A constructionist, imagineering learning system with the metaverse: a study of learning outcomes at secondary schools in Thailand

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ABSTRACT: The constructionist, imagineering learning system with the metaverse (CILM) is a tool that was designed to promote self-directed learning in both the virtual and physical world. In the metaverse world, users must simulate themselves into avatars to access the system, so they can learn by doing and present their works by means of virtual technology. This study is based mainly on the concepts related to technologies and platforms in the virtual world, as well as teaching platforms in the *new normal* era in Thailand. The aim is to facilitate continuous learning anywhere and anytime by making the ultimate use of existing technologies in education management in Thailand, and to pave ways for young innovators in the digital age. The results of this study indicate that the CILM is an efficient tool to promote learning through the virtual world, and that young learners capable of creating innovations can work and add new knowledge to that space that can be further utilised or transferred to others. Furthermore, the system can increase the learning achievement of its users thanks to the application of digital technologies and tools that satisfy the needs of learners.

Keywords: Imagineering learning system, CILM, metaverse, virtual world technology, young innovators

INTRODUCTION

Due to the advent of digital technologies, every society has to adapt to digital environments, which also reflects the ways of today's learning. Instruction management has evolved and extended from learning in the classroom to context-based learning via communication channels and on-line world, which is believed to create important motivations to learn [1]. According to educational perspectives, digital technologies have brought a huge change in learning behaviours, because they can be used as tools to increase educational opportunities, promote lifelong learning for all genders, all ages and professions, and help achieve the goals, regardless of time and place [2].

Since the new normal education in Thailand focuses mainly on digital environments that will pave ways to Thailand 4.0, in this context digital literacy is considered an important issue for instruction management at all levels. One of the important factors that enable the country to become Thailand 4.0 is the management of education in the ways that correspond to the behaviours of both the current and new generation learners [3].

The integration of virtual world technologies with instruction management was quite evident and concrete during the Covid-19 pandemic as these technologies were employed to facilitate the creation of new knowledge, exchange of knowledge and collaboration. As a consequence, the quality of social and educational services has been improved since then, especially those related to learning via a network system that has provided Thai people with unlimited access to information [4].

A virtual learning environment has been applied to assist in instruction management, particularly in terms of learning design and learning through digital platforms [5]. This enables learners to do activities together anywhere and anytime, which is suitable for learning styles in the digital age. The characteristics of virtual learning environment can be summarised as below [6][7]:

1) Virtual learning environment is a social space, in which the interaction takes place in a shared working space.
2) Virtual space is clearly represented by means of a 3D immersive learning environment.
3) Virtual learning environment promotes enthusiasm for learning because each learner can have his/her own role in the virtual space.
4) Virtual learning environment supports borderless learning and encourages class learning activities that can be carried out under the virtual learning environment.
5) Virtual learning environment combines a variety of technologies and various teaching approaches.
6) Virtual environment is an overlap of virtual world environments and physical world environments.

Constructionist learning is a style of learning that encourages learners to create their own knowledge based on learning by doing and participatory learning; and then connect their experiences to their existing knowledge and understanding in order to generate new knowledge that are suitable for certain individuals. Constructionist learning consists of five steps, i.e. sparkling, searching, studying, summarising, and showing and sharing [8][9].

Imagineering learning is a learning process that focuses on the use of imagination to find out goals or outcomes that can be put into the planning and design processes in order to obtain concrete inventions or innovations [10][11]. The process of imagineering learning can be summarised in six steps, including imagine, design, create innovation, present, improve and evaluate [12][13]. Nilsook et al stated that imagineering learning can be applied in instruction management at all levels, and it is a learning process that encourages and enables learners to learn independently, develop creativity and create their own innovations [12]. The metaverse is a new dimension of borderless education management since it employs virtual technology to increase the ability to access learning resources and exchange information through a 3D virtual world [14]. In the metaverse, learning activities can be created and carried out in an immersive learning environment, which is believed to help learners achieve deep learning by means of experiential learning [15]. Due to the rapid growth and evolution, the metaverse is one of the technologies selected to manage education according to the new normal learning system that is thought to promote continuous learning [7].

In view of the afore-mentioned concepts, the authors of this article came up an idea to develop a CIL system with the metaverse for use as a tool to promote self-directed learning in both the virtual and physical world, in which learners can use avatars to enter the metaverse. The system is also intended to promote young learners in the digital age, who have the competency to invent, innovate and create useful innovations; and also to help them manage the current life with the aid of digital technologies that can be applied in instruction management for lifelong learning.

THE STUDY AND RESEARCH QUESTIONS

This study was focused on the examination of the participants' perspectives towards the CILM development and their learning outcomes after using this system. All of the participants gave their consent to join this study with confidentiality and anonymity ensured. The objective of this study was to verify that the CILM can support instruction management in the new normal era of Thailand, which focuses mainly on the use of digital technologies. Also, the study was aimed to prove that the system can exceptionally well promote the attributes of young innovators. Thereby, this study consisted of the following four research questions.

RQ1: What are the processes of the CILM?
RQ2: What are the processes of learning activities in the CILM?
RQ3: What is the format of the CILM used to promote young innovators in secondary schools in Thailand?
RQ4: What are the learning outcomes after using the CILM?

RESEARCH METHODOLOGY

Research Design

The constructionist, imagineering learning with the metaverse is conducted in the form of research and development by means of a pre-experimental research method with one-group pretest-posttest design. The hypotheses of this research are based on the expected learning results after using the CIL system with the metaverse. The hypotheses include:

H1: The scores of learning achievement after using the CILM are higher than before with the significance level of 0.05.
H2: The scores related to the attributes of young innovators after using the CILM are higher than 80%.
H3: The level of satisfaction after learning through the CILM is high.

Table 1: Average scores and interpretation of the attributes of young innovators.

Average score range	Interpretation of results
11.00 - 15.00	Attributes of young innovators are at a very high level
6.00 - 10.00	Attributes of young innovators are at a high level
Below 5.00	Attributes of young innovators need improvement

Participants

Research participants included 46 students in grade 8 of Ongkharak Demonstration School, Srinakharinwirot University in Thailand, and they were derived by means of cluster sampling. In addition, all of the participants were reassured of confidentiality and anonymity in this study.

Research Instruments and Data Collection

The data collection tools included: 1) the CILM; 2) learning plans in the CILM; 3) quality evaluation form of the CILM; 4) learning achievement measurement form; 5) evaluation form on the attributes of young innovators; and

6) satisfaction evaluation form. The statistics used for data analysis were the mean, standard deviation, and the *t*-test dependent. Prior to the data collection process, the participants had been informed about the criteria and complete details of all forms of evaluation.

Methodology

The design and development of this study regarding its methodology were conducted on the basis of concepts and theories related to constructionist learning, imagineering learning, metaverse, virtual learning environment and young innovators' attributes. The methodology can be summarised into the following four phases as below.

Phase 1: study and synthesis of the learning process in the CILM. The researchers studied the relevant research documents regarding the theory of constructionist learning and imagineering learning, so as to synthesise the learning process for use in the CILM, which was expected to promote young innovators in secondary schools in Thailand.

Phase 2: design of learning activities in the CILM to promote young innovators. In this part, the learning process for use in the CILM derived from phase 1 was used as a guideline to design the learning activities in the metaverse, which were expected to promote young innovators in secondary schools in Thailand.

Phase 3: development of the CILM for use as a tool to promote young learners who have appropriate attributes to devise creative innovations. This stage concerned the creation of a virtual learning environment by means of the Spatial.io platform based on the learning process and learning activities for use in the CILM obtained from phase 1 and phase 2, respectively, with an aim to develop the desired system capable of young innovators.

Phase 4: study of the learning outcomes after using the CILM. In this part, the evaluation tools were used with the 46 participants that were students in grade 8 of Ongkharak Demonstration School, Srinakharinwirot University in Thailand. All of the participants were derived by means of cluster sampling and they gave consent to join this study with confidentiality and anonymity ensured. The average scores and the interpretation of the results based on Kanasutra [16] are included in Table 2.

Table 2: Average score range and the interpretation of results.

Average score range	Interpretation of results
4.50 - 5.00	Very high level of suitability
3.50 - 4.49	High level of suitability
2.50 - 3.49	Moderate level of suitability
1.50 - 2.49	Low level of suitability
1.00 - 1.49	Very low level of suitability

THE CONSTRUCTIONIST, IMAGINEERING LEARNING WITH THE METAVERSE

The objective of this research was to prove that the constructionist, imagineering learning system with the metaverse can be applied to promote young learners who have the appropriate attributes to develop creative innovations. Moreover, the system is intended to enhance the competency of these innovators and transfer their new knowledge via digital innovations and technologies to be potentially utilised in instruction management. Consequently, it is expected that this can lead to new dimensions of borderless learning within the virtual environment in the new normal era as it can provide learners with first-hand experiences. Thereby, this study was designed to answer the three research questions below:

RQ1: What are the processes of the CILM?
RQ2: What are the processes of learning activities in the CILM?
RQ3: What is the format of the CILM used to promote young innovators in secondary schools in Thailand?

Study and Synthesis of the Learning Process in the CILM

This phase concerned the synthesis of the learning process for use in the CILM, which was carried out by studying the relevant research documents pertaining to the theories of constructionist learning and imagineering learning, so as to develop an appropriate process capable of promoting young innovators in secondary schools in Thailand. The results of this synthesis are shown in Table 3.

Table 3: Results of the synthesis of the learning process for use in the CILM.

Imagineering learning [12][13]	Constructionist learning [8][9]	Learning process in the CILM
1. Imagine	1. *Sparkling*	1. Imagine
	2. Searching	2. *Sparkle*
		3. Search supporting evidence

2. Design		4. Design and write a script
3. Create innovation	3. Studying	5. Create empirical innovation
	4. Summarising	6. Summarise
4. Present	5. Showing and sharing	7. Show and evaluate feedback
5. Improve		8. Improve
6. Evaluate		

Table 3 presents the synthesis of the learning process for use in the CILM, which consists of eight steps, i.e. imagine, *sparkle*, search supporting evidence, design and write a script, create a practical innovation, summarise and improve. The synthesis results of the capacity of all steps in the learning process in the CILM are included in Table 4.

Table 4: Synthesis results of the capacity of all steps in the learning process in the CILM.

Learning process in the CILM	Explanation
1. Imagine	Stimulate and motivate learners to develop interest and intention to brainstorm with creativity, so that they can analyse problems in a comprehensive manner.
2. *Sparkle*	*Sparkle* the ideas by analysing and finding solutions to problems in daily life.
3. Search for supporting evidence	Ability to find out supporting evidence for the issues and the solutions of their interest.
4. Design and write a script	Ability to design the layout and the model of an innovation designated to solve the target problem.
5. Create a practical innovation	Ability to promote the innovation in social media.
6. Summarise	Ability to crystallise the ideas based on the reflection and the creation.
7. Show and evaluate feedback	Ability to publicise the innovation and conduct evaluation with others.
8. Improve	Ability to improve the innovation and then present the improvement.

Design of Learning Activities in the CILM to Promote Young Innovators

In this part, the learning process derived from phase 1 was used as a guideline to design the learning activities for use in the CILM. The activities were expected to equip learners with the attributes of young innovators, and encourage them to learn by doing, which should lead to the creation of innovations via the metaverse. The learning activities are presented in Table 5.

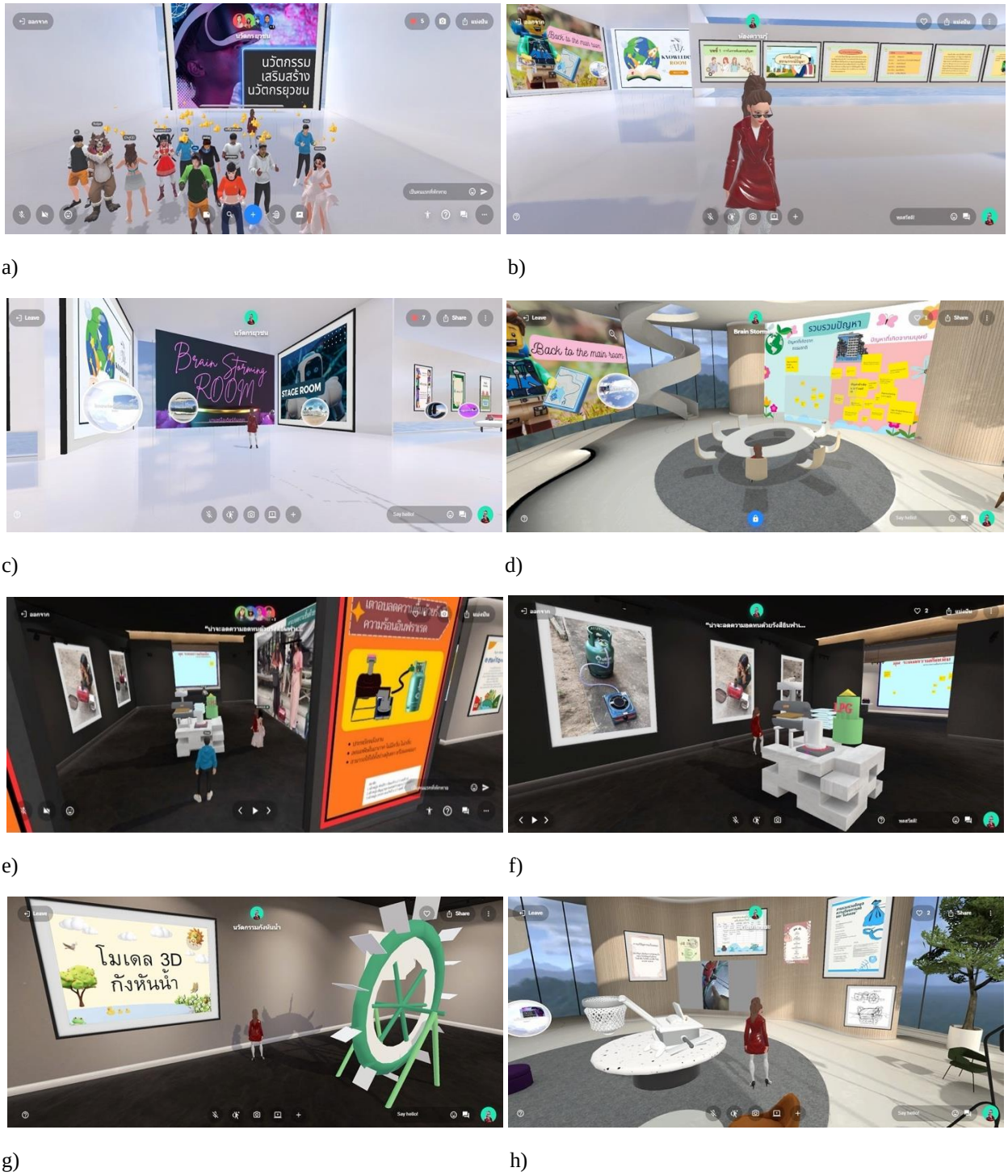
Table 5: Learning activities in the CILM to promote young innovators.

Learning process in the CILM	Learning activities in the CILM
1. Imagine	1.1 Brainstorm to analyse problems in the metaverse chatroom.
	1.2 Present the works on the brainstorming board.
2. *Sparkle*	2.1 Identify issues in the metaverse.
	2.2 Present the issues in the metaverse.
3. Search for supporting evidence	3.1 Search for supporting evidence through the metaverse (search or URL).
	3.2 Present the acquired supporting evidence in the metaverse lounge room.
4. Design and write a script	4.1 Identify the layout and the design of an innovation via the metaverse.
	4.2 Present the developed layout and the design of an innovation via the metaverse.
5. Create a practical innovation	5.1 Present the innovation via the metaverse.
6. Summarise	6.1 Summarise the new knowledge via the metaverse.
7. Show and evaluate feedback	7.1 Publicise the innovation via the metaverse.
	7.2 Evaluate the innovation with sticky notes via the metaverse.
8. Improve	8.1 Present the results of improvement on the innovation via the metaverse.

Development of the CILM at Secondary Schools in Thailand

The CILM was developed based on the concepts related to virtual technologies, virtual platforms and new teaching platforms combined with the system approach concepts of instructional design that consists of systematic elements and procedures [17][18]. Therefore, the CILM is regarded as a tool designed to promote self-directed learning in both the virtual and physical world. Thereby, users must simulate themselves into avatars in order to access the system and then they can learn by doing and present their works by means of virtual technology.

The system is also compatible with all displays on smartphones, and this enables users to learn anywhere and anytime in an instant manner. In addition, the system focuses on the ultimate use of technologies to facilitate instruction management in Thailand with an intention to promote young innovators in the digital era. The CILM is demonstrated in Figure 1 a-h.



a) b)

c) d)

e) f)

g) h)

Figure 1: CILM at secondary schools in Thailand.

Evaluation of the CILM at Secondary Schools in Thailand

Table 6: Evaluation of the quality of the CILM - results.

Items for evaluation		Mean	SD
Functional requirement	1. Ability to run the system	5.00	0.00
	2. Ability to add data	5.00	0.00
	3. Ability to update data	4.43	0.53
	4. Ability to present data	5.00	0.00
	5. The database system is accurate and complete	4.86	0.38
Overall functional requirement		4.86	0.26
Functions	6. Validity of data segmentation	4.86	0.38
	7. Validity of added data	4.71	0.49
	8. Validity of data update	4.43	0.53
	9. Validity of data presentation	4.57	0.53
	10. Overall validity of functions	5.00	0.00
Overall functions		4.71	0.23

Usability	11. Ease of use	5.00	0.00
	12. Suitability of screen design	4.43	0.53
	13. Clarity of content presentation	4.86	0.38
	14. Ease of access	4.57	0.79
	15. Attractiveness and interestingness	5.00	0.00
Overall usability		4.77	0.34
Performance	16. Speed of displaying the results from a link	4.71	0.49
	17. Speed of database connection	4.43	0.53
	18. Speed of data saving and updating	4.86	0.38
	19. Speed of data presentation	5.00	0.00
	20. Overall speed of functions	5.00	0.00
Overall performance		4.80	0.26

According to Table 6, it was found that the overall quality of the CILM in terms of functional requirements, functions, usability and performance, is very high. Thus, it can be opined that the CILM with such high quality and efficiency can be applied as a tool to promote learning in the virtual world.

FINDINGS OF THE STUDY

This study is focused on the examination of the participants' perspectives towards the CILM development and their learning outcomes after using the system. As mentioned above, 46 students in grade 8 from Ongkharak Demonstration School, Srinakharinwirot University participated in this study, and they were derived by means of cluster sampling. All of the participants were reassured of confidentiality and anonymity. The research tools herein included a learning achievement measurement form, an evaluation form on the attributes of young innovators, and a satisfaction evaluation form. The following research question was formed:

RQ4: What are the learning outcomes after using the CILM?

Attributes of Young Innovators in Secondary Schools in Thailand

Young innovators are those who possess the skills to develop creative innovations and dare to do new things, take risks wisely, and think differently but creatively. All of these attributes can further enhance their competence and enable them to transfer the new knowledge through appropriate technologies in an efficient manner.

Table 7: Synthesis of the attributes of young innovators.

Attributes of innovators [19]	Attributes of young innovators
1. Linking problems	1. Ability to link questions, problems and ideas relevant to the subject of interest, which can result in a more systematic thinking process.
2. Questioning	2. Ability to ask questions or make assumptions that are challenging to existing knowledge.
3. Observation	3. Ability to observe details or insights of new approaches, including small behavioural details, with caution, attention and consistency, in order to analyse problems arising in society.
4. Experiment	4. Ability to design concepts before implementing them into concrete results, while trying to generate new ideas by making models, thinking out of the box and coming up with innovative ideas. Dare to accept the consequences and ready to adapt themselves.
5. Building networks	5. Ability to build a network in order to extend and publicise the innovations. Dedicate both time and energy to finding and testing ideas across the varied networks so as to broaden knowledge and learn other different perspectives.

The learning outcomes after using the CILM are divided into three sections, i.e. 1) comparison of learning achievement before and after using the system; 2) results of evaluation on the attributes of young innovators; and 3) results of evaluation on the satisfaction.

The results of comparison of learning achievement scores before and after using the CILM are shown in Table 8.

Table 8: Comparison of learning achievement before and after using the system.

Test	Number of students	Full score	Mean	SD	*t*-value
Pre-test	46	30	8.59	1.52	36.89*
Post-test	46	30	24.33	2.31	

* Significant at the level of 0.05 ($\alpha = 0.05$, df = 45)

In reference to the results of comparison of learning achievement scores before and after using the CILM included in Table 8, it was found that the students of one-group pre-test-post-test design, who had learned with the CILM, obtained higher learning achievement scores.

When considering the average scores of learning achievement, it was found that the average scores after learning with the system (mean = 24.33, SD = 2.31) were higher than those before learning with the system (mean = 8.59, SD = 1.52).

This results show that learning through the CILM enables students to have a better learning achievement with the significance level of 0.05. Therefore, it can be concluded that the CILM can enhance the learning achievement of students, which is compliant with hypothesis 1.

The results of evaluation on the attributes of young innovators after using the CILM are presented in Table 9.

Table 9: Results of evaluation on the attributes of young innovators.

Number of students	Full score	Mean score	Mean	SD	Percentage %
46	15	12	2.43	0.14	80.94

When considering the results of evaluation on the attributes of young innovators after learning through the CILM included in Table 9, which were acquired using rubric-based assessment score system with the rating scale of 4-levels, it was found that the students' mean scores of attributes of young innovators after learning with the system were at a very high level (mean score = 12) and higher than 80% (percentage = 80.94).

This is in accordance with hypothesis 2. Furthermore, the outcomes also indicate that the learning process and the learning activities in the CILM encourage students to transfer the new knowledge to the metaverse by means of linking, questioning, observation, experimentation and network creation. As a result, the students seem to have more interest and develop attributes of young innovators through the learning process and learning activities.

The results of evaluation on the satisfaction after learning via the CILM are presented in Table 10.

Table 10: Results of evaluation on the quality of the CILM.

Items for evaluation		Mean	SD
Design	1. Suitability of the system elements design	4.00	0.00
	2. Suitability of the user interface design	4.67	0.52
	3. Easy to use system tools	4.67	0.52
	4. Suitability of font colours and sizes	4.50	0.55
	5. Continuity of use	4.67	0.52
	6. Response to the needs of learners	4.50	0.55
Contents	7. Contents are easy to understand and use	4.33	0.52
	8. Contents are well organised	4.50	0.55
	9. Contents can satisfy the students' needs quite well	4.50	0.55
	10. Contents are interesting and compliant with the learning objectives	4.67	0.52
Virtual reality	11. Ability to browse surrounding locations	4.83	0.41
	12. Speed of operation	4.00	0.00
	13. Coverage of use	4.67	0.52
Design of learning activities	14. Learning activities can promote constructionist, imagineering learning with the metaverse	4.83	0.41
	15. Students have appropriate opportunities to create knowledge	5.00	0.00
	16. Learning activities promote the attributes of young innovators	4.83	0.41
	17. Suitability of feedback for reinforced learning	4.83	0.41
	18. Satisfaction towards avatars in the CILM; satisfaction towards the creation of learning classrooms in CILM	4.17 4.83	0.41 0.41
Overall		4.58	0.19

Table 10 shows that the overall satisfaction, regarding 19 items for evaluation, after learning through the CILM was at a very high level (mean = 4.58, SD = 0.19), which is in line with hypothesis 3. The results above also indicate that the CILM can be employed as a tool to promote self-directed learning, which can encourage students to develop the attributes of young innovators. This is because the system development is mainly based on virtual technologies and digital tools that can fulfil the students' learning needs while facilitating their full engagement when learning.

DISCUSSION AND CONCLUSIONS

This research concerns the development of the CILM system including the learning outcomes of students after using it. The main objective of this system is to promote the attributes of young learners who are able to devise and develop creative innovations. At the same time, the system is also expected to elevate the competency of learners and support them to transfer the new knowledge via suitable technologies by making use of innovations and digital technologies in the virtual environment in the new normal world. It is also believed that the system will be beneficial to education management in Thailand that can respond to young innovators in the digital age.

According to the results of this research, it was found that 1) the scores of learning achievement after learning with the system were higher with the significance level of 0.05; 2) the scores of the attributes of young innovators after learning with the system were higher than 80%; and 3) the level of satisfaction after learning with the system was at a very high level. These results correspond to the hypotheses.

Noteworthy, these results are also in compliance with the research of Chatwattana et al, who pointed out that the integration of concepts related to new teaching technologies and platforms, in order to generate the new concepts of instruction design, can be applied in the new normal learning management [20]. This is because such instruction management can generate new knowledge derived from self-directed learning via digital technologies. Further, it facilitates the exchange of knowledge via social networks, leading to a learning society that will equip learners with new and creative ideas along with skills necessary for the 21st Century.

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