Journal of Education and Learning; Vol. 12, No. 4; 2023
ISSN 1927-5250 E-ISSN 1927-5269
Published by Canadian Center of Science and Education

Constructionism Imagineering Learning Model via Metaverse to Enhance Young Innovators

Suputtra Sapliyan[1], Pinanta Chatwattana[2] & Prachyanun Nilsook[1]

[1] Information and Communication Technology for Education, Faculty of Technical Education, King Mongkut's University of Technology North Bangkok, Thailand

[2] Electronics Engineering Technology, College of Industrial Technology, King Mongkut's University of Technology North Bangkok, Thailand

Correspondence: Suputtra Sapliyan, Information and Communication Technology for Education, Faculty of Technical Education, King Mongkut's University of Technology North Bangkok, Bangkok, Thailand.

Received: March 30, 2023 Accepted: May 17, 2023 Online Published: May 30, 2023

doi:10.5539/jel.v12n4p81 URL: https://doi.org/10.5539/jel.v12n4p81

Abstract

Constructionism imagineering learning model via metaverse is an instrument for promoting self-learning through hands-on. To create new knowledge for young innovators by combining the concepts of technology and new learning platforms to create new ideas. Designing teaching and learning that can be used to learn in the new normal focuses on continuous learning at any time, anywhere, with the benefits of using technology. The sample group is six experts in designing and developing learning models and learning systems from various institutions in higher education by purposive sampling. The research instruments are as follows. 1) The constructionism imagineering learning model via metaverse to enhance young innovators. 2) The constructionism imagineering learning process via metaverse to enhance young innovators. 3) An assessment form for the constructionism imagineering learning model via metaverse to enhance young innovators. 4) An assessment form for the constructionism imagineering learning process via metaverse to enhance young innovators. Analyse data using mean and standard deviation. The researchers found that the constructionism imagineering learning model via metaverse and the constructionism imagineering learning model via metaverse, which is developed is appropriate to enhance young innovators at the highest level, following the research hypotheses.

Keywords: imagineering learning, constructionism learning, constructionism imagineering learning, metaverse, young innovators

1. Introduction

Due to changes in technology and social conditions, the application of digital technology in education management has improved efficiency and solved various problems, assisting learners to learn rapidly. This change helps make lessons enjoyable, diversifies teaching materials, and supports learning anytime and anywhere. With a simplified teaching process, instructors can organize a variety of activities at the same time. This gives instructors plenty of time to prepare for teaching (Ministry of Education, 2022). Teachers must be able to use media literacy and various applications appropriate for learning management activities. The materials used must affect the learning management system under which the students are able to achieve learning objectives and for the instructors to be able to conduct quality assessments (Tingtrong & Chatrupachewin, 2022).

Imagineering learning means turning what is imagined into something tangible in practice, to use what is visualized in an idea to become fundamental inventions and innovations in education. It appears in the imaginary learning method, which has a sequential learning model that brings the imagination of human thoughts to real life. In addition, educational activities that require the application of imaginary engineering concepts to achieve abstract learning become concrete, understandable, and ultimately practical (Nilsook et al., 2014).

Today's technology can connect online communications. Therefore, it becomes a combination of all services within the metaverse. Besides, connecting people from all over the world to know each other through various service providers. Those with leading technology will be able to create their meta. For the metaverse, it is seen as the hope of the future. Therefore, technology has been developed to be modern and able to bring the communication of the new generation to be convenient and connect from all over the world. The metaverse is

defined as a new virtual world with benefits that will be used by individuals and businesses (Ananda Development Public Company Limited, 2023). Kim (2021) summarized the common features of many definitions of the metaverse as follows; Persistence of identity and objects, a shared environment, use of avatars (embodied self), synchronization, three-dimensional (or virtual), interoperability, an interactive, immersive and social user experience.

For the mentioned above, the researchers have the idea of developing the constructionism imagineering learning model via metaverse to enhance young innovators of students in the digital age. The objective is to study the results of the development of the constructionism imagineering learning model via metaverse, which was developed by experts in the design and development of learning models and learning systems from various institutions in higher education. It can be used as a guideline for further designing and developing the constructionism imagineering learning model via metaverse.

2. Literature Reviews

Development of the constructionism imagineering learning model via metaverse to enhance young innovators, the researchers studied, analyzed, and synthesized from documents and relevant research as follows.

Constructionism learning is a form of learning that focuses on the learners creating their knowledge of the interaction. Learning benefits learners when they learn by doing. In addition, if we look deeper into the development of learners in learning, which is not only hands-on but also the reaction between the learner's knowledge and the external environment. Learners will be able to collect information from the external environment and store the structure of knowledge in their brains (Charles & Rankin, 2018). Therefore, learning by doing will work if the learners understand themselves, see the importance of what they learn, and connect knowledge between new knowledge and previous knowledge (know what you have learned) (Hong & Cho, 2019). Therefore, constructionism learning has influenced the development of interactive learning.

Interactive learning is an approach to teaching and learning that focuses on various ways in which learning activities can "interact" with learners (Soutthaboualy et al., 2022). Students can prepare for class by interacting with provided resources to reduce lecture time and allow more engagement in class. Such engagement helps create a comfortable level of interaction between learners and teachers. This is an area that motivates learners, especially children and young people, who are close to the new generation of electronic devices (Wannapiroon et al., 2021).

Interactive learning is advantageous as it helps establish a friendly atmosphere among the participants and have them connect, helps boost learner self-reliance and self-assurance, and has participants make active and continual use of the knowledge and experience gained earlier (Abykanova et al., 2016). Therefore, interactive learning is based on the concept of constructionism learning theory.

Imagineering learning is an application of imagineering, a combination of the words imagine and engineering, meaning to do what is imagined into something real in practice. It is the use of what is visualized in mind to become tangible inventions and innovations in education. It appears in imaginary learning, which has a sequential learning style by bringing the imagination of human thoughts into real things. In addition, educational activities require the application of imaginary engineering concepts to achieve learning from abstract to concrete and understanding and finally be useful (Nilsook et al., 2014).

The metaverse is a virtual reality in which various people interact by performing 3D images, interacting with each other in a real-time virtual environment in the same virtual space appearing and seeing through their avatars. People can adapt the avatar characteristics to each person to reflect a person's expression, resulting in engaging and increasing the interest of learners (Mystakidis, 2022). Therefore, metaverse technology is a new technology that will focus on working, studying and entertainment in the future where all activities can be done with the help of Augmented Reality (AR) and Virtual Reality (VR) technology (Kongpha & Chatwattana, 2023).

Young innovators are not only knowledgeable but also about attitudes or thoughts deeply embedded in a person, including an observant, skeptical, persistent, and fearless character of failure. Currently, several case studies aim to instill in children learning to be innovators and innovate by using technology to make new initiatives more straightforward and diverse by focusing on the characteristics of knowing how to think and analyze problems, dare to believe, dare to act, and be an innovator (Piyarungsi et al., 2022).

Research on the constructionism imagineering learning model via metaverse to enhance young innovators, the researchers formulated a research hypothesis consisting of 1) the assessment results of the appropriateness of the imagineering learning model developed by experts is at a highly appropriate, and 2) the results of the assessment of the appropriateness of the imagineering learning process via metaverse developed by experts is at a highly

appropriate.

3. Method

3.1 Scope of the Study

The scope of the population and sample, the population is experts in designing and developing learning models and learning systems from various institutions in higher education; the sample is five experts in designing and developing learning models and learning systems from multiple institutions in higher education selected by cluster sampling.

The scope of the study's variables includes the appropriateness of imagineering learning models and the imagineering learning process via metaverse.

3.2 Research Instruments

The research instruments used in the study include the following. 1) The constructionism imagineering learning model via metaverse to enhance young innovators. 2) The constructionism imagineering learning process via metaverse to enhance young innovators. 3) An assessment form for the appropriateness of the constructionism imagineering learning model via metaverse to enhance young innovators is a five-level rating scale. 4) An evaluation form for the appropriateness of the constructionism imagineering learning process via metaverse to enhance young innovators is a five-level rating scale.

3.3 Research Processes

The study is a research and development. The research processes are divided into four phases according to the following research objectives.

Phase 1 synthesizes the conceptual framework of the constructionism imagineering learning process via metaverse to enhance young innovators.

Phase 2 Develop the constructionism imagineering learning process via metaverse to enhance young innovators. At this stage, it is a synthesis of the imaginary learning process. Study the documents and research relevant to the imaginary learning process, both nationally and internationally, published from 2014 to 2021. To complete the imaginary learning process consists of six stages as follows: 1) imagination, 2) design, 3) test and development, 4) publish, 5) improvement, and 6) evaluation.

Phase 3 Develop the constructionism imagineering learning process via metaverse to enhance young innovators. This phase is a synthesis of constructionism. Study the documents and research relevant to constructionism nationally and internationally, published from 2017 to 2021. To complete the constructionism imagineering learning process consists of eight stages include: 1) imagine, 2) start with an idea, 3) research/explore/learn, 4) design and write the script, 5) create Innovation, 6) summarise the knowledge, 7) present and evaluate and feedback, and 8) improvement.

Phase 4 Study the results of developing the constructionism imagineering learning process via metaverse to enhance young innovators. This phase assesses the appropriateness of designing and developing the constructionism imagineering learning process via metaverse, with an assessment form by a five-level rating scale.

4. Results

The researchers concluded that the data analysis was divided into four phases according to the following research objectives.

4.1 Result of Synthesizing the Conceptual Framework of Constructionism Imagineering Learning Model via Metaverse to Enhance Young Innovators

The study of relevant documents, concepts, and theories then synthesizes elements of the developed constructionism imagineering learning model via metaverse to enhance young innovators. The conceptual research framework is shown in Figure 1.

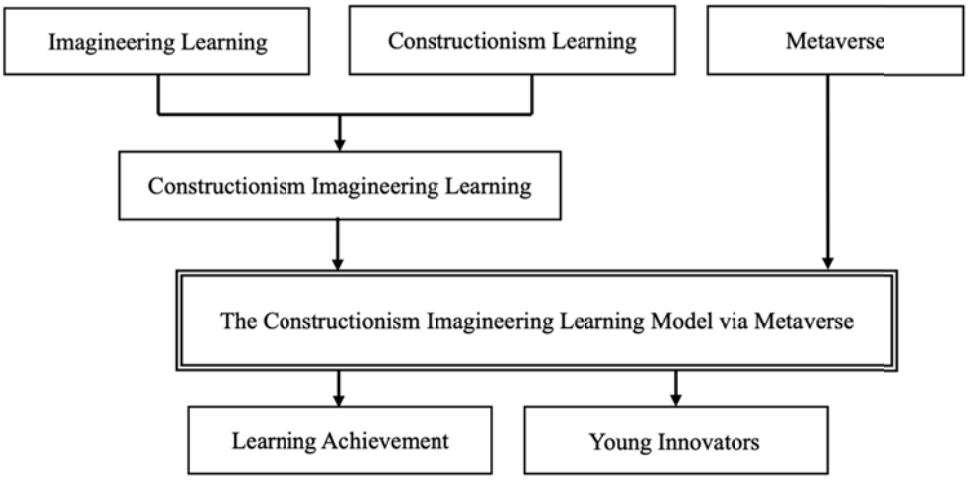

Figure 1. Conceptual research framework

Figure 1 shows the conceptual research framework of the constructionism imagineering learning model via metaverse to enhance young innovators. Researchers conducted studies, analyzed, and synthesized research papers, including imagineering learning theory, constructionism learning theory, metaverse theory, learning achievement, and young innovators, etc.

4.2 Developing Constructionism Imagineering Learning Model via Metaverse to Enhance Young Innovators

Developing the constructionism imagineering learning model via metaverse to enhance young innovators, the researchers designed a learning model by combining the imaginary learning process and constructionism learning to develop the learning model, as shown in Figure 2.

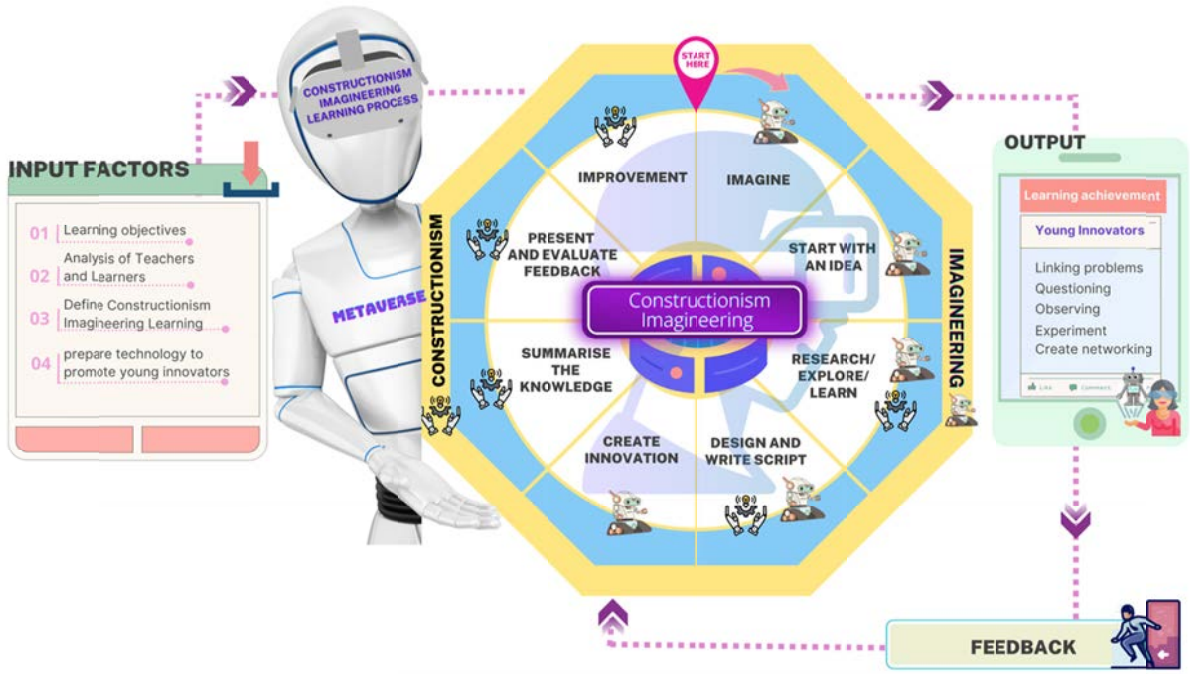

Figure 2. Developing constructionism imagineering learning model via metaverse to enhance young innovators

Figure 2 shows the development of the constructionism imagineering learning model via metaverse to enhance young innovators consisting of four main elements, which can be described as follows:

1) *Input factors*: Inputs of the constructionism imagineering learning model via metaverse to enhance young innovators are: define learning objectives; analysis of teachers and learners; define constructionism imagineering learning; and prepare technology to promote young innovators, summarising as the following.

Define learning objectives. It aims to identify the knowledge and skills at the end of the study with measurement and evaluation tools.

Analysis of teacher and learners. The analysis of learners is the general information, such as basic knowledge, fundamental skills, interests, and aptitude, to lead to the design of appropriate learning models and meet the needs of learners. Besides, analyzing teachers as having up-to-date knowledge and the ability to describe processes and teaching skills clearly.

Define learning activities using constructionism imagineering learning. Organizing learning activities by using what is in the image to identify problems, provoking suspicion and curiosity. It creates new knowledge to develop innovative works by building on existing knowledge. The teacher is in charge of mentoring.

Prepare technology to promote youth innovators by using the metaverse as a form of collaboration. Data can be added to images, videos, or even 3D technology, which dramatically exceeds the motivation to learn.

2) *Learning process*: The learning process is organized with the constructionism imagineering learning model via metaverse to enhance young innovators. At this stage, the researchers applied the principles of imaginary learning theory to constructionism learning, consisting of eight steps. Imagine; start with an idea; research/explore/learn; design and write the script; create innovation; summarise the knowledge; present and evaluate the feedback and improve.

3) *Output*: The constructionism imagineering learning model via metaverse to enhance young innovators has two parts of output: learning achievement; young innovators. A summary of the desired characteristics of young innovators is shown in Table 1.

Table 1. Synthesis of young innovators

Young innovators	(Jeffrey et.al., 2009)	(Wongtienlai et al., 2019)	(Tonghom et al., 2017)	(National Innovation Agency, 2022)	(Phatrawat, 2020)	(Tsou et al., 2014)	(Yams, 2017)	*Results of Analysing*
Linking problems	✓	✓		✓	✓		✓	✓
Questioning	✓	✓	✓	✓	✓	✓	✓	✓
Observing	✓	✓	✓		✓	✓		✓
Experiment	✓	✓	✓	✓	✓	✓	✓	✓
Create networking	✓		✓	✓	✓	✓	✓	✓

Table 1, it can be concluded that young innovators consist of five aspects as follows. Linking problems by learners using problems as a catalyst for problem-solving; questioning or defining a hypothesis by allowing learners to ask a series of questions systematically; observing details or collecting insights data on new methods to predict the possibility of innovation; experiment, daring to make decisions, daring trial and error; and create networking, expanding innovation to social media.

4) *Feedback*: The feedback process uses data from the output stage, then feedback to improve the learning process and input factors consisting of learning achievement scores, young innovator skills, and expert opinions to be analyzed to enhance the learning process and inputs to be more appropriate to each step thoroughly.

4.3 Results of Developing the Constructionism Imagineering Learning Process via Metaverse to Enhance Young Innovators

The researchers formulated a learning process synthesized from the imagineering learning process and the constructionism learning process to be used in learning via metaverse, as shown in Figure 3.

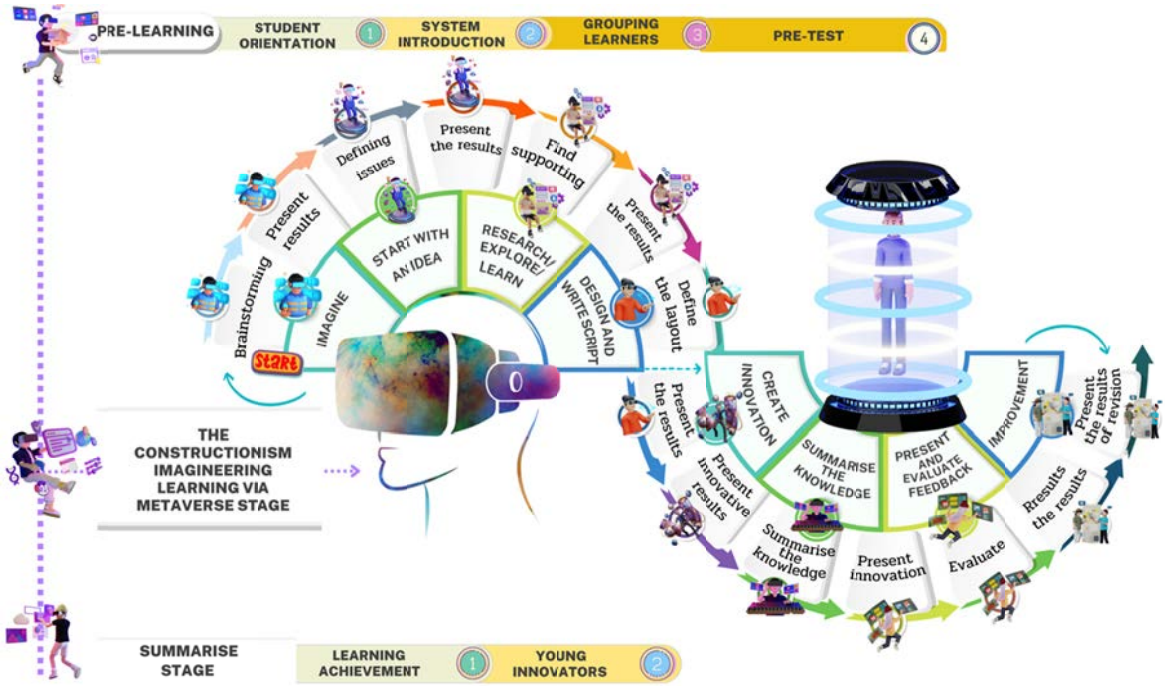

Figure 3. The constructionism imagineering learning process via metaverse to enhance young innovators

Figure 3 illustrates the constructionism imagineering learning process via metaverse to enhance young innovators. The researchers defined the learning process, which summarises into three stages as follows.

1) Pre-learning stage consists of four steps: student orientation; system introduction; grouping learners; and pre-test. (1.1) Learner orientation, the teacher explains the learning objectives to the learners before embarking on activities. (1.2) System introduction, the teacher explains the activities or learning methods that will apply to the students. (1.3) Grouping learners by mixing them according to their abilities so that the outstanding, moderate, and weak learners are in the same group. (1.4) Pre-test measures the learner's basic knowledge before studying so that the teacher knows what level of understanding the learner has in the subject.

2) The constructionism imagineering learning via metaverse stage. At this stage, the researchers applied the principles of imaginary learning theory to constructionism learning and the metaverse, consisting of eight steps: Imagine; Start with an idea; Research/explore/learn; Design and write the script; Create innovation; Summarise the knowledge; Present and evaluate feedback; and Improvement, the details of each step as follows.

(2.1) Imagine, the teacher encourages and motivates learners to be interested in the subject, brainstorming using creativity to analyze problems comprehensively via the Metaverse with two steps as follows. 2.1.1) Brainstorming and analyzing problems through the conference room via the metaverse (brainstorming space). 2.1.2) Present results through a brainstorming board.

(2.2) Start with an idea, stimulates the problems encountered in everyday life, then analyze solutions with two steps through the metaverse as follows. 2.2.1) Defining issues through the metaverse. 2.2.2) Present the results of defining the problems through the metaverse.

(2.3) Research/explore/learn, focuses on learners finding supporting information to solve problems that interest them. There are two steps through the metaverse as the following. 2.3.1) Find supporting evidence through the metaverse with search or URL tools 2.3.2) Present the results of the search for supporting evidence through the metaverse.

(2.4) Design and writing script, focuses on learners designing casual innovations to solve problems. There are two steps through the metaverse as follows. 2.4.1) Define the layout of the 3D design with the Tinkercad program, importing the metaverse through the add content tool. 2.4.2) Present the results of the 3D design layout through the metaverse by the lounge room.

(2.5) The create innovation, focuses on learners bringing their innovation results to online social media through the metaverse as follows. 2.5.1) Present innovative results through the auditorium room.

(2.6) Summarise the knowledge, focusing on learners crystallizing their thoughts through the metaverse as follows. 2.6.1) Summarise the knowledge through brainstorming meeting rooms.

(2.7) Present and evaluate feedback, focuses on learners presenting innovations to the public by having learners take turns evaluating. There are two steps through the metaverse as the following. 2.7.1) Present innovation through the stage room. 2.7.2) Evaluate with a sticky note through the metaverse.

(2.8) The improvement, focuses on the learners applying the assessment results in step 2.7.2 to revise and present the improvement results through the metaverse as follows. 2.8.1) Present the results of the revision through the auditorium room. 2.8.2) Evaluate the results of the revision with a sticky note through the metaverse.

3) Summarise and post-test stage, to measure learning achievement after the learners have completed the content and activities according to the specified course. This is measured by taking the learning achievement test, which has the characteristics of a multiple-choice test with four options and a young innovator assessment form.

4.4 Study the Results of Developing the Constructionism Imagineering Learning Model via Metaverse to Enhance Young Innovators

A study of the development of the constructionism imagineering learning model via metaverse to enhance young innovators. The objective is for experts to determine the appropriateness of the developed learning model the researchers have developed. Before used as a guideline for developing the constructionism imagineering learning process via metaverse to enhance young innovators. Evaluation and interpretation criteria are shown in Table 2.

Table 2. Average score range and interpretation of results (Kanasutra, 1995)

Average score range	Interpretation of results (Appropriateness)
4.50–5.00	Highest
3.50–4.49	High
2.50–3.49	Moderate
1.50–2.49	Low
1.00–1.49	Lowest

A study of the development of the constructionism imagineering learning model via metaverse to enhance young innovators. The researchers used the research instruments to study the results with a sample of five experts in designing and developing learning models and systems from various higher education institutions, as follows.

1) Assessment of the appropriateness of the constructionism imagineering learning model via metaverse to enhance young innovators (compound elements) is shown in Table 3.

Table 3. Assessment of the appropriateness of the constructionism imagineering learning model via metaverse (compound elements)

Assessment issues	Mean	S.D.	Appropriateness
1. The imagineering learning model is created following the principles for developing learning models.	4.71	0.49	Highest
2. Elements of the imagineering learning model created are comprehensive according to the main elements of the learning models.	4.71	0.49	Highest
3. Sequencing elements in the imagineering learning model created are clear.	4.71	0.49	Highest
4. Arrangement of the order of elements in the imagineering learning model created is appropriate and easy to understand.	4.86	0.38	Highest
5. Overall elements in the imagineering learning model created are completed, comprehensive, and meet the research objectives.	4.71	0.49	Highest
Overall	4.74	0.05	Highest

Table 3. Results of the assessment of the constructionism imagineering learning model via metaverse developed (Compound elements) are the highest appropriate (Mean = 4.74, S.D. = 0.05). It found that assessing all issues is also appropriate when considering each aspect.

2) Assessment of the appropriateness of imaginary learning styles created through the universe to promote young innovators (Individual element) shown in Table 4.

Table 4. Evaluation of the appropriateness of the constructionism imagineering learning model via metaverse (Individual element)

Assessment issues		Mean	S.D.	Appropriateness
1. Input factors	1.1 Learning objectives.	5.00	0.00	Highest
	1.2 Analysis of learner.	4.86	0.38	Highest
	1.3 Define learning activities.	4.71	0.49	Highest
	1.4 Prepare tools to promote young innovators.	4.57	0.53	Highest
2. Learning process	2.1 Pre-learning stage.	4.57	0.53	Highest
	2.2 Constructionism imagineering learning model via metaverse stage.	4.57	0.53	Highest
	2.3 Evaluation stage.	4.71	0.49	Highest
3. Assessment of the output	3.1 Learning achievement.	4.29	1.11	High
	3.2 Young innovator skills.	4.57	0.79	Highest
4. Feedback	4.1 Learning achievement score.	4.57	0.79	Highest
	4.2 Young innovator skills.	4.71	0.76	Highest
	4.3 Expert opinions.	4.71	0.49	Highest
	Overall	4.65	0.27	Highest

Table 4 Results of the assessment of the constructionism imagineering learning model via metaverse developed are the highest appropriate (Mean = 4.65, S.D. = 0.27). The developed learning model can also be used as a guideline for further development as a constructionism imagineering learning system via metaverse to enhance young innovators because it has a straightforward design based on the system approach and has completed composition.

3) Assessment results of the appropriateness of the constructionism imagineering learning process via metaverse to enhance young innovators as shown in Table 5.

Table 5. Assessment results of the appropriateness of the constructionism imagineering learning process via metaverse

Assessment issues		Mean	S.D.	Appropriateness
1. Pre-learning stage	1.1 Learner orientation.	5.00	0.00	Highest
	1.2 System Introduction.	5.00	0.00	Highest
	1.3 Grouping learners.	4.86	0.38	Highest
	1.4 Pre-test.	4.57	0.79	Highest
2. Constructionism imagineering learning via metaverse stage	2.1 Imagine.	5.00	0.00	Highest
	2.2 Start with an idea.	5.00	0.00	Highest
	2.3 Find supporting evidence.	4.86	0.38	Highest
	2.4 Design and write the script.	4.86	0.38	Highest
	2.5 Create innovation.	4.71	0.49	Highest
	2.6 Summarise the knowledge.	4.86	0.38	Highest
	2.7 Present and evaluate feedback.	4.86	0.38	Highest
	2.8 Improvement.	5.00	0.00	Highest
3. Summarise the stage	3.1 Learning achievement score.	4.43	1.13	High
	3.2 Young innovator skills.	4.43	1.13	High
Overall		4.82	0.40	Highest

Table 5 Assessment results of the appropriateness of the constructionism imagineering learning process via metaverse, which was developed in the highest appropriate (Mean = 4.82, S.D. = 0.40). The developed learning process can encourage learners to enhance the attribute of young innovators and learning achievement.

4) Assessment results of the appropriateness of the constructionism imagineering learning model via metaverse to enhance young innovators (Implemented) are shown in Table 6.

Table 6. Assessment results of the appropriateness of the constructionism imagineering learning model via metaverse to enhance young innovators (Implemented)

Assessment issues	Mean	S.D.	Appropriateness
1. The appropriateness of the constructionism imagineering learning model via metaverse to enhance young innovators.	4.71	0.49	Highest
2. The appropriateness of the constructionism imagineering learning process via metaverse to enhance young innovators.	4.43	0.53	High
3. The possibility of implementing the constructionism imagineering learning model via metaverse to enhance young innovators.	4.86	0.38	Highest
Overall	4.67	0.08	Highest

Table 6 Assessment results of the appropriateness of the constructionism imagineering learning model via metaverse to enhance young innovators, which was implemented. Overall, it is the highest appropriate (Mean = 4.67, S.D. = 0.08). Assume that the constructionism imagineering learning model via metaverse to enhance young innovators developed has the suitable elements, procedures, and processes to use as a development guideline.

5. Discussion

The constructionism imagineering learning model via metaverse to enhance young innovators is a prototype for teaching and learning in the digital age by integrating the imagineering learning process with the constructionism learning process to develop the learning process. The metaverse is also integrated, a virtual environment in a digital space where learners can participate in interactions and activities through avatar identities as 3D graphics. It uses technology and accessories through the community by learning via a virtual community.

The results of the study showed the following. 1) The constructionism imagineering learning model via metaverse consists of four main elements as follows: inputs, learning process, output, and feedback. 2) The constructionism imagineering learning process via metaverse consists of three stages: Pre-learning, constructionism imagineering learning via metaverse, and summarise stage. 3) The development of the constructionism imagineering learning model via metaverse to enhance young innovators, which was developed, is the highest appropriate. This is in line with the study of Sanglub et al. (2019) stated that the integration of the imagineering learning process in the design of teaching and learning could encourage learners to achieve higher learning achievement and develop young innovator skills. Which skills are beneficial for teaching and learning in the future. It is also consistent with the study of Hong and Cho (2019) that constructionism focuses on putting learners into action or creating something meaningful for themselves. Therefore, the tools used must be conducive to allowing learners to create work successfully, meet the learner's thoughts and imaginations and enhance the higher attribute of young innovators.

Acknowledgments

Thank you to the research team and the Demonstration School of Srinakharinwirot University, Ongkharak, for supporting the data collection. Researchers sincerely thank King Mongkut's University of Technology North Bangkok for the financial support. We also thank the experts for their valuable evaluation and helpful feedback on the study.

Recommendations

Assessment of the constructionism imagineering learning model via metaverse to enhance young innovators is an assessment of the appropriateness of the initial design and development for use as a guideline for developing the constructionism imagineering learning model via metaverse in the future. For further study, exploration of learning achievements and imagineering design skills should be considered. In addition, satisfaction reflects that constructionism imagineering learning model via metaverse and the learning processes which are implemented are suitable and can be used to enhance young innovator skills and learning achievement.

References

Abykanova, B., Nugumanova, S., Yelezhanova, S., Kabylkhamit, Z., & Sabirova, Z. (2016). The use of interactive learning technology in institutions of higher learning. *International Journal of Environmental & Science Education*, *11*(18), 12528–12539.

Ananda Development Public Company Limited. (2023). *What is Metaverse the future of the new world You can't miss it*! Retrieved March 18, 2023, from https://www.ananda.co.th/blog/thegenc/metaverse

Charles, L., & Rankin, W. (2018). *Education, Learning, and Knowledge a review of Research and Theory about Constructionism and Making*. Retrieved from http://pi-top.com

Hong, K. C., & Cho, Y. S. (2019). A novel engineering and creative learning process based on constructionism. *Journal of Information and Communication Convergence Engineering*, *17*(3), 213–220. https://doi.org/10.6109/jicce.2019.17.3.213.

Jeffrey, H. D., Hal, G., & Clayton, M. C. (2009). *The innovator's DNA*. Retrieved from https://hbr.org/2009/12/the-innovators-dna

Kanasutra, P. (1995). *Statistics for Research in the Behavioral Sciences*. Bangkok: Chulalongkorn University Press.

Kim, J. (2021). Advertising in the Metaverse: Research Agenda. *Journal of Interactive Advertising*, *21*(3), 141–144. https://doi.org/10.1080/15252019.2021.2001273

Kongpha, R., & Chatwattana, P. (2023). The Virtual Interactive Learning Model using Imagineering Process via Metaverse. *Higher Education Studies*, *13*(1), 35–41. https://doi.org/10.5539/hes.v13n1p35

Ministry of Education. (2022). *MOE Digital Transformation for Education Action Plan 2020–2022*. Ministry of Education. Retrieved from https://bict.moe.go.th/wp-content/uploads/2022/03/digital-63-65.pdf

Mystakidis, S. (2022). Metaverse. *Encyclopedia*, *2*(1), 486–497. https://doi.org/10.3390/encyclopedia2010031

National Innovation Agency. (2022). *National Innovation Agency* (NIA). Retrieved from https://www.nia.or.th/

Nilsook, P., Utakrit, N., & Clayden, J. (2014). Imagineering in Education: A Framework to Enhance Students' Learning Performance and Creativity in Thinking. *Education Technology*, *54*(1), 14–19. https://www.researchgate.net/publication/262676980

Phatrawat, K. (2020). *5 important STEPS 'innovators' for educational equality*. Education Equality Fund (NSO). Retrieved from https://www.eef.or.th/infographic-10-06-20/

Piyarungsi, K., Swathanan, S., Inthanan, N., & Hanwong, U. (2022). Attributes of Young Innovators. *Journal of Liberal Arts*, *22*(2), 438–458.

Sanglub, A., Nilsook, P., & Wannapiroon, P. (2019). Imagineering on augmented reality and digital twin for digital competence. *International Journal of Information and Education Technology*, *9*(3), 213–217. https://doi.org/10.18178/ijiet.2019.9.3.1201

Soutthaboualy, T., Chatwattana, P., & Piriyasurawong, P. (2022). Interactive Augmented Reality Technology via Blended Instruction Lesson on Cloud. *Higher Education Studies*, *12*(3), 9–18. https://doi.org/10.5539/hes.v12n3p9

Tingtrong, C., & Chatrupachewin, C. (2022). A Study of Technology Digital for Learning Management of Teacher at School under Sukhothai Primary Education Service Area Office 2. *Journal of Roi Kaensarn Academi*, *7*(8), 404–418.

Tonghom, J., Sripahol, S., Patphol, M., & Wannapiroon, P. (2017). Develop of online curriculum to enhance creative innovation skills. *Veridian E-Journal*, *10*(2), 138–156. Retrieved from https://he02.tci-thaijo.org/index.php/Veridian-E-Journal/article/view/96075/75039

Tsou, H. T., Chen, J. S., & Liao, W. H. (2014). Market and Technology Orientations for Service Delivery Innovation: The Link of Innovative Competence. *Journal of Business and Industrial Marketing*, *29*(6), 499–513. https://doi.org/10.1108/JBIM-09-2011-0128

Wannapiroon, P., Nilsook, P., Kaewrattanapat, N., Wannapiroon, N., & Supa, W. (2021). Augmented reality interactive learning model, using the imagineering process for the SMART classroom. *TEM Journal*, *10*(3), 1404–1417. https://doi.org/10.18421/TEM103-51

Wongtienlai, K., Usaho, C., & Chaemchoy, S. (2019). A Needs Assessment of Academic Management for Nursing College under the Jurisdiction of Ministry of Defence Based on the Concept of Innovator Competencies of Nursing Students. *Royal Thai Navy Medical Journal*, *46*(3), 506–521.

Yams, N. B. (2017). Integrated Model of Innovative Competence. *Journal of Creativity and Business Innovation*, *3*, 140–169. Retrieved from http://www.journalcbi.com/integrated-model-of-innovative-competence.html