AIPBLQ structured questionnaire. This questionnaire evaluated their attitudes towards AI-PBL situational issues (Q1), attitudes towards teachers (Q2), attitudes towards multimedia learning environment (Q3), attitudes towards AI-PBL classmates (Q4), and attitudes towards AI-PBL students (Q4), attitudes towards self-learning AI-PBL courses (Q5), and attitudes towards AI-PBL course learning outcomes (Q6). This evaluation tool emphasized strategic application to examine their six subscales of learning attitude.

A series of one-way ANOVA statistical analyses presented the relations between dependent and independent variables. Six subscales acted as dependent variables in the AIPBLAQ evaluation tool. Then, independent included background information such as gender, enrollment method, the frequency of using 3C products, the degree of disposition toward AI courses, and AI-related knowledge they have learned. The Wilks' Lambda variable selection method adaptive test multivariate reached significance (p <.05). The results of one-way ANOVA are as follows in Table 5. In Table 5, the independent variable, gender for the six dependent variables of the AIPBLAQ, only the subscale of the attitude of AI-PBL classmates (Q4) is significant. In addition, females (M= 3.87) are better than males (3.47), Cohen's (1988) effect size, f is .264 above the medium (f= .25), other dependent variables have no significant difference, and Cohen's effect sizes are below medium.

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Table 5
Three Comparative Case Dispositions of Individual Learning Attitude in ANOVAs

locking Variable	Analysis of Variance	Attitude				Measure	
		Q1	Q2	Q3	Q4	Q5	Q6
Gender	*F*-ratio	.780	1.978	2.818	4.563	1.104	.608
1. males, 24	*p*-value	.378	.164	.098	.036	.297	.438
2. females, 44	*f*	.110	.173	.207	.264	.128	.095
Enrollment	*F*-ratio	5.315	2.699	3.043	1.786	2.137	2.25
1. Registration, 14	*p*-value	.001	.038	.023	.143	.087	.074
2. Recommendation, 6	*f*	.580	.413	.440	.337	.368	.378
3. Applying, 37	Scheffé	1>3; 5>3					
4. Stars, 7							
5. Other, 4							
Frequency	*F*-ratio	3.24	4.908	7.671	1.345	2.115	1.997
1. Never, 0	*p*-value	.076	.030	.007	.250	.151	.162
2. Occasionally, 4	*f*	.222	.272	.341	.143	.179	.173
3. often, 64							
Disposition	*F*-ratio	7.644	8.088	4.699	6.800	3.253	5.712
1. very positive, 17	*p*-value	.001	.001	.012	.002	.045	.005
2. Positive, 39	*f*	.484	.498	.380	.457	.335	.418
3. Neutral, 12	Scheffé	1>3	1>2; 1>3	1>3	1>2; 1>3	1>3	1>3
AI-related knowledge	*F*-ratio	3.079	1.115	1.409	1.324	3.247	3.084
1. Basic, 27	*p*-value	.034	.350	.248	.274	.028	.033
2. PYTHON, 13	*f*	.380	.229	.257	.248	.390	.380
3. None, 25							
4. other, 3							

In Table 5, the independent variable enrollment method is significant for the six dependent variables of AIPBLAQ. Attitude towards Q1, Q2, and Q3, and their Cohen (1988) experimental effect size *f*-values are better than .4. Furthermore, Scheffé post hoc comparisons found that only Q1 has a significant difference, and registration distribution is better than applying for admission, and others are better than applying for admission. The dependent variables Q4-Q6 are no significant differences. While the frequency of use of 3C products is another independent variable, among the six dependent variables of AIPBLAQ, only Q2a and Q3 reveal significant differences, and their effect sizes are above medium. After further Scheffé's post hoc comparisons find no significant difference, and other dependent variables Q1, Q4, Q5 and Q6 are no significant differences.

In Table 5, five independent variables show disposition toward AI courses in this research. The six dependent variables are all significantly different. Their Cohen (1988) experimental effect sizes are above the medium level. After further Scheffé's post hoc comparisons, they present significant differences from Q1 to Q6. From subscale Q1 to Q6, all show 1>3, which means "very positive disposition" more than "neutral", and another subscale Q2 and Q4 show 1>2, which means "very positive disposition" more than the "positive disposition". Both Q2 and Q4 indicate above the large Cohen's effect sizes ($f = .4$).

In Table 5, in the independent variable of AI-related knowledge for the six dependent variables of the AIPBLAQ, there are three dependent variables, Q1, Q5, and Q6 showing significant differences. Cohen's effect sizes are above

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medium. Further, Scheffé post hoc comparisons found no significant difference. In addition, there are no significant differences in the dependent variables Q2 to Q4.

Finally, in their **feedback**, this research designed a semi-structured interview questionnaire to conduct tests after the experimental teaching post-test and the learning attitude questionnaire. After that, randomly select 3-4 participating students in each group, a total of 38 students in the academic year to conduct interviews (the code names are S1, S2, S3...) to understand their perceptions of AIPBL learning, their impressions of question teaching after learning, and question interview. The student feedback results were summarized as follows:

Interviewed students, their response to interview question Q1 illustrated as follows:

Both S1 and S10 students believed that listening to everyone's opinions, motivating, communicating, and learning from each other contribute to scientific problem-solving. Two students, S2 and S3, thought that the teaching material guided them to think and learn in AI. Let us discover problems, and after group discussions, put forward ideas and discussions on problem-solving, which aroused my interest in AI learning. Six students, S5, S6, S8, S19, S29, and S37, found that collecting information on AI-related issues could broaden AI knowledge and increase self-learning willingness. Eight students, including S4, S7, S9, S15, S16, S17, S18, and S20, believed that PBL guided teaching and group discussions would help us communicate about self-driving issues, realize in-depth learning, and combine the role of technology to achieve the purpose of the problem-solving. S9 and S20 believed that the PBL teaching method could profound their understanding through group communication. Integrating the application of technology into human life makes us more curious about the issue of self-driving cars. Eleven students, including S11, S12, S14, S21, S22, S23, S24, S25, S26, S27, and S28, felt that this AI-PBL situational teaching let them have a better understanding of the development, origin, and the importance of AI, and it allowed them to collect AI-related information. Such as the application of robots in uninhabited inns, medical treatment, and food production enriched my learning connotation and improved my learning horizons. Moreover, five students, including S13, thought that AI was not acceptable to just a computer application with many problems, not as good as the media was just a basic demonstration.

Most of the interviewed students were aware of the PBL method, which guided me to solve problems and apply them in my daily life. Their response contents to interview question Q2 were as follows:

Six students, including S7, S9, S10, S22, S28, and S29, found that the way through group questions helped to inspire thinking, simplified complex things, and found ways to solve problems from divergence to convergence. During the group communication, using the PBL method to find solving problems, you could also establish a personal network passbook. Six students, consisting of S11, S16, S19, S21, S24, and S30, believed that PBL problem-solving method would help improve the ability of logical thinking and make things more efficient. Furthermore, combined with the function of AI robots to accompany learning it would help find answers and solve problems. Eleven students, including S4 and others, thought that PBL had not encountered any problem yet and had no personal experience. If they have the opportunity in the future, they will try to experience it.

In terms of comprehensive evaluation and feelings, excerpts from students' feedback of interview question Q3 were as follows:

Four students, S8, S19, S29, and S37, found PBL to teach AI situational issues, which teacher gave suggestions and proposed many vivid examples, such as the application of AI in uninhabited inns. This business model made me curious, surprised, and apprehensive. The curious one was that the technology was so advanced, and the one who was surprised and frightened was the future graduates of the hospitality department, the pressure to find a job will increase. Seven students, including S9, S10, S11, S15, S16, S21, and S32, felt that the group discussion would allow everyone to participate in the PBL teaching. A more detailed analysis of the topics discussed in the group also helped understand the rapid changes in society due to emerging technologies. Then, it would help me change and improve my shortcoming and understand the different thinking patterns among classmates. Five students, including S22, S23, S27, S30, and S38, pointed out that we could not underestimate the contribution to the PBL cooperative learning. This teaching method let us impress and experience the new issue of the face recognition system, self-driving car, and robot. More cross-disciplinary knowledge and more feel the previous listening-style courses of learning differences. The decision-making model was more affirmative and more confident that it enhanced my value and vision for science learning.

Discussion

The most responsibility of education was to promote their self-learning, critical thinking, decision-making, and problem-solving abilities. AI social issues integrated with PBL instruction, used in this research to help students proactively conceptualize (Shemwell et al., 2010) and enhance their reasoning skills (Sonnleitner et al., 2013). It would reduce the memory learning of recitation and enable students to link and construct knowledge for positive learning effectiveness (Hwang et al., 2011; Liu et al., 2009). Therefore, this research successfully designed three

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constructive social application situation issues for AI-PBL experience science content. According to this study of Lopez et al. (2014), their cultivation of problem-solving skills and knowledge of emerging technology concepts were authentic cognition applications of cross-disciplinary. The diligence and application of knowledge were science learning essential elements for their knowledge development and accumulation.

As STEM scholars (Mohtar et al., 2019) thought that the integrated cross-disciplinary knowledge could help students enhance their learning efficiency, ensure continuous interest, and get better creations. Therefore, the results of this research responded to the thesis of STEM scholars and combined the content of general education courses in natural sciences. Students who use emerging technology products, such as recognition systems, self-driving cars, and AI robots engage in hands-on and brain-based multiple cross-disciplinary learning. Therefore, instructors integrated emerging technologies into learned thinking and showed their brand new literacy to enhance their vision and value in science education. The purpose of this research was to allow students to evolve the truth from the transfer of knowledge to the skills they have learned so that they do not only accept it.

An assessment tool of five open-ended test items with validation evaluates the learning effectiveness of their AI-PBL textbooks. To sum up, after the AI-PBL situational topic teaching conducted the post-test administration with this evaluation tool and compared it with the pre-test. The results showed that the number of students with nothing to do with the questions, blank and incomprehensible (I) papers decreased from 3.7% to 0%, students with SM decreased by 13.5%, PUSM students increased by 9.6%, PU students increased by 6.7%, and CU students increased by 0.9%. Su (2018) pointed out that an effective auxiliary tool could help students explore questions, present problem-solving abilities, and cultivate reasoning skills. Sonnleitner et al. (2013) stressed that students' problem-solving skills were related to their reasoning skills. Researchers (Sadler et al., 2016) had also emphasized the importance of the PBL method of contextual issues, whose knowledge and cognitive learning helped activate logical skills in problem-solving.

Because this research emphasized the social application of AI in daily life texts, PBL provided real situational-based problems, allowing students to learn from the cross-disciplinary of emerging technologies. They could experience the practical value of new scientific knowledge and understand the functionality of AI in social applications. The importance of new knowledge could improve their thinking ability and decision-making skills, generate new insights by the agitation of emerging technologies, and solve the scientific problems in life.

All six dependent variables included the learning attitude for AI-PBL courses, the teacher, the multimedia learning environment, attitudes towards AI-PBL classmates, self-learning AI-PBL courses, and AI-PBL course learning results. In this research, a learning attitude from their descriptive statistical analysis presented a positive learning attitude. The analysis results of the students' AI situational issues AIPBLQ showed that the overall average of the dependent variable was 3.71(>3.50). Su pointed out that this data presented positive attributes for their learning attitudes. This finding responded to scholars' arguments that PBL-guided learning could help students improve their learning attitudes, deepen learning abilities (such as collaboration, synthesis, communication), and enhance their problem-solving skills (Adesope & Nesbit, 2012; Jansson et al., 2015). In addition, the results of the one-way ANOVA found that students' disposition toward AI courses indicated the most impact on learning attitude. Secondly, the effect factors were their learning attitudes towards AI-related knowledge and enrollment methods; the lastly influencing factors were the use frequency of 3C products and gender.

Owing to the guidance of the questions, students drove their AI curiosity and interest in the interview for group discussion. This research found that students liked to learn from the group discussion of emerging technology AI. In the group discussion, they constructed new knowledge and used group discussion to search for information and enhance cooperative learning. Students would be brave enough to accept the challenges of new problems. In this research, due to the integrated limitation and higher-order thinking ability lack, spending more time and training were required to exhibit higher learning effectiveness. Their group cooperative learning showed an atmosphere of teamwork, which was conducive to correct thinking guidance and training. In short, the lack of communication skills and self-confidence were obstacles to effective teaching and learning. It took a long time to construct a teaching environment, which was also a reason for the teaching practice in class.

The quantitative and qualitative results showed that integrating AI situational issues into PBL teaching helped improve their learning effectiveness and attitude, achieved the purpose of problem-solving, and enabled students to participate in these spaces more meaningfully (Mayer, 2011; Mundilarto, 2018). The application of semi-structured interviews could indeed strengthen the inadequacy of structured questionnaires. From the perspective of constructive learning theory, teachers were more aware of the students' demand for teaching materials. Therefore, this study found that the PBL approach offered great potential in supporting real-world problem solving of AI contextual

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issues in science education (Hernández-Ramos et al., 2021). As mentioned above, Rillero and Chen (2019) found that PBL could combine diverse AI subjects with meaningful experiences for authentic learning outcomes.

Conclusion and Implications

Based on the result and discussion, the fruitful results of integrating AI emerging technologies into natural science education and the PBL teaching method in this research were encouraging and helpful. AI-PBL teaching contexts helped most students enrich learning connotations, nurture problem-solving thinking, and enhance their learning levels through interaction and guidance. Evaluating tools consisted of open-ended test items, attitude questionnaires, and semi-structured interview questionnaires in this research. All had good validity and reliability. They examined the learning effect of quantitative analysis of incomprehension and the specific misconception to promote partial understanding and clear understanding in nature science learning.

All findings suggested that their logical reasoning and thinking skills could promote problem-solving abilities. Descriptive statistical analysis of learning attitudes revealed that cooperative learning enhances their positive thinking attributes. The One-way ANOVA indicated that the disposal of AI courses had the most influence on their learning attitudes; AI-related knowledge and enrollment methods were the second factors. The third influencing factors were the frequency of using 3C products and gender. In addition, the interview found that the PBL method was helpful for students to learn and reflect, apply to simple problem-solving in daily life, apply communication in group discussion, and apply the concept of cross-disciplinary emerging technologies to provide positive learning effectiveness.

In fact, in addition to comparing, analyzing, and critical thinking with literature, students learned problems in class that needed to be solved urgently and then practiced teaching objectives. The research focused on the social application of AI in daily life is helpful to the positive learning effect of students. It could provide a pedagogical reference for teachers of general education in the natural field; however, the limited sample size and time at the teaching site led to the need for moderation in making inferences. Therefore, from the perspective of teaching practice and future research on design thinking, this research put forward the following two suggestions:

1. From the perspective of teaching practice, the time constraints of the curriculum design it was impossible to provide students with more discussion time, giving students a full grasp of the essence of the problem and key decision-making skills. Furthermore, the on-site teaching found that students lack communication skills and self-confidence. These limitations of learning growth require long-term cultivation in the educational environment to exhibit significant learning outcomes. In the future, teaching will focus on students' cognition, application ability, and literacy to construct and design to make learning more flexible.
2. In terms of research, future research will increase the number of samples and allow more students to participate. Students are passionate about learning, brave to accept new challenges, and have team spirit in the teaching field to improve the inference of research value and the vision. Therefore, increasing the sample size will help them produce more positive thinking.

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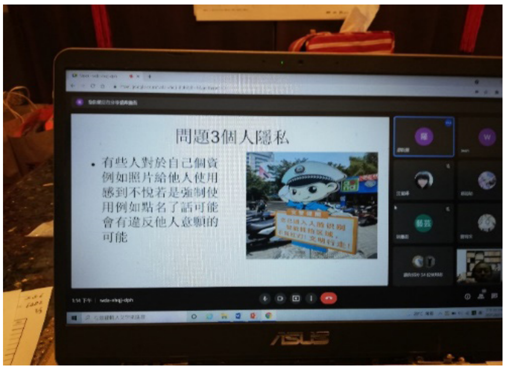
Appendix 1

Group cooperative learning to report on stage for a) robot issue; and b) online face recognition issue in Chinese (Covid-19 impact)

a)

b)



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