Flipped-Classroom Demonstration Learning Platform via Metaverse to Enhance AI Competency

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***Abstract*—The Flipped-Classroom Demonstration (FCWD) learning platform via metaverse to enhance artificial intelligence competency, or FCWD learning platform via metaverse, was fabricated with the integration of flipped classroom concepts and demonstration learning, using virtual reality technology to create learning environments that can promote students' Artificial Intelligence competency (AI competency). The main objective of this study is to explore the perspectives towards the development of the FCWD learning platform via metaverse in order to prove whether this learning platform is efficient enough for students to use it so as to improve the three aspects of AI competency, i.e., learning achievement of artificial intelligence, artificial intelligence skills, and awareness of the impact of using artificial intelligence. The research instruments in this study include 1) the architecture of the FCWD learning platform via metaverse, 2) the FCWD learning platform via metaverse, 3) the evaluation form on the suitability of the architecture of the FCWD learning platform via metaverse, 4) the evaluation form on the quality of the FCWD learning platform via metaverse, and 5) the evaluation form on the learning achievement of artificial intelligence. It can be clearly seen from the results of this research, which are corresponding to the hypotheses, that the FCWD learning platform via metaverse can be used as a tool to enhance AI competency. This is because the learning platform was devised based on the theories of flipped classroom combined with demonstration learning via metaverse, and it is aided with the application of virtual reality technology. It is believed that the learning of this style shall promote self-directed learning that further encourages learners to gain direct experiences through virtual learning environments. In addition, this is considered an education management that will lead to the creation of virtual learning communities and borderless learning. It can be clearly seen that the FCWD learning platform via metaverse can enhance the students' learning achievement of artificial intelligence with statistical significance. In addition, referring to the tracking of the students' artificial intelligence skills in the long run, it is found that the FCWD learning platform via metaverse can promote their engagement in self-learning through hands-on learning in virtual environments, in which the real situations are simulated by means of AI technology in order for these students to take part in learning management and do activities therein.**

***Keywords*—flipped-classroom, demonstration, metaverse, self-directed learning, virtual learning environment, artificial intelligence competency**

I. Introduction

The teaching and learning formats after the COVID-19 era (Next Normal) have been greatly improved and changed from the traditional ones. As a consequence, many educational institutions in Thailand have started to adjust the models of knowledge freedom and access to knowledge sources with an attempt to deal with the dynamic changes in digital technologies and innovations. This is all to provide students with a wide range of learning experiences and allow them to have greater roles in their own development and learning than the previous eras, in which a greater emphasis was usually placed on teachers [1]. The study in high school level is regarded as a transition point from basic education to higher education and a number of students generally turn to focus more on looking for their desired universities as their future goals during this time, which always makes them lose interest in the study at school. Therefore, it is quite necessary for teachers to adjust their teaching styles and learning activities, and meanwhile find out the more flexible teaching techniques and methods in order to cope with the above problems and initiate new and innovative instruction processes that not only support continuous learning but can also be accessed anywhere and anytime.

The learning management in the 21st century is the management of education aiming to equip humans with living skills and enhance the quality of Thai youths. Therefore, teachers must be able to integrate varied technological media in different formats of learning management because this will provoke learners to make use of technologies when searching for information, achieve self-learning, develop analytical thinking skill, and manage information in a more systematic manner [2]. The development of the 21st century knowledge and skills is not limited to the mastery of learning contents, but it also includes information and communication skills, critical thinking skill, problem-solving skill, interpersonal skill, and digital skills. These are deemed as indispensable skills that the 21st century learners should possess because these skills not only enhance the quality of education but also encourage learners to focus on the pursuit of knowledge, improve their skills, and foster positive attitudes towards lifelong learning [3].

One of the important factors to move towards Thailand 4.0 is to have the education management that is consistent with learners' behaviors in the current contexts and meanwhile capable of supporting the future contexts of the new generation education [4]. The integration of technologies with instruction management has become more and more evident and tangible, and this has led to the new formats of learning that can stimulate and open up opportunities for the creation of knowledge, exchange of knowledge, and collaboration. The flipped classroom [1] is one of the modernized learning styles that enable learners to have greater roles in learning. To illustrate, the flipped classroom is a learner-centered instruction model that relies on the flipped learning approach, in which students are able to gain

new bodies of knowledge outside the classroom because the traditional classroom contents are converted into an online format so that they can review the contents and explore the information on their own before classroom learning. So, upon the classroom learning, this method allows students to have more participation in the interactive activities, discussions, and collaboration to jointly solve the problems in a more creative manner [5, 6]. Accordingly, the flipped classroom is considered an education approach that allows learners to acquire new bodies of knowledge outside the classroom, which is in contrast to the traditional methods in which teaching and learning could take place only in the classroom. Hence, it can be said that the flipped classroom can effectively support today's instruction management and it is also widely accepted as an approach of self-directed learning [7].

Demonstration learning is a learning approach in which a teacher or a student demonstrates something to others in the class. Thereby, the said demonstration may be about the use of a tool, which is conducted to describe its process, methods, or strategies in order to generate the desired learning [8]. Teaching with this demonstration process helps learners understand and enables them to do what they have learned correctly. Demonstration learning can also prompt learners to develop the observation processes and skills, and then they are likely to find out a learning process based on their hands-on experiences immediately. Accordingly, this method is suitable for the teaching that requires learners to see and clearly understand the steps of specific practices [9].

Metaverse is a new dimension of borderless education that makes use of virtual reality technologies to enhance the ability to access learning resources available in the 3D virtual world. It is believed that this will enable learners to gain deep learning through direct experiences [10] in an environment where everybody can use their own avatars to participate and interact with others and even with activities. Basically, metaverse refers to a virtual world fabricated in such a way that users can use technologies and devices to access the said virtual environment and interact with one another through their avatars [11]. Therefore, metaverse is considered an immersive digital environment in which all users can create their own avatars and participate and interact with others in the activities therein. Metaverse has been widely used as a new social communication space [12] where learners are able to share their learning experiences with others.

Recently, Artificial Intelligence (AI) is recognized as an emerging technology that uses a huge amount of data to do analysis and prediction in order to seek for new algorithms. The positive tendency in the practical use of AI is quite evident as it has been widely employed [13], resulting in a number of AI applications having been devised and widely used, too. These AI applications began to become a popular issue of discussions in Thailand's education sector in early 2023, and since then they have had more and more influence on our daily life. The increasing use of AI clearly reflects the upcoming transformation of the era in terms of economy and careers, and even the probability that AI may be extensively used in place of humans in the future. Likewise, this will also lead to big changes of the world's education in many aspects [14, 15]. Maneehae and Wannapiroon [16] stated that the factors that make AI have such significance are its abilities to learn repeatedly from massive amounts of data and function with high speed [17]. Consequently, all sectors have turned to support and promote the learning models that are related to the application of AI more and more, with an intention to develop greater competencies among their workforce.

Artificial Intelligence (AI) is playing more and more significant roles in many aspects of instruction process, including the tools, aids, techniques, and methods used in teaching. Thus, a new term "Artificial Intelligence Competency" has been created. According to United Nations Educational, Scientific and Cultural Organization (UNESCO), the term "Artificial Intelligence Competency" refers to the abilities to make use of Artificial Intelligence (AI) with responsibility and creativity, along with the in-depth understanding of technical, ethical, and social impacts of AI technology. Not only that, AI competency is said to prepare users to have necessary knowledge, understanding, and skills, as well as more participation in the development of AI for society in the future [18].

II. Literature Review

In recent years, there has been more and more interest in the learner-centered teaching approach, especially in the field of education, with an attempt to increase classroom engagement, problem-solving skills, and active and critical thinking skills [19]. The learner-centered education emphasizes not only the application of acquired knowledge, but also the abilities to create new bodies of knowledge. This approach is very important for students as it makes them enthusiastic to participate in the learning process, and this will result in deeper understanding and better memory of the contents [20]. New technologies have also been employed to open up more opportunities about creation of knowledge, interaction among learners, sharing of knowledge, and collaboration. It is believed that all of these can lead to the modernized and innovative forms of learning processes with greater emphasis on the roles of learners. Accordingly, the researchers analyzed the following theories with an attempt to identify the concepts relevant to this study:

- Flipped classroom
- Demonstration learning
- Metaverse
- Artificial intelligence
- Artificial intelligence competency

A. Flipped Classroom

The flipped classroom is an education approach in which learners can obtain new bodies of knowledge even outside the classroom and it is considered a very effective teaching method at present, in contrast to the traditional classroom learning in which the learning process takes place only in the classroom. To be successful in this learning style, teachers must be able to provide the well-structured instruction and active learning activities [7, 21]. Koh and Kim [20] mentioned that the flipped classroom has proven to be effective as it provides students with more opportunities to develop advanced thinking skills with guidance and assistance from their teachers and classmates. The flipped classroom also promotes learner-centered environments where students can interact and communicate with one

another; it is said that all of these can increase learner motivations. In addition, this teaching method allows students to learn with more enthusiasm all the time in the classroom. The flipped classroom can also make learning more flexible, promote self-directed learning skills, and allow teachers to assist their students in a more effective manner [22]. Basically, the flipped classroom focuses mainly on the pre-class learning via online media and then the in-class activities. In the classroom, a greater emphasis is usually placed on discussions and problem-solving, and meanwhile students are encouraged to have more engagement and gain personalized learning experiences [23]. Although the flipped classroom is believed to support learning and pave ways for many developments, there are still some issues to be taken into account. For instance, teachers need to find out the alternative approaches or methods in order to cope with the issues that may arise outside the classroom and find the most appropriate teaching methods that can support this process [24]. The synthesis on the flipped classroom process can be concluded as seen in Table 1.

Table 1. Synthesis on the flipped classroom process

Learning process		[5]	[21]	[22]	[25]	This work
Outside the classroom	Preparation of contents	✓	✓	✓	✓	✓
	Presentation of contents	✓	✓	✓	✓	✓
	Transmission of contents			✓		
	Self-learning		✓	✓	✓	✓
	Improvement and refinement			✓		✓
In the classroom	Participation in classroom activities	✓	✓	✓	✓	✓
	Interactive in classroom			✓		
	Summary of contents and suggestions	✓	✓		✓	✓
	Evaluation	✓	✓	✓	✓	✓

According to the synthesis on the processes used in the flipped classroom from the related documents and researches [5, 21, 22, 25], the process of the flipped classroom can be summarized into the following seven steps:

- Step 1 Preparation of contents: Teachers prepare the learning contents in the format of online media that can be used in the pre-class instruction.
- Step 2 Presentation of contents: Teachers install the contents and instruction media on a platform or any learning resources outside the classroom before having students study these contents and media.
- Step 3 Self-learning: Students begin to conduct self-learning on the contents that have been prepared by teachers.
- Step 4 Improvement and refinement: Teachers review and correct the errors found in the contents and media. In case the media or learning resources can be used effectively, teachers may continue to further develop them.
- Step 5 Participation in classroom activities: Both teachers and students do the classroom activities together.
- Step 6 Summary of contents and suggestions: Teachers summarize what have been learnt outside the classroom and what have been gained from the classroom activities so that students can have more understanding. Then teachers may give some suggestions for students so that they can correct their mistakes and do better in the next session.
- Step 7 Evaluation: Teachers conduct evaluation on students while allowing them to assess themselves. The results of evaluation shall be used as guidelines for the next instruction, and for improvement that can lead to the more effective learning

B. Demonstration Learning

Demonstration learning is an approach of learning that relies mainly on the demonstration of examples, presentations, or actions for students to see and understand better. This style of learning encourages students to learn by means of observation and listening to what are being demonstrated step by step, and then they are allowed to do practices by their own [8]. Referring to its advantages, demonstration learning can make teaching much clearer and more concrete, allowing students to have better understanding in what they are learning with more enthusiasm to do the class activities [26–28]. Furthermore, demonstration learning can significantly enhance students' understanding of concepts while increasing their perception and engagement in learning activities [29].

Demonstration method is a teaching process that gives prime significance to teachers because they are the ones who design, plan, and carry out the teaching process predominantly while students have just a little participation only. This method is therefore suitable for the teaching process that intends to let students see the explicit steps of specific practices [30]. In demonstration method, students are allowed to observe the practices first and then they will be shown with detailed demonstration later in class. Teachers begins with explanation on each step of practice and then demonstrates it by doing all of these steps for students to see and observe [31]. The learning processes and steps that occur from this demonstration will enable students to understand the concepts more easily [32]. The synthesis on the demonstration learning process can be concluded as seen in Table 2.

Table 2. Synthesis on the demonstration learning process

Learning process	[8]	[9]	[32]	[33]	This work
Preparation	✓	✓	✓	✓	✓
Motivation		✓			
Introduction to the lesson	✓		✓	✓	
Demonstration	✓	✓		✓	✓
Participation		✓	✓	✓	
Practice	✓			✓	✓
Evaluation		✓	✓	✓	✓
Conclusion and discussion		✓	✓	✓	

After doing the synthesis on the documents and researches relevant [8, 9, 32, 33] to demonstration learning, the stages of learning in this style can be concluded as below:

- Preparation: In this stage, teachers prepare learning media, contents, materials or equipment needed for demonstration including instructions on how to use them before the actual demonstration.

- Demonstration: Teachers lead the practices through the media or devices and explain the instruction in detail. At the meantime, teachers may use pictures or teaching aids to make it easier for students to understand.
- Practice: Students practice as to the demonstration from teachers in stage 2. At the meantime, teachers will oversee the practice to make sure that it is proceeded in a complete and correct manner. During this time, teachers may give advice and corrections to students' mistakes.
- Evaluation: Teachers will assess the learning outcomes of students in order to check the completeness and accuracy of learning. Also, teachers shall evaluate their own teaching to get feedback that can be used to improve their teaching techniques and methods in the next time

C. Metaverse

First introduced in 1992 in the science fiction novel "Snow Crash" by Neal Stephenson [34], "Metaverse" refers to a virtual world in which users can use their "avatars" to interact with one another through technologies and devices that support the access to that virtual world. So, metaverse is widely recognized as an immersive digital environment where people can create their own avatars, have participation in activities, and interact with others. For this reason, metaverse is now widely used as a brand-new social communication space [35] where users are able to share and exchange their learning experiences. Not only that, in recent years, metaverse has also been applied in a number of new instruction models that integrate the use of mobile devices into education, leading to the more comprehensive learning experiences. At the same time, more and more learners are becoming more eager to perform self-learning as they are able to learn anywhere and anytime in any environments that can promote learning [11]. In addition, the metaverse is a 3D virtual reality in which people can interact with one another in real time under virtual environments [36]. Park and Kim [37] stated that metaverse is composed of four elements of, i.e., environment, interface, interaction, and privacy policy

Once considering the overall concepts, theories, and literatures related to metaverse [35, 10], it is found that metaverse can be integrated with education because it offers more convenience and more accessibility to learning processes. This enables learners not only to use all resources available in virtual world but also to participate in activities and interact with others therein, which opens more opportunities for collaborative learning. Moreover, the interaction in metaverse allows learner to learn and create interactive contents during the learning process by means of digital technology, which enables them to learn anywhere and anytime in almost all virtual environments

D. Artificial Intelligence

Artificial Intelligence (AI) is a brand-new technology initiated by the combination of human intelligence and technologies in order to create the more intelligent tools and devices that are easy to use but with more capabilities Kingchang *et al.* [38]. AI has been playing more and more vital role in facilitating and promoting learning and education because this technology makes it possible to create the helpful learning models or learning processes with a variety of commands, which can respond well to the needs of users [15]. In addition, AI can be employed to follow up academic progress and engagement levels, giving such valuable insights about learning trends that users can use them in decision-making or in the design of courses and teaching methods appropriate for individual learners. It is believed that all of the aforementioned can lead to better educational outcomes [39].

Nonetheless, AI technology also has negative aspects that users and developers have to face with if it is put to wrong use. The research of Mikalef *et al.* [40] points out the following negative aspects and impacts of AI that are caused by its misuse:

1) Increase inequalities: AI is likely to create or exacerbate inequalities in society, particularly in terms of employment and economic development. This issue may arise from developers who have biases during the processes of system development and construction.
2) Lack of transparency: The functions and operations of AI systems are often not easily to understand, making it difficult for users to monitor or explain the results in an explicit manner.
3) Dehumanization: With too much reliance on AI for decision-making, humans are likely to lose control or authority over some major decisions.
4) Discrimination: AI can yield the unfair outcomes, such as discrimination against certain groups of people in hiring processes or service provision.
5) Privacy risks: The use of AI to collect and analyze personal information may lead to the breaches of privacy and data security.
6) Psychological impact: The application of AI may cause some psychological problems like technostress, technology addiction, etc.

Nonetheless, good understanding of these AI impacts can help designate the proper guidelines to develop and use AI in a more responsible manner, which can prevent the plausible negative impacts that may arise in the future.

E. Artificial Intelligence Competency

The term "artificial intelligence competency", or AI competency, stems from the combination of two words, i.e., "competency" and "artificial intelligence". A scholar named McClelland [41] had studied the behaviors of individuals and found that they possess different abilities to work. Individuals who are highly efficient have something called competency. Additionally, UNESCO [18] stated that "Artificial intelligence competency refers to the ability of learners to use and participate with artificial intelligence in a responsible and creative manner." After studying the above concepts and the related researches [42], the researchers have received the overall conclusion of AI competency for use as a guideline in this study. To illustrate, AI competency in this study refers to the components of knowledge, skills, and capabilities that users must have in order to understand, use, and apply AI technology effectively. Besides, AI competency also means having discretion, responsibilities, awareness of data security, and ethics related to the use of AI.

III. Research Objectives and Hypotheses

A. Research Gabs

The main problem of this research is that the instruction management after the pandemic of COVID-19 has been greatly changed and improved, which results in some significant changes in learning styles, learning outcomes, and perspectives of teachers and students. In addition, a great number of AI applications have been invented and widely used, leading to many changes in the world of education. Many theories and researches have been discussing about online learning, the use of learning media, approaches, methods, and assessment of time allocation to achieve the set goals. Therefore, there should be the raise of awareness and importance on learning through the online learning environments as well as positives attitude towards the use of AI. The most noticeable part of these changes is the changing from traditional classroom learning to the education management that is corresponding to the behaviors of learners in the current contexts and meanwhile capable of supporting the future contexts of the new generation education. To illustrate, the education management for today's learners must enable them to find out a learning process based on their hands-on experiences immediately.

In reference to the thorough examination of the overall concepts herein, it is found that this study still has some significant research gaps. So, there is great necessity to further study the guidelines for the development of the flipped classroom with demonstration learning platform via metaverse so as to enhance learners' knowledge, skills, and positive attitudes towards the use of AI, which will eventually promote their artificial intelligence competency, or AI competency. It is said that AI competency is highly important for learners in the 21st century because it not merely helps improve the quality of Thai youth but also affects the enhancement of education quality that focuses on the pursuit of knowledge, improvement of skills, and fostering of positive attitudes towards lifelong learning.

B. Research Objectives

RO1: To synthesize the conceptual framework of architecture of the FCWD learning platform via metaverse to enhance artificial intelligence competency.

RO2: To design the architecture of the FCWD learning platform via metaverse to enhance artificial intelligence competency.

RO3: To develop the FCWD learning platform via metaverse to enhance artificial intelligence competency.

RO4: To study the results of the development of the FCWD learning platform via metaverse to enhance artificial intelligence competency.

C. Research Hypotheses

RH_1: The suitability of the architecture of the FCWD learning platform via metaverse to enhance artificial intelligence competency is at high level.

RH_2: The quality of the FCWD learning platform via metaverse to enhance artificial intelligence competency is at high level.

RH_3: The students, who learnt with the FCWD learning platform via metaverse to enhance artificial intelligence competency, have got better learning achievement of artificial intelligence at the significance level of 0.01.

IV. Materials and Methods

The development of the FCWD learning platform via metaverse to enhance artificial intelligence competency is based mainly on systems approach [43, 44], which is used to design and develop the instruction system containing systematic structure and elements, and the theories of the System Development Life Cycle (SDLC) [45] that represents the steps and processes used to develop an online learning system.

A. Research Design

In this study, the researchers relied on the pre-experimental research method with one group pretest/posttest design [46] with an intention to prove the capability and efficiency of the platform developed herein by comparing the students' outcomes of knowledge before and after learning with the said platform. Also, this is to find out whether the students who learned with this platform have got significantly higher learning achievement or not. The sample group for actual testing is quite small with limited number of students due to the required individual characteristics and specific course subjects. Therefore, the researchers decided to employ the pre-experimental research method with one group pretest/posttest design in the study. This study is also intended to prove all three research hypotheses based on the following guidelines:

To prove the research hypothesis 1 (RH_1): The researchers had designed the architecture of the FCWD learning platform via metaverse and used it as a prototype for further development of the platform that can be put in practical use. The architecture developed herein contains all details and complete elements that are consistent not only with the concepts of systems approach but also with the flipped classroom and demonstration learning, which is said to enhance artificial intelligence competency. In order to verify the suitability of the architecture of the FCWD learning platform via metaverse, the researchers employed the questionnaire comprising the questions about the elements of this learning platform. This is to find out how suitable the elements and steps designed herein are, and whether they can be applied as guidelines to further develop the platforms that can be used practically.

To prove the research hypothesis 2 (RH_2): The researchers used the elements and the learning process designed in the architecture of the FCWD learning platform via metaverse in the previous stage as guidelines to develop the FCWD learning platform via metaverse and put it in practical use in order to find out whether it is efficient enough to promote AI competency. To prove the quality of this learning platform, the researchers used the 5-level rating scale questionnaire produced based on Likert Scale [47], containing 19 questions asking about different elements in the platform, e.g., quality of the platform, suitability of design, efficiency of functions, suitability for application, etc. This is to verify whether the elements and the learning process of the FCWD learning platform via metaverse can be put in practical use and whether the said platform can enhance AI competency.

To prove the research hypothesis 3 (RH_3): The researchers tested the FCWD learning platform via metaverse with 32

participants who were derived by means of cluster sampling; thereby, these participants are the students of Rajinibon School, all of whom are at grade 12 enrolled in the course "Computer for Career". The researchers employed the evaluation form (multiple choice of 4 alternatives) containing 30 questions to measure their learning achievement of artificial intelligence before and after letting them learn with this platform. This is all to compare their ability to learn through this platform, and to see whether these students have higher learning achievement with significance level or not after learning with the FCWD learning platform via metaverse.

B. Participants

The participants in this research include: 1) five experts in the field of educational management from Rajinibon School; 2) four experts with at least seven years of experiences in design and development of instruction system architecture from different higher education institutions, all of whom were derived by means of purposive sampling and invited personally by the researchers; and 3) 32 students of Rajinibon School, all of whom are studying at grade 12 and enrolled in the course "Computer for Career" in semester 2 of academic year 2024. The three groups of these research participants were well protected with the policies of confidentiality and anonymity in accordance with the research ethics.

C. Instruments and Data Collection

The instruments used for data collection in this research are: 1) the architecture of the FCWD learning platform via metaverse to enhance artificial intelligence competency, 2) the FCWD learning platform via metaverse to enhance artificial intelligence competency, 3) the evaluation form, produced based on Likert Scale, on the suitability of the architecture of the FCWD learning platform via metaverse to enhance artificial intelligence competency, of which the questions were synthesized from the concepts of systems approach that takes obvious elements and processes into consideration, 4) the evaluation form on the quality of the FCWD learning platform via metaverse to enhance artificial intelligence competency, produce in the format of 5-level rating scale questionnaire based on Likert Scale [47], containing 19 questions asking about different elements in the platform, e.g., quality of the platform, suitability of design, efficiency of functions, suitability for application, etc., and 5) the evaluation form (multiple choice of 4 alternatives) on the learning achievement of artificial intelligence before and after using the FCWD learning platform via metaverse. In order to collect the data in this study, the researchers had the evaluation forms on suitability, quality, and learning achievement of artificial intelligence proved for validity and for index of Item Objective Congruence (IOC) by experts. Especially, the evaluation form on learning achievement of artificial intelligence was also proved for index of discrimination, difficulty, and reliability before being used with the participants in this research.

The statistics used in data analysis are mean, standard deviation, and t-test dependent. In order to collect the data, the researchers asked the participants to complete the evaluation form on the learning achievement of artificial intelligence, which had been proved for validity and for index of Item Objective Congruence (IOC), in order to study the results of the development of the FCWD learning platform via metaverse to enhance artificial intelligence competency.

D. Method

This research is designated to examine the perspectives towards the FCWD learning platform via metaverse to enhance artificial intelligence competency, which was developed on the basis of systems approach [43, 44] and the theories of SDLC [45]. Thereby, the research methodology can be summarized into four phases as below:

Phase 1: Synthesize the conceptual framework of the architecture of the FCWD learning platform via metaverse to enhance artificial intelligence competency for use as a guideline to further create the learning process used in the FCWD learning platform via metaverse. In this phase, the conceptual framework of the architecture was derived by means of study, analysis, and synthesis on the documents and researches related to the FCWD learning platform via metaverse. Then, the said conceptual framework would be applied to design the learning process for use in the platform developed in this study.

Phase 2: Design the architecture of the FCWD learning platform via metaverse to enhance artificial intelligence competency. This phase is about the synthesis of processes acquired from the study and synthesis on the related theories in phase 1. These processes were then applied as guidelines to design the architecture of this platform, which consists of three elements, i.e., (1) input factor, which refers to the related components used as data within the platform, (2) the FCWD learning process via metaverse, which is a learning process synthesized from the flipped classroom learning process combined with the demonstration learning process, coupled with the learning environments via metaverse that can support outside-classroom learning, and (3) output, which refers to learning competency and artificial intelligence competency.

Phase 3: Develop the FCWD learning platform via metaverse to enhance artificial intelligence competency. The researchers relied on the principles of systems approach combined with the SDLC techniques as guidelines to develop the FCWD learning platform via metaverse with the aid of Spatial.io platform. This platform can support outside-classroom learning with virtual classrooms, which can provide learners with various learning experiences and enable them to learn anywhere and anytime. Besides, the researchers also applied the theories and concepts of AI technology in order to provide users with more convenience, along with user authentication to access the contents. This is all to promote the learning throughout all processes and meanwhile monitor the learning outcomes with real-time responses. This method is believed to help students perceive information quickly with no violation of privacy. Furthermore, they are able to participate in learning and do activities and practices by their own in virtual environments that are simulated by means of AI technology.

Phase 4: Study the perspectives towards the FCWD learning platform via metaverse to enhance artificial intelligence competency. This phase is related to the examination of the perspectives of all three groups of participants towards the development of the FCWD learning platform via metaverse in order to prove the three research

hypotheses. The research hypothesis 1 (RH_1) and 2 (RH_2) were proved by the study on the suitability of the architecture and the quality of the platform before putting it in practical use, which was assessed by the nine experts derived by means of purposive sampling. For the research hypothesis 3 (RH_3), it was proved based on the learning outcomes of 32 students of Rajinibon School who are studying at grade 12, after letting them use the platform developed in this research. Whereby, the criteria and the interpretation of the 5-level rating scale evaluation form are as follows:

The criteria and the interpretations [47] of this 5-rating scale evaluation form are as follows:

- Average score of 4.50–5.00 refers to very high level
- Average score of 3.50–4.49 refers to high level
- Average score of 2.50–3.49 refers to average level
- Average score of 1.50–2.49 refers to low level
- Average score of 0.00–1.49 refers to very low level

V. Results and Discussion

The results of the development of the flipped-classroom demonstration learning platform via metaverse to enhance artificial intelligence competency (FCWD learning platform via metaverse) can be summarized into four phases as below:

Results of Phase 1: Synthesis of the conceptual framework of the architecture of the FCWD learning platform via metaverse to enhance artificial intelligence competency

After the study, analysis, and synthesis on the documents and researches concerning the FCWD learning platform via metaverse to enhance artificial intelligence competency for use as a guideline to establish the conceptual framework and create the learning process in this research, the researchers obtained the conceptual framework of the FCWD learning platform via metaverse as shown in Fig. 1.

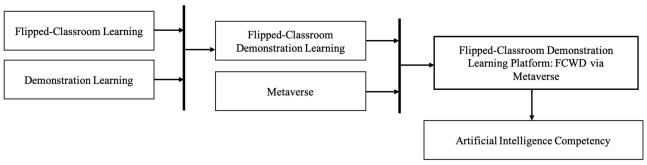

Fig. 1. Conceptual framework of the FCWD learning platform via metaverse.

Results of Phase 2: Design of the architecture of the FCWD Learning Platform via metaverse to enhance artificial intelligence competency

The architecture of the FCWD learning platform via metaverse is a research tool that was employed to facilitate the instruction management using the flipped classroom learning process coupled with demonstration learning. The emphasis is primarily placed on the integration of virtual world technologies with learning management and instruction activities, aiming to stimulate learners to develop AI competency, which includes learning achievement of artificial intelligence, artificial intelligence skills, and awareness of the impact of using artificial intelligence. Thereby, the FCWD learning platform via metaverse is illustrated in Fig. 2.

According to Fig. 2, the architecture of the FCWD learning platform via metaverse to enhance artificial intelligence competency is composed of the following details:

1) Input factor: This refers to the three main elements employed in the design and development of the FCWD learning platform via metaverse, including (1) stakeholders, i.e., teachers and students, (2) interface devices such as computer, tablets, notebooks, smartphone, etc., and (3) network and connection, which refers to a variety of network systems that can be used to access the FCWD learning platform, e.g., wireless network, cellular, broadband internet, web browser, etc.
2) The FCWD learning process via metaverse: The researchers divided the learning process into 2 formats (outside-classroom learning and classroom learning) corresponding to the current learning management. In this study, the researchers synthesized the FCWD learning process via metaverse from the documents and researches related to the flipped classroom learning management, which consists of seven steps [5, 21, 22, 25] (preparation of contents, presentation of contents, self-learning, improvement and refinement, participation in classroom activities, summary of contents and suggestions, and evaluation) and demonstration learning, which comprises only four steps [8, 9, 32, 33] (preparation, demonstration, practice, and evaluation). As a result, the researchers acquired four steps for use in the FCWD learning process via metaverse as seen in Table 3.

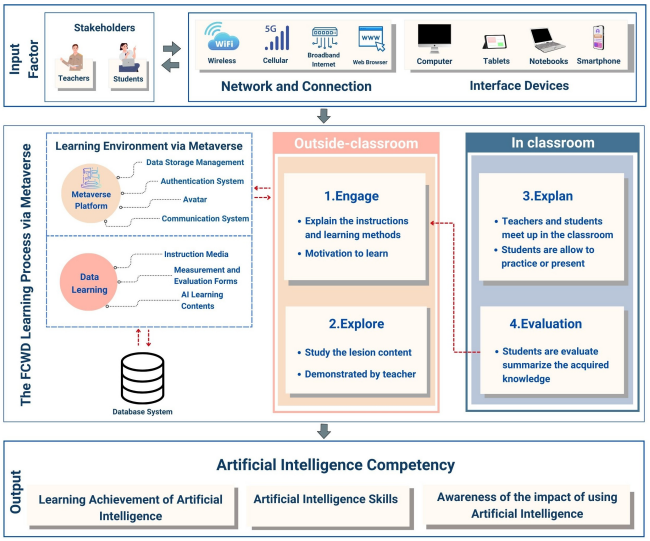

Fig. 2. Architecture of the FCWD learning platform via metaverse to enhance artificial intelligence competency.

Table 3 represents the FCWD learning process, which was synthesized from the related documents and researches [5, 8, 9, 21, 22, 25, 32, 33]. Thereby, the FCWD learning process used in this study can be summarized into the following stages:

- The outside-classroom learning refers to the learning process in which learners spend the time outside the classroom studying the contents, images, videos, and other information prepared by teachers before classroom learning. There are two stages in the outside-classroom learning. The first one is the stage of "Engage", which refers to the preparation before the instruction process both in and outside the classroom. To illustrate, teachers prepare the contents, media, and documents for learning. Once meeting students in the classroom, teachers will explain the usage of media and learning methods, as well as the objectives, goals and what students have to do in the instruction process

before starting the class. The other stage is "Explore", in which learners are encouraged to study the lesson contents posted by teachers. Students study the said contents and do both practices and tests through the media, documents, and videos step by step as demonstrated by teachers. In case of any problems or questions, students can note them down and ask teachers for help in classroom learning. This is considered a style of self-learning outside the classroom before meeting teachers in the classroom learning.

Table 3. The FCWD learning process via metaverse

Steps of the FCWD learning process		Teachers' roles	Students' roles
In classroom	Outside-classroom		
	1. Engage step	- Define learning objectives - Prepare learning media for outside-classroom learning - Present the said learning media	- Listen to the learning process - Inquire about doubts and problems related to learning
	2. Explore step	- Answer students' questions and doubts - Test students' knowledge	- Study the contents step by step - Follow the demonstration steps - Note problems and doubts
3. Explain step		- Give suggestions to students - Give advice on questions - Manage the classroom - Monitor the progress	- Present the process learnt from the demonstration - Listen to suggestions and troubleshooting
4. Evaluate step		- Test knowledge and skills by means of exercises - Set up plans for the next lessons - Improve and modify the learning media - Evaluate learners - Link the learning contents	- Link the knowledge - Evaluate their own works - Gather the knowledge gained - Evaluate their own performance

Learning environment via metaverse refers to the virtual environment designated for the instruction management outside classroom. The necessary elements required in such virtual learning environment include metaverse platform, instruction media, AI learning contents, and measurement and evaluation forms.

- The classroom learning is the session when students meet teachers in the classroom after doing self-learning in the earlier stages. Students present what they have done or practiced to teachers, and then teachers shall conduct assessment on the said practices. The classroom learning consists of two stages. The first stage is "Explain". Teachers and students meet up in the classroom, and students do practices or present what they have learned from the outside-classroom learning process to teachers. Teachers listen to problems and questions of students and then give advice, suggestions, improvements, and help them solve the said problems. At the meantime, teachers evaluate what the students have practiced or presented and examine their progress. The other one is the stage of "Evaluate", in which teachers assess the lessons and media that have been used in the instruction process to see whether they can help learners understand the lesson contents better or not. Should there be any problems, teachers must adjust these learning materials so that they become more appropriate for learning. In case the lessons and media seem quite efficient, it is still necessary to further improve them in order to increase their efficiency. Also, learners are allowed to evaluate their own works, summarize the knowledge gained, and then apply or link it with their future work.

3) Output: This element refers to AI competency, which consists of bodies of knowledge, skills, and capabilities that users need in order to understand, utilize, and apply AI technologies in an efficient, discerning, and responsible manner. AI competency also covers the abilities to analyze and assess all data derived from artificial intelligence systems. There are three aspects of AI competency, i.e., learning achievement of artificial intelligence, artificial intelligence skills, and awareness of the impact of using artificial intelligence.

Results of Phase 3: Development of the FCWD Learning Platform via metaverse to enhance artificial intelligence competency.

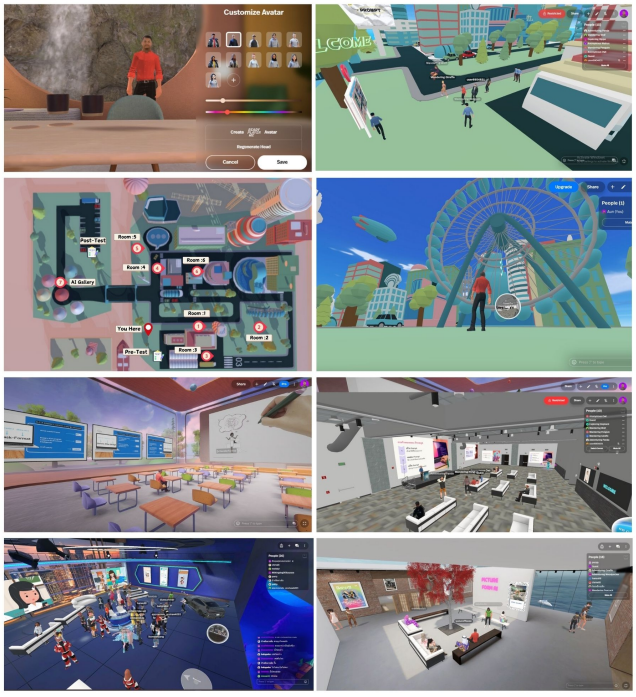

Fig 3. The FCWD learning platform via metaverse to enhance artificial intelligence competency.

The FCWD learning platform via metaverse is a practical tool designated to support and promote learning. Devised with Spatial.io platform, this learning platform can also support a variety of functions. Thanks to the FCWD learning platform, learners have no limitations of time and place when they desire to access and study the contents before attending the classroom learning. Basically, this study emphasizes the design of a learning environment and a virtual classroom intended for learning about artificial intelligence. The researchers employed learning technologies in metaverse to develop the learning platform in this study with an attempt to

provide learners with new experiences that may increase their interest in self-learning, especially the learning about different aspects of artificial intelligence, the responsible application of this technology, and the good attitudes towards the use of artificial intelligence. In addition, the researchers also adopted the theories and concepts of AI technology along with user authentication to access the contents in order to provide users with more convenience. This is to promote the learning throughout all processes and meanwhile follow up the students' learning outcomes with real-time responses. It is believed that this method not only helps students perceive information quickly with no violation of their privacy but also ensures that the AI system used in this learning platform is transparent and explicable. It is expected that all of the aforementioned shall make students feel quite satisfied with the capabilities of the said platform.

Thereby, the FCWD learning platform via metaverse is illustrated in Fig. 3.

Results of Phase 4: Study of perspectives towards the use of the FCWD learning platform via metaverse to enhance artificial intelligence competency

The study of the said perspectives was conducted by considering the evaluation results obtained from the three groups of research participants. This is to prove the three research hypotheses established in this study. The results of the study can be concluded as below:

A. Results of Evaluation on the Suitability of the Architecture of the FCWD Learning Platform via Metaverse to Enhance Artificial Intelligence Competency

The study of the suitability of the architecture of this platform was carried out with the 5-level rating scale evaluation form produced based on Likert Scale. The details and the elements mentioned in this form are obviously consistent with the concepts of systems approach and the FCWD learning process, both of which were used as guidelines to develop the practical FCWD learning platform via metaverse. The results of evaluation on the architecture of the FCWD learning platform via metaverse are shown in Table 4.

Table 4. Suitability of the architecture of the FCWD learning platform via metaverse

Lists		Mean	SD	Result
The suitability of the architecture of the FCWD learning platform via metaverse (overall)				
1. Suitability of principles and concepts used in the design of the architecture of the FCWD learning platform via metaverse		4.56	0.53	Very high
2. Suitability of the elements in the architecture of the FCWD learning platform via metaverse		4.78	0.07	Very high
3. Suitability of the architecture of the FCWD learning platform via metaverse to promote AI competency		4.67	0.50	Very high
4. Ability to promote AI competency of learning stages and activities in the architecture of the FCWD learning platform via metaverse		4.67	0.50	Very high
5. Overall suitability of the architecture of the FCWD learning platform via metaverse to be applied in the development of the FCWD learning platform via metaverse		4.67	0.50	Very high
Average		**4.67**	**0.20**	**Very high**
The suitability of the architecture of the FCWD learning platform via metaverse				
Input factor	1. Stakeholders	4.78	0.44	Very high
	2. Interface devices	4.89	0.33	Very high
	3. Network and connection	5.00	0.00	Very high
Average		**4.89**	**0.23**	**Very high**
FCWD learning process via metaverse	1. Engage step	4.67	0.50	Very high
	2. Explore step	4.67	0.50	Very high
	3. Explain step	4.78	0.44	Very high
	4. Evaluation step	4.56	0.53	Very high
Average		**4.67**	**0.41**	**Very high**
Learning environment via metaverse	1. Metaverse platform	4.89	0.33	Very high
	2. Instruction media	4.78	0.44	Very high
	3. AI learning contents	4.67	0.50	Very high
	4. Measurement and evaluation forms	4.78	0.44	Very high
Average		**4.78**	**0.36**	**Very high**
Output	1. Learning achievement of artificial intelligence	4.89	0.33	Very high
	2. Artificial intelligence skills	4.67	0.50	Very high
	3. Awareness of the impact of using artificial intelligence	4.89	0.33	Very high
Average		**4.81**	**0.34**	**Very high**

Note. SD (Standard Deviation)

In reference to the results of evaluation in Table 4, it is evident that the suitability of the architecture of the FCWD learning platform via metaverse (overall) is at very high level (mean = 4.67, SD = 0.20). Once considering each element separately, the suitability of input factor (mean = 4.89, SD = 0.23), FCWD learning process via metaverse (mean = 4.67, SD = 0.41), learning environment via metaverse (mean = 4.78, SD = 0.36), and output (mean = 4.81, SD = 0.34) is all at very high level as well.

The results mentioned above are corresponding to the research hypothesis RH_1; that is, the architecture of the FCWD learning platform via metaverse can be applied as a prototype to develop the FCWD learning platform via metaverse that can be put in practical use in the future because the said architecture contains the clear stages and all essential elements that are compliant to the FCWD learning process. Moreover, the learning environment via metaverse was also applied in the outside-classroom learning and activities, which is believed to enable learners to follow up the contents continuously, interact with others in collaborative activities, and enhance their AI competency after learning with the FCWD learning process. This is in line

with the research of Chatwattana *et al.* [48], who stated that the utilization of digital innovations and technologies in instruction management, research, and academic services can not only promote future learning and lifelong learning in a seamless manner, but also give more chances to receive self-learning experiences directly. Furthermore, the results are also consistent with the research of Muensopha *et al.* [7], who used the flipped classroom learning process coupled with the activity-based learning process that focuses on student-centered instruction management as a guideline to develop the flipped classroom model with activity-based learning via metaverse. The said study also insists that the flipped classroom model with activity-based learning via metaverse can be employed as a tool to effectively improve English speaking skills.

B. Results of Evaluation on the Quality of the FCWD Learning Platform via Metaverse to Enhance Artificial Intelligence Competency

To prove the quality of the FCWD learning platform via metaverse, the researchers used the questionnaire containing 19 questions asking about different elements in the platform, e.g., quality of the platform, suitability of design, efficiency of functions, suitability for application, etc. Thereby, the results of evaluation on the quality of the FCWD learning platform via metaverse are presented in Table 5.

According to the results of evaluation on the quality of the FCWD learning platform via metaverse in Table 5, it is found that the quality (mean = 4.58, SD = 0.10), design (mean = 4.75, SD = 0.03), efficiency (mean = 4.73, SD = 0.10), and application for practical use (mean = 4.74, SD = 0.07) are all at very high level, which is in compliance to the research hypothesis RH_2; that is, the FCWD learning platform via metaverse is considered such an efficient learning tool that it can be applied practically to enhance the three aspects of AI competency, i.e., learning achievement of artificial intelligence, artificial intelligence skills, and awareness of the impact of using artificial intelligence. The FCWD learning process under virtual learning environments can create self-learning experiences through interactive and collaborative activities on metaverse, which is said to lead to the more effective learning. The results are in line with the research of Sisamud *et al.* [49], who used the real world or metaverse to promote the learning management using digital environments that can provide immersive experiences, integrated with the five steps of design thinking process (empathize, define, ideate, prototype, and test) designated to promote Buddhist innovators, who are able to disseminate Buddhist principles to the public through practices and collaboration. The findings of contexts related to the application of the real world from this study indicate that it is possible to provide learners with brand-new experiences that lead to the so-called immersive self-learning since they can interact and respond to each other as if they were in the physical world. The results are also consistent with the research of Kingchang *et al.* [38], who developed the AI Chatbots Platform for higher education guidance. The said research found that the use of AI technology and digital innovations in the creation of decision-making tools for further education can fulfill the needs of users because the said tools can be practically applied in education guidance thanks to the capabilities of AI technology that can analyze and examine questions accurately and precisely. Not only that, AI in the said tools is capable of selecting response data that are consistent and appropriate with users' aptitudes.

Table 5. Quality of the FCWD learning platform via metaverse

	Lists	Mean	SD	Result
Quality	1. Ease and convenience to use and understand	4.89	0.33	Very high
	2. Images and languages	4.44	0.53	High
	3. Fonts and colors	4.44	0.53	High
	4. Completeness of information	4.56	0.53	Very high
Total average		**4.58**	**0.10**	**Very high**
Design	5. Suitability of classroom arrangement and its continuity	4.67	0.50	Very high
	6. Design of classroom on metaverse	4.78	0.44	Very high
	7. Design of classroom's elements on metaverse	4.78	0.44	Very high
	8. Design of the platform that can promote the flipped classroom learning	4.78	0.44	Very high
Total average		**4.75**	**0.03**	**Very high**
Efficiency	9. Capabilities of the platform	4.78	0.44	Very high
	10. Speed of connection to the classroom on metaverse	4.56	0.53	Very high
	11. Speed of data presentation on metaverse	4.56	0.53	Very high
	12. Overall response time	4.89	0.33	Very high
	13. Efficiency of functions	4.89	0.33	Very high
Total average		**4.73**	**0.10**	**Very high**
Application for practical use	14. FCWD learning platform can promote knowledge and understanding concerning the use of AI.	4.67	0.50	Very high
	15. FCWD learning platform can promote AI skills.	4.67	0.50	Very high
	16. FCWD learning platform can promote positive attitudes towards AI.	4.67	0.50	Very high
	17. FCWD learning platform can be practically used to promote instruction.	4.89	0.33	Very high
	18. FCWD learning platform can promote self-learning.	4.78	0.44	Very high
	19. FCWD learning platform can be put in practical use.	4.78	0.44	Very high
Total average		**4.74**	**0.07**	**Very high**

Note. SD (Standard Deviation)

From the in-depth interview with the research participants, it is obvious that the FCWD learning process in the FCWD learning platform via metaverse is quite systematic and reliable as it was synthesized from the related documents and researches. The said learning process can be employed as a guideline to develop the FCWD learning platform via metaverse that can be put in practical and effective use. Besides, the FCWD learning platform via metaverse is also

capable of presenting contents and faciliating collaborative activities via metaverse environment, in which learners are able to join activities, chat with others, and assign their responsibilities before classroom learning. This is deemed as the good preparation before learning in the classroom, which can increase students' interest in following the contents continuously. The aforementioned details are in accordance to the research of Chatwattana *et al.* [50], who said that the integration of new technology concepts to devise new innovations to promote learning in the New Normal era will provide direct experiences through virtual learning environments. Then this can lead to virtual learning communities with borderless education and learning that can support active learning and provide learners with self-learning experiences. The results on the quality of FCWD learning platform is illustrated in Fig. 4.

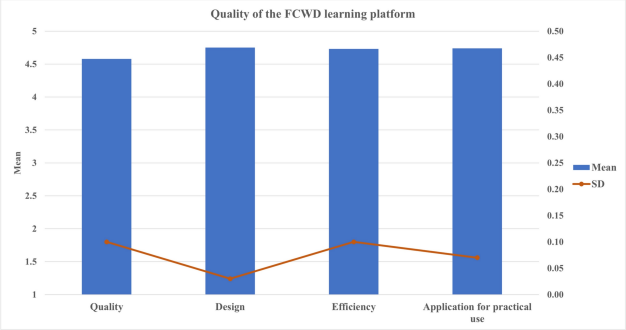

Fig 4. Results on the quality of the FCWD learning platform via metaverse by experts.

C. Results of Learning Achievement of Artificial Intelligence Score Before and After Learning with the FCWD Learning Platform via Metaverse

Table 6. Comparative of learning achievement (N = 32)

Test	Full score	Mean	SD	t-test	Sig.
Pre-test	30	19.00	2.67	17.00	0.00**
Post-test	30	25.50	2.83		

** Significant at the level of 0.01 (α = 0.01, degrees of freedom (df) = 31)
Note. SD (Standard Deviation)

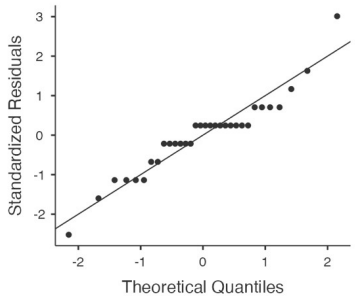

Fig. 5. Distribution diagram of learning achievement of artificial intelligence using the Jamovi program.

Table 6 represents the comparison of learning achievement of artificial intelligence score before and after learning with the FCWD learning platform via metaverse. It is found that the students, or the research participants in one-group pretest-posttest design, who had already learned with the FCWD learning platform via metaverse, received higher learning achievement of artificial intelligence score. It can be clearly seen that the mean of the learning achievement of artificial intelligence score of these students after learning with this platform (mean = 25.50, SD = 2.83) is higher than before learning with this format (mean = 19.00, SD = 2.67). This insists that the FCWD learning process via metaverse really helps students achieve higher learning achievement of artificial intelligence score at the significance level of 0.01, which is corresponding to the research hypothesis RH_3. Referring to the distribution coefficient in Fig. 5, the score distribution is obvious and it is not clustered, which indicates that the FCWD learning platform via metaverse is capable of distinguishing the differences of students' learning outcomes.

The findings above are compliant to the research of Muensopha *et al.* [7], who stated that the integration of concepts, principles, and theories about the application of new teaching innovations to design systematic processes in the instruction models based on systems approach can assist learners to learn in a systematic way with more creative engagement. And this shall lead to the development of knowledge and thinking skills as well as higher academic achievements. This is also in line with the research of Dobrovská *et al.* [51], who said that the application of AI technology in education has aroused more interest among teachers, scholars, researchers, and students. The said research found that the use of AI technology in education can encourage learners not only to learn new topics promptly, but also to manage and understand a large amount of data efficiently. Additionally, it is expected that the use of AI technology can promote creative thinking skill, problem-solving skill, and decision-making skill. However, the reliability in the use of AI is still in doubt and it is one of the limitations found in with this study.

According to the discussion with the focus groups of 3–5 students, it is found that the FCWD learning platform via metaverse can promote their engagement in self-learning through hands-on learning in virtual environments, in which the real situations are simulated by means of AI technology in order for these students to take part in learning management and do activities therein. In addition, there is the real-time feedback system that allows students to receive information quickly and meanwhile follow the contents continuously, which can lead to the more effective learning. The results of the practical discussion are corresponding to the study of learning achievement of artificial intelligence, which was described in detail in the previous study. Besides, the researchers conducted the in-depth interview about the teaching methods and processes used in the FCWD learning platform via metaverse and compared them with the traditional teaching methods used in classroom learning. It is found that the students were more interested in the application of virtual technology as it was seemed as new things that could motivate them to learn rather than listening to the lecture generally used in traditional classroom learning. The students could also engage more in interaction with their team members, enabling them to gain new bodies of knowledge more quickly. This will eventually lead to the development of technology skills, digital literacy skills, and artificial intelligence skills. All are regarded as the specific skills related to AI that have influence on practical learning in the long run.

VI. Conclusion and Limitations

The FCWD learning platform via metaverse is considered

a learning tool designated to enhance artificial intelligence competency. The main concept of this learning platform is based on the integration of the flipped classroom learning with demonstration learning via metaverse, with an intention to use virtual reality technology to promote the New Normal learning that can provide hands-on experiences through virtual learning environments. Also, it is believed that the learning of this style can pave ways to the creation of virtual learning communities and borderless education management.

A. Investigation of Learning Outcomes

This study is intended to examine the perspectives towards the development of the FCWD learning platform via metaverse in order to find out whether this learning platform is efficient enough for students to use it so as to improve the AI competency. In reference to the evaluation results derived from the research participants, it is obvious that the results are corresponding to all the three research hypotheses. This confirms that the FCWD learning platform via metaverse developed in this study has enough quality and efficiency to be put in practical use in order to promote self-learning and provide hands-on learning experiences via digital learning environments.

After conducting the in-depth interview about the teaching methods and processes used in the FCWD learning platform via metaverse and comparing them with the traditional teaching methods used in classroom learning, the researchers found that the FCWD learning platform via metaverse consists of both flipped-classroom learning process and demonstration learning process via metaverse, which were synthesized from the related documents and researches in a systematic and reliable manner. In addition, the students seemed to have more enthusiasm to learn with the presentation of contents and collaborative activities facilitated via metaverse environments, enabling them to have preparedness before learning in classroom and then making them pay more attention to the contents and quickly perceive new bodies of knowledge. Furthermore, the more interactions with team members are said to help the students develop some specific skills related to AI that will affect practical learning in the long term. All of the aforementioned are vividly different from the traditional teaching methods. The study above can be employed as a guideline to support the research of Sapliyan *et al.* (2023) [10], who promoted the learning and activity management in virtual environments that allow access to hands-on learning and presentation of the works through virtual technology. Thereby, the said learning management is compatible with most displays on smartphone devices, and this is said to help learners have higher learning achievement as well as the characteristics of young innovators who are able to connect, question, observe, experiment, and build networks in order to transfer knowledge. All of the aforementioned can prove the findings that the application of the real world to facilitate learning and activities can promote learners' engagement and real-time interaction through digital technology, which shall result in practical learning and then higher learning achievement.

B. Limitations and Future Research

Primarily, this research can be practically employed as a guideline to study the development results of the FCWD learning platform via metaverse that can encourage learners to achieve self-learning via the FCWD learning process. Thereby, it is expected that the FCWD learning platform can increase learning flexibility, create enthusiasm, and promote self-learning skills through the simulated environments and situations on metaverse. Once considering the limitations in this research, it is found that the sample group of this research is rather small, so the findings acquired herein are considered just the findings from a pilot study. Thus, for future development, it is recommended to carry out studies with a larger sample group along with more additional tests so as to study the results of using the FCWD learning platform via metaverse in other learning environments. This may include assessment on other aspects of AI competency, such as specific skills or ability to apply knowledge in the practical situations. This method can demonstrate the effectiveness of the FCWD learning platform via metaverse in other relevant contexts. Not only that, there should be the study of further practical research results in order to confirm the effectiveness of the FCWD learning platform via metaverse in a more comprehensive manner. The other limitation is that the experiment in this research was conducted with a single pre-test/post-test group, and this limits the usability of the platform. Therefore, in order to confirm the study results more clearly, the three sample groups in this research should be combined to increase the sample size. Besides, the researchers should employ the methodology that can make a comparison with conventional teaching methods, e.g., a control group or a quasi-experimental design, in order to confirm the validity and reliability of the research results. Not only that, there should be the study of scalability of the virtual classroom and its maintenance including the examination of learning outcomes in the long run so that the study can be applied even more broadly.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

SN contributes to creating research ideas, wrote the paper, and analyzing the data; PC and PP developing the research methodology, revised and compose the writing quality of the manuscript; all authors had approved the final version.

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