The outcomes of project-based learning with problem solving using generative artificial intelligence

Suthada Muengsan, Pinanta Chatwattana & Pallop Piriyasurawong

King Mongkut's University of Technology North Bangkok
Bangkok, Thailand

ABSTRACT: Project-based learning with problem solving using generative artificial intelligence, or the 2Pro learning system using generative AI, is a research tool designed with the concepts of project-based learning that primarily encourages learners to engage in self-learning based on their interest, aptitudes and abilities, and enables them to practically use the knowledge and experience derived from this learning. In addition, the problem-solving process is also integrated in 2Pro learning using generative AI. This is to stimulate learners to find reasons for problems and problem-solving methods in a step-by-step manner, and then summarise and evaluate the results to solve these problems and create their own works. It is expected that this learning style will enable learners to create works efficiently based on their knowledge and experience. Moreover, in this learning system, AI has been combined with Google Classroom as a learning tool to allow learners to enhance further their self-directed learning and apply various technologies to generate innovative works, which can pave ways for their future careers.

INTRODUCTION

Education is recognised as not only an important tool for the development and transformation of people, society and nation, but also a main mechanism to develop quality human resources. Due to the rapid changes in the 21st century along with the external pressures from globalisation and the critical problems within the country, Thailand has placed more emphasis on the management of education coupled with the enhancement of capabilities and competencies of the Thai people. The aims is to have well prepared generations equipped with skills, knowledge and attitudes that are corresponding with the demands of the labour market and national development plans, and provide solid grounds for a good quality of life and the ability to cope with present and future changes on the world [1].

Also, Thailand is determined to be the education centre of the Association of Southeast Asian Nations (ASEAN) by making use of local cultures and wisdoms to promote learning. Still, it is critical to further improve the accessibility to information sources and infrastructure in the education system [2] to achieve higher quality and equity in education.

The current quality of education and the use of appropriate technologies in Thailand has already demonstrated some improvement as most educational models have shifted from the traditional, passive and teacher-centred models to active student-centred learning. This change is aimed to upgrade the quality of education and to satisfy the needs of learners regarding the application of their knowledge in practice. Accordingly, the integration of different technologies with education is quite crucial for the development and adjustment of learning to fulfil the demands of digital economy and the changing technological landscape [3].

The student-centred approach places importance on the enhancement of learners' skills and abilities considering their own potential, including self-development and creativity. To increase education quality in a continuous manner, the teaching and learning processes should be assessed on a regular basis and then improved for maximum effectiveness [1]. Above all, the integration of technologies in education should be always promoted, so as to increase learning efficiency and prepare learners for the upcoming rapid changes in the digital age.

Scientific and technological innovations have become important mechanisms for education management that can yield the quality output in line with professional standards and/or international educational standards. Learners should be encouraged to develop 21st century learning skills, such as analytical thinking and problem solving, language and communication, technology and information, and teamwork skills. All of these skills increase learners' competitiveness and respond to the demands of the labour market.

Moreover, learners will be able to apply these skills in their careers in different sectors and further of studies. Once equipped with these skills, they will have more opportunities to continue their study at higher levels and have more

chances to achieve advancement in their chosen career [4]. The development of vocational personnel, both quantitative and qualitative, must be compliant with the country's economic growth rate; therefore, there must also be co-operation from business establishments when carrying out curriculum development, education management and evaluation in order to create the quality output required in the labour market, which will further lead to national development.

Importance of Project-based Learning with Problem Solving to Learners in the 21st Century

The learning approach that focuses mainly on the improvement of skills and knowledge through project-based learning combined with problem solving allows learners to engage in a student-centred learning model, in which they can solve problems and practise on their own in order to produce creative works and achieve 21st century learning goals [5].

Thus, project-based learning is considered an approach that can assist learners to actively participate in learning and prepare them for future careers, which usually require high-level skills and creativity. This learning method also promotes student-centred learning and increase the effectiveness of classroom instruction management. Moreover, it also encourages learners to create their own works through hands-on practice, which helps develop the skills needed in the 21st century [6].

Project-based learning is a learning process that promotes learners to develop life skills needed in the 21st century. In this learning format, an instructor is acting as a learning manager, facilitator or advisor in order to help learners advance and complete the project. Every single step of the project-based learning process allows learners to engage in hands-on practice; to illustrate, they are encouraged to explore and search for information, set up learning plans, design learning, create and apply the knowledge gained from learning, and evaluate their works [7-9].

Furthermore, project-based learning also emphasises instruction management that allows learners to have direct experiences, learn how to solve problems, think creatively while working, know how to plan their work using scientific methods, communicate and work with others, and assess their own works [10]. Accordingly, project-based learning is regarded as one of the approaches that should be integrated into instruction management so as to provide learners with indispensable skills for the 21st century.

The problem-solving method is a kind of instruction management that makes use of problems in the learning process. When learners are given problems, they rely on a systematic problem-solving process, as well as the scientific process in order to think and find out the reasons behind these problems and methods for solving them; and then they must be able to conclude and evaluate the achieved results [11]. The enhancement of problem-solving skills not only assists learners to solve problems in varied situations, but also strengthens their critical thinking and innovation skills, which are highly needed in the labour market. Therefore, the problem-solving method is a kind of thinking process that is employed to eliminate all obstacles and then achieve the goal of solving problems. Studies point out that the problem-solving skill of individuals can be developed to the full potential [12].

In reference to the reviewed documents and studies [13-15], the problem-solving method can be divided into the following five steps:

- Define problems: This step is related to the collection of information about the problem, considering the details of the problem from all aspects, and then defining the specific nature of the problem.
- Set up hypotheses: Hypotheses are established by means of observation and collection of data, facts and previous experiences, all of which are used to predict solutions to the problem in a logical manner.
- Collect data: This step is about the collection of data from reading, observation, interviews and other data collection methods; upon the collection, data are carefully stored for further analysis in order to find answers to the problem.
- Analyse data: The data obtained from literature search, experiments and other sources are presented to learners in order to provide them with opportunities to discuss, ask questions, respond to questions, and express their opinions; at this step, instructors are giving some assistance and suggestions. All of these will lead to the conclusions based on the analysis of the collected data.
- Summarise and evaluate results: It is the final step of the problem-solving method, in which the data obtained from different sources are summarised into learning results. After that, both instructors and learners jointly evaluate the results leading to problem-solving, which further develops learners.

Generative artificial intelligence (generative AI) is an artificial intelligence technology that is capable of understanding data processing, designing and creating works in the form of texts, images, audio and animation [16]. Particularly, generative AI is designated to innovate and create brand-new or unprecedented products and content.

Recently, generative AI has been widely applied in numerous fields for convenience, and it has also been used as a tool to promote learning in the form of digital humans with an aim to initiate new formats of learning that involve interaction with various platforms [17]. However, the application of artificial intelligence (AI) in any task should be conducted with great cautions and it is advisable to take into account the laws, social contexts and ethics when using it. AI can be utilised in an efficient manner if it is put in correct and proper use [18].

Based on the above background, the researchers came up with an idea to develop a learning system that would combine project-based learning with problem solving using generative artificial intelligence, or the 2Pro learning system using generative AI, with an intention to equip learners with 21st learning skills by practising in virtual environments The researchers synthesised the learning process that can assist learners to cope with the rapid technological changes. The learning process outlined in this article is intended to particularly increase efficiency of students in vocational courses and create paths for careers that correspond with the current demands of the labour market. Using generative AI technology, the learning process has been enhanced and organised in such a way that learning activities encourage learners to engage in new things and apply the acquired knowledge to produce creative vocational media and to solve problems in 21st century situations.

RESEARCH OBJECTIVES AND HYPOTHESES

This study is primarily designed to examine the perspectives of research participants towards the development of the 2Pro learning system using generative AI in order to find out whether this system can be applied as a guideline for further practical use. Whereby, the objectives of this study are as follows:

RO1:   To synthesise the 2Pro learning process using generative AI.
RO2:   To design the 2Pro learning model using generative AI.
RO3:   To develop the 2Pro learning system using generative AI.
RO4:   To examine the perspectives towards the development of the 2Pro learning system using generative AI.

This study relies on the pre-experimental research method using a one-shot case study with research participants willing to join this research and answer a five-point rating scale questionnaire. Most importantly, all of the participants were well protected according to the policies of confidentiality and anonymity, as well as educational ethics. The hypotheses of this research are as follows:

H_1:   The suitability of the design of the 2Pro learning model using generative AI is at a high level.
H_2:   The quality of the 2Pro learning system using generative AI is at a high level.

MATERIALS AND METHODS

The 2Pro learning system using generative AI was designed with the concepts and theories of the systems approach [19][20], of which the main system elements include input, process, control, output and feedback.

Participants

The research participants were nine experts from different higher education institutions, all of whom are specialised in instruction system design and development. Selected by means of purposive sampling, all the participants gave their consent to join in this research and they were well protected under research ethics guidelines and policies, as mentioned above.

Materials and Data Analysis

The research instruments included: 1. the 2Pro learning model using generative AI; 2. the 2Pro learning system using generative AI; 3. the evaluation form on the suitability of the designed learning model using of a five-point Likert rating scale [21] and questions prepared in accordance with the systems approach that contains clear elements and steps; and 4. an evaluation form on the quality of the designed learning system which contains 15 questions on a five-point rating scale - with all questions related to the details of the developed system, e.g. quality, usability, etc. The statistics used for data analysis are mean and standard deviation.

Collection Method

The researchers used an evaluation form, which was verified for validity and for the index of item-objective congruence (IOC) to collect data from research participants, who gave their consent to take part in this study. Also, these participants were assured that the information they had given would not be revealed and/or used to track their identities.

Method

This study, which is based mainly on the concepts of the systems approach, was conducted to explore the perspectives towards the development of the 2Pro learning system using generative AI. The methodology of this study can be summarised into four stages as below:

Stage 1: Synthesise the 2Pro learning process using generative AI. In this stage, all relevant documents and studies were synthesised in order to acquire guidelines needed to develop the 2Pro learning process using generative AI.

These guidelines relate to project-based learning, problem-solving, generative artificial intelligence and creative vocational media.

Stage 2: Design the 2Pro learning model using generative AI. In this part, the outcome obtained in stage 1 was employed as a guideline to design the 2Pro learning model using generative AI that includes the main elements of the systems approach.

Stage 3: Develop the 2Pro learning system using generative AI. The researchers applied software development lifecycle (SDLC) techniques [22] for instruction system design to develop the 2Pro learning system using generative AI, which can not only enable learners to participate in a variety of learning experiences depending on the learning styles, but it also supports all formats of learning anywhere and anytime.

Stage 4: Examine the perspectives towards the development of the 2Pro learning system using generative AI. In this stage, the researchers used an evaluation form with five-point rating scale questions to explore the perspectives of the nine research participants. All of these participants are specialists with experience in the design and development of instruction systems and they were all willing to join this study. The rating points, criteria used on the evaluation form, and the interpretation of the ratings [21] are as follows:

- 4.50 - 5.00 the suitability/quality is at a very high level;
- 3.50 - 4.49 the suitability/quality is at a high level;
- 2.50 - 3.49 the suitability/quality is at a moderate level;
- 1.50 - 2.49 the suitability/quality is at a low level;
- 0.00 - 1.49 the suitability/quality is at a very low level.

RESULTS

The 2Pro learning system using generative AI is an on-line learning tool that allows learners to engage in self-learning and monitor their own progress anywhere and anytime. Moreover, this learning system also promotes innovative learning and the creation of works in new environments which can increase learners' competitiveness and response to the needs of the 21 century labour market. The results of this research are presented below:

Results of the Synthesis of the 2Pro Learning Process using Generative AI

The 2Pro learning process using generative AI was initiated by the integration of project-based learning concepts and the problem-solving process to be applied in the new learning model. The objective was to encourage learners to engage in the problem-solving process that requires systematic and logical thinking, to utilise the acquired knowledge to produce creative vocational media. The results of the synthesis of the 2Pro learning process using generative AI are presented in Table 1.

Table 1: Results of the synthesis of the 2Pro learning process using generative AI.

Project-based learning process	Problem-based process	2Pro learning process	Details
1. Preparation	1. Define problems 2. Define hypotheses	1. Prepare and analyse the problems	This step is about preparation before class learning. The instructor reviews the contents and facilitates understanding by the learners by introducing activities in the instruction management plan along with guidelines for different learning resources. The learners are allowed to participate in setting the conditions and evaluation criteria for the project results.
2. Operation	3. Solve problems	2. Study the contents	Activity topics are defined and selected in this step. The instructor and learners jointly determine the topics of projects and study the feasibility and worthiness of each topic. While the learners are studying the contents in the prepared environments, the instructor is supervising and monitoring them closely.

3. Evaluation		3. Evaluate	This step reflects the achievement of each step in the project, ranging from the processes before starting the project to the completion of the project. The assessment on knowledge, processes, behaviours and works of the learners is conducted on a continual basis, using various methods and tools and focusing on each achievement.
4. Reflection	4. Collect data 5. Analyse data	4. Analyse data and feedback	In this step, the evaluation results are analysed for further improvement and development of the works.
5. Presentation of learning outcomes		5. Present the empirical results	The works and working processes are clearly presented to the public.

According to the synthesis of documents and studies related to project-based learning [6-10] and the problem-solving process [13-15], the guidelines for the learning process for use in this study were obtained, and can be summarised in five steps: prepare and analyse the problems, study the contents, evaluate results, analyse data and feedback, and present the empirical results.

Results of the Design of the 2Pro Learning Model using Generative AI

The 2Pro learning model using Generative AI was designed with the concepts of the systems approach [19][20], in which all elements are organised in a systematic manner. The model is illustrated in Figure 1.
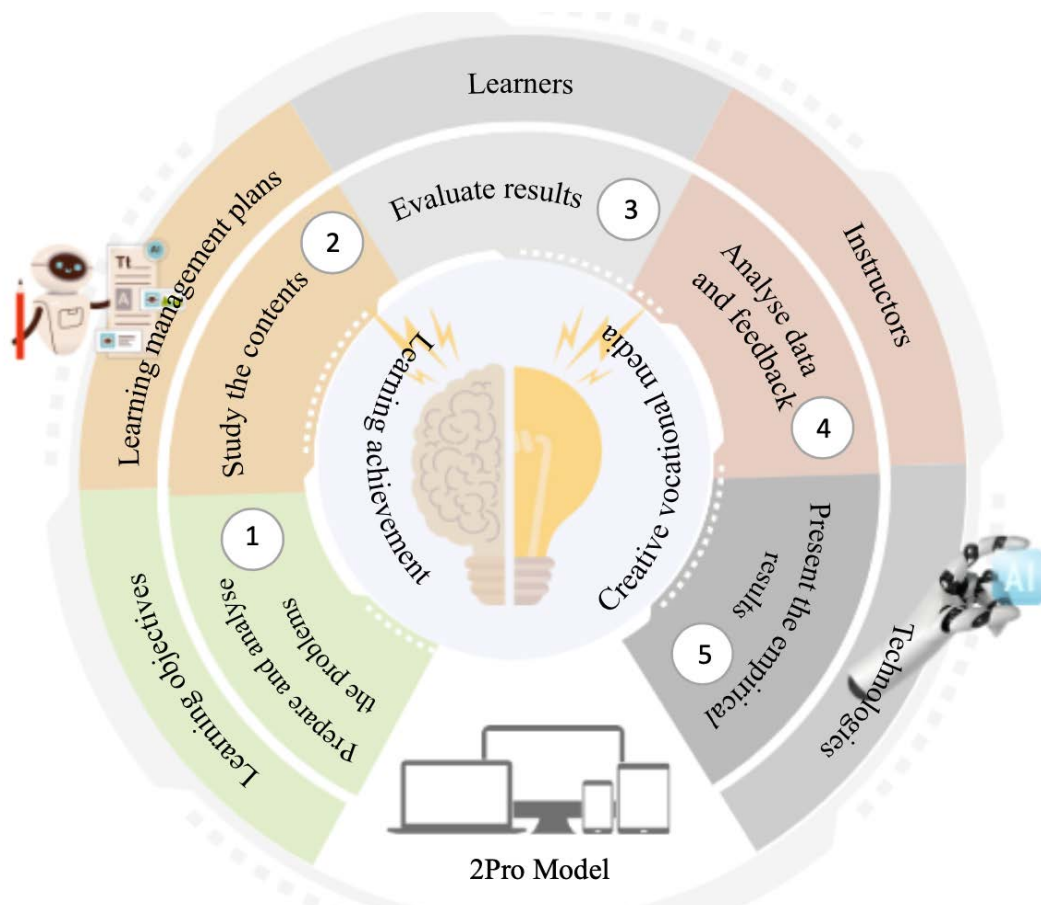

Figure 1: Project-based learning with problem solving using generative AI.

Referring to Figure 1, the learning model consists of four elements as follows:

- Input factor: This element refers to all related factors required in the design of this learning model, including learning objectives, learning management plans, learners, instructors and technologies.
- The 2Pro learning process using generative AI: This element was developed with the combination of project-based learning concepts and the problem-solving process. Moreover, the researchers also used the technology of generative AI to support learning and project implementation with an expectation that the learners will be able to produce brand-new creative vocational media. The 2Pro learning process is composed of five steps, i.e. prepare

and analyse the problems, study the contents, evaluate results, analyse data and feedback, and present the empirical results.

- Output: This is the results after learning with the developed learning process, which include learning achievement and creative vocational media. The criteria for consideration in this element are the following seven characteristics, i.e. consistency of the contents and specific topic, creativity (brand-new and unprecedented ideas), attractiveness of compositions, techniques of using generative AI, accuracy of language use, communication via images, utilisation and dissemination.

- Feedback: It is about the use of information derived from the output to improve the learning process. The feedback consists of learning achievement and creative vocational media.

Table 2: Evaluation results of the suitability of the 2Pro learning model using generative AI - overall elements.

Items	Mean	SD	Results
1. The 2Pro learning model using generative AI is consistent with the research objectives.	4.89	0.33	Very high
2. The main elements (input factors, 2Pro learning process using generative AI, output, feedback) are all suitable.	4.89	0.33	Very high
3. The design of this learning model has clarity and coherence.	4.56	0.53	Very high
4. The main elements are consistent and related to each other.	4.44	0.53	High
5. The sequence of all elements is easy to understand.	4.56	0.73	Very high
6. The overall elements of this learning model are complete and they cover the learners' needs.	4.89	0.33	Very high
Average score	4.70	0.46	Very high

In reference to Table 2, it is evident that the suitability of the overall elements of the 2Pro learning model is at a very high level (mean = 4.70, SD = 0.46). The results also indicate that the model contains all necessary elements and it can be applied as a guideline to further develop this learning system that can be put to practical use in the future.

Table 3: Evaluation results of the suitability of the 2Pro learning model using generative AI - specific elements.

Items		Mean	SD	Results
Input factor	Learning objectives	5.00	0.00	Very high
	Learning management plans	4.67	0.50	Very high
	Learners	4.78	0.44	Very high
	Instructors	4.89	0.33	Very high
	Technologies	4.89	0.33	Very high
Average		4.84	0.32	Very high
The 2Pro learning process using generative AI	The 2Pro learning process	4.67	0.71	Very high
	Generative AI technology	4.67	0.71	Very high
Average		4.67	0.71	Very high
Output	Learning achievement	5.00	0.00	Very high
	Creative vocational media	4.67	0.71	Very high
Average		4.83	0.35	Very high
Feedback	Results of measurement on learning achievement	5.00	0.00	Very high
	Results of measurement on creative vocational media	4.67	0.71	Very high
Average		4.83	0.35	Very high

Table 3 shows the results of evaluation of the suitability of the developed model in regard to individual elements. It was found that the overall suitability of each element, including the input factor (mean = 4.84, SD = 0.32), learning process (mean = 4.67, SD = 0.71), output (mean = 4.83, SD = 0.35), and feedback (mean = 4.83, SD = 0.35), is at a very high level.

The above results indicate that the developed learning model includes appropriate elements and that can be employed as a guideline to further develop other tools that can promote the production of creative vocational media based on generative AI. Project-based learning combined with the problem-solving process shall encourage learners to engage in active learning when carrying out their projects. During this process, learners are urged to think step by step in a logical manner, which will not only lead to the creation of novel and unprecedented works, but also pave ways for their future careers.

The obtained results are in line with the research of Wongkumsin and Singhwee, who stated that the integration of the project-based learning with generative AI can be regarded as a model of learning outside classroom that focuses mainly on learners [23]. Learners are allowed to learn what they are interested in in their own way based on their aptitudes and competencies, and then apply their knowledge and experiences to devise brand-new innovations.

Additionally, the results are also consistent with the research of Vongtathum, who pointed out that the problem-solving process leads to a significant skill development for vocational students because it helps them find out new approaches to solve complicated and unprecedented problems [24].

Results of the Development of the 2Pro Learning System using Generative AI

The 2Pro learning system using generative AI is compatible with varied interactive screens so it can display information in many different formats, such as texts, images, animations, hyperlinks to Web sites, etc. enabling users to access information anywhere and anytime in an instant manner. At this stage, after designing the interactive screen corresponding to the needs of users, along with the structure and the elements concordant with the learning contents that are related to artificial intelligence, the researchers also used the Gamma application, and Google Classroom as a learning tool in order to promote learning within the system, so that the learners could learn at their own pace and produce their own innovative works. Selected screens of the 2Pro learning system are demonstrated in Figure 2.
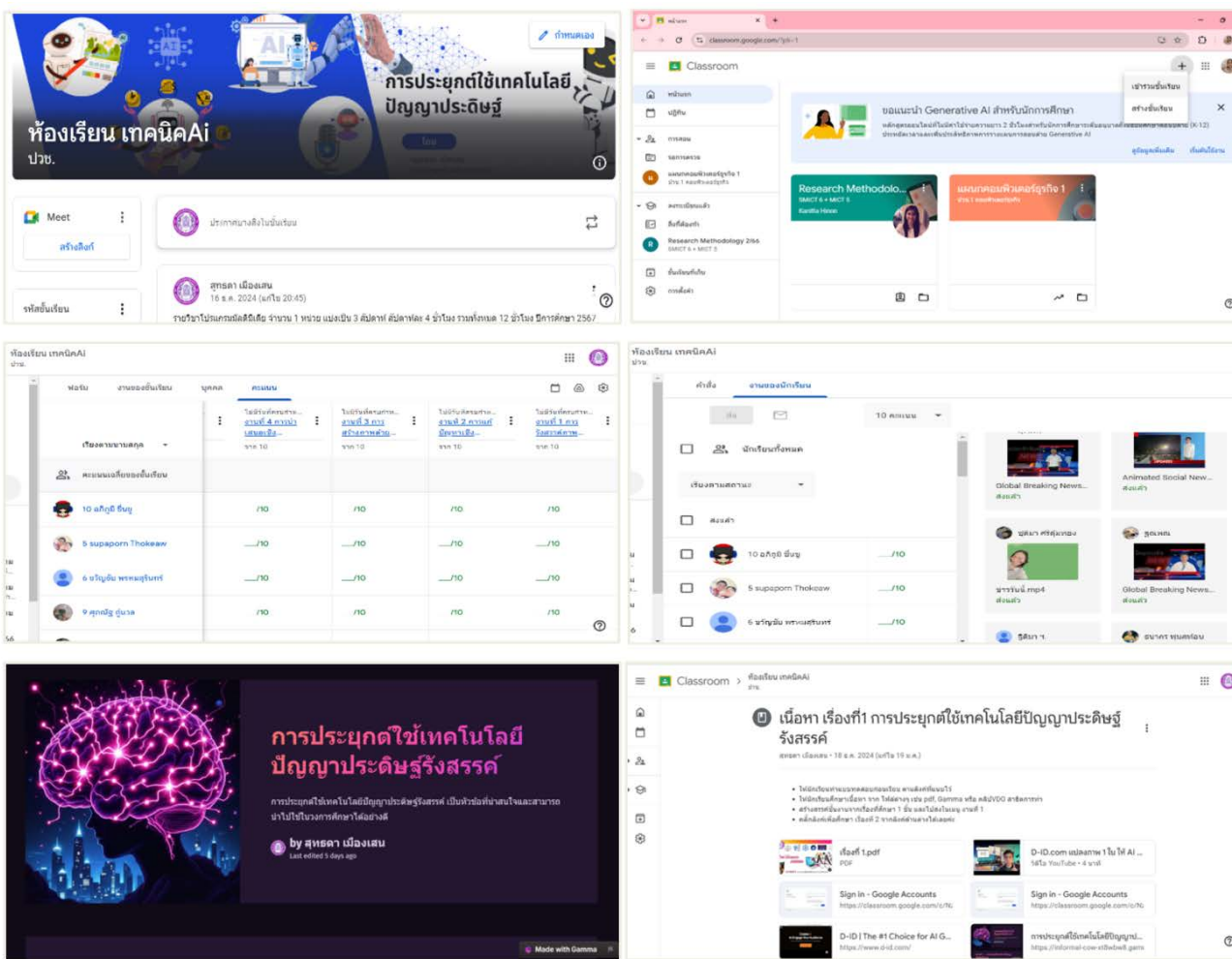

Figure 2: Project-based learning with problem solving using generative AI - selected screens.

Examination of the Perspectives towards the Development of the 2Pro Learning System using Generative AI

In this study, views and opinions about the developed system were also examined, involving nine experts that were research participants. Particularly, the research participants' perspectives towards the quality of the system were investigated before applying it to practical use with vocational students in Thailand in the future. As mentioned above, there were nine research participants in this study, all of whom are specialised and experienced in the field of instruction system design and development. All participants gave their consent to rate various aspects using a five-point rating scale. The results of quality evaluation are summarised in Table 4.

Table 4: Evaluation results of the quality of the 2Pro learning system using generative AI - perspectives.

Aspect	Items	Mean	SD
Quality	1. Suitability of elements within the system.	4.89	0.33
	2. Ease and convenience to access information.	4.67	0.50
	3. Clarity and understandability of activities.	4.67	0.50

	4. Variety of activities to enhance creative vocational media.	4.67	0.50
	5. Accuracy of presentation.	5.00	0.00
	6. Accuracy and coherence between contents and knowledge.	4.78	0.44
	7. Convenience of using the learning supporting tools.	4.89	0.33
	8. Clarity and attractiveness of interactive screen design.	4.67	0.50
	9. Coherence between the design of learning contents and the enhancement of creative vocational media.	4.67	0.50
	10. Overall quality for practical use.	5.00	0.00
Average quality		4.79	0.09
Efficiency	11. System performance	4.78	0.44
	12. Functionality	4.78	0.44
	13. Usability	4.78	0.44
	14. Efficiency of technology in terms of learning improvement.	5.00	0.00
	15. Overall efficiency for practical use.	5.00	0.00
Average efficiency		4.87	0.14

According to the results of quality evaluation presented in Table 4, the mean of quality is at a very high level (mean = 4.79, SD = 0.09), and the mean of efficiency is also at a very high level (mean = 4.87, SD = 0.14). Therefore, it can be clearly seen that the 2Pro learning system using generative AI is a learning tool that can be applied to practical use. It is also efficient enough to promote the skills related to the production of creative vocational media, which are new and unprecedented works created with the aid of generative AI and by self-directed learning. Moreover, this new learning system can be considered a pathway to future careers since the system uses digital technologies and digital tools to support learning and this method can fulfil the needs of learning and labour market requirements in the 21st century.

DISCUSSION AND CONCLUSIONS

This research was primarily designated to examine the perspectives towards the development of the 2Pro learning system using generative AI. The researchers synthesised information about project-based learning with the problem-solving process from relevant documents and studies, and obtained five steps of the learning process (i.e. prepare and analyse the problems, study the contents, evaluate, analyse data and feedback, and present the empirical results) that are appropriate to design the 2Pro learning model using generative AI. The 2Pro learning model was employed as a prototype for further developing the 2Pro system which is of high quality and efficiency, and can be applied to practical use. Also, it is expected that the 2Pro learning system will encourage learners to engage in self-learning and generate their own projects that can eventually lead to the production of creative vocational media.

The results of this research support the two hypotheses established in this study. It was found that the 2Pro learning system can promote the production of creative vocational media based on generative AI. Project-based learning combined with the problem-solving process can stimulate learners to think systematically, learn how to solve problems, set up their working plans, and collaborate effectively with others. In addition, the researchers also made use of the Gamma application and Google Classroom to promote learning within this system, enabling learners to learn at their own pace and produce creative works.

The study results are in line with the research of Muensopha et al, who indicated that the integration of virtual technology with appropriate learning processes and learning activities, both in and outside classroom, is considered one of the greatest initiatives of educators because this method does not only enhance learners' communication skills, but also leads to more engagement, motivations and self-directed learning [25].

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