Metaverse Learning Ecosystem for Hyflex Learning Snoopathon to Enhance Systematic Thinking and Innovative Thinking

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Manuscript received January 16, 2024; revised March 5, 2024; accepted April 12, 2024; published July 23, 2024

***Abstract*—This article presents research on a metaverse learning ecosystem for Hyflex learning using Snoopathon to enhance systematic and innovative thinking. This research endeavor focused on leveraging a metaverse learning ecosystem to facilitate Hyflex learning while utilizing Snoopathon methodology to augment systematic and innovative thinking skills. The study aimed to achieve three main objectives: 1) synthesizing the conceptual framework of the metaverse, 2) developing a creative metaverse learning ecosystem, and 3) evaluating the outcomes of the implemented strategies. A total of eleven participants took part in the research, selected through purposive sampling. These participants were experts drawn from diverse educational institutions, each holding academic positions and possessing specialized knowledge in designing and developing teaching systems. Importantly, all participants boasted a minimum of five years of professional experience in their respective fields. To assess the effectiveness of the interventions, two main research tools were employed. Firstly, the evaluation involved scrutinizing the components of the Hyflex learning process, particularly focusing on the Snoopathon methodology. Secondly, the research evaluated the metaverse's capacity to enhance systematic and innovative thinking among participants. By employing these research tools and methodologies, the study aimed to provide insights into the efficacy of integrating a metaverse learning ecosystem with Hyflex learning approaches, along with the impact of utilizing Snoopathon to foster systematic and innovative thinking skills within this context. According to the research findings, both the elements and the capacity to promote systematic and innovative thinking were remarkably elevated.**

***Keywords*—metaverse, learning eco-system, Hyflex learning, Snoopathon, systematic thinking, innovative thinking**

I. Introduction

Nowadays, technology and connectivity through the internet are spreading rapidly. Teaching and learning must take into account the needs of learners and be consistent with the current social context in order that learners can realize their maximum potential and thrive in society. The concept of a metaverse has gained popularity and stimulated development and innovation in many fields. This is a period that has revolutionized learning and personal growth, presenting a learning format with immense potential to reshape education in the years to come [1, 2].

Metaverse and learning ecosystem concepts help to create a learning space that is limitless and time limited. This allows flexible and diverse access to knowledge and teaching in a virtual space. The metaverse is a new form of reality that combines physical and digital virtual realities to provide users with a novel experience. The components of the metaverse have been employed in education, enhancing students' learning experiences through hands-on activities. Technologies like Augmented Reality (AR) and Virtual Reality (VR) enable educational simulations without associated risks, such as realistic simulations of aeroplane models and surgical procedures. Additionally, VR eliminates the need for cruel experiments involving animals, as these simulations can provide a lifelike experience with the same learning content [3, 4].

A learning ecosystem is an environment conducive to individual learning. It consists of various elements that promote learning. In an era where technology and communication are beginning to spread rapidly, learning has no boundaries and deadlines. Creating a learning environment involves initiating a sense of inspiration for curiosity and a desire to learn. This leads to the pursuit of knowledge, information, or the creation of experiences that contribute to self-directed learning. The space provided allows learners to experiment or apply this knowledge to real-life situations. Reflective processes and feedback mechanisms result in new knowledge that can be shared and transmitted, potentially inspiring others to pursue more complex or advanced learning experiences than before [5, 6].

Hyflex learning is a rapidly growing concept that caters to the flexibility and diversity of learning. It emphasizes giving users the freedom to choose a preferred learning method. Hyflex learning not only increases learning freedom, but is also a concept that emphasizes the use of technology and digital tools in organizing the learning process [7].

Snoopathon is a useful learning activity. For participants who want to develop systems, thinking skills and creativity activities are designed to practise skills through engaging learning experiences. The five steps of Snoopathon are as follows: 1) Seeking knowledge. It is important to clearly define the goal of knowledge acquisition, choose appropriate and reliable sources, and then use reading and rapid comprehension skills to acquire knowledge. 2) Information retrieval. This is the process of searching for relevant information from various sources, using reading and rapid comprehension skills to summarize the key points from the data, and then linking the data together. 3) The third step is data analysis. This involves processing data to discover relationships within it, identify trends in data, and draw conclusions. 4) The fourth step involves innovation and data summary. This is the process of creating new innovations

from data by defining the goal of innovation, gathering relevant data, and then brainstorming to develop innovation. 5) The final step is the presentation and discussion of the results of the innovation. This involves preparing the content and media for the presentation, practising the presentation, and then presenting the work effectively and answering questions from participants in the discussion [8].

Systems thinking and innovative thinking are important learning skills in the 21st century. Today's world is complex and rapidly changing. Therefore, these skills are needed to solve complex problems and create new things [9, 10].

The objectives of the research are: 1. To synthesize the conceptual framework of the MLES to enhance systematic and innovative thinking. 2. To develop an MLES based on this framework. 3. To evaluate the MLES model developed.

Based on the ideas mentioned above, this article's author developed the idea of studying the creation of a Metaverse Learning Ecosystem (MLES) for Hyflex learning of Snoopathon activities. The abbreviation MLES consists of M for metaverse, L for learning, E for ecosystem, and S for Snoopathon This is a learning activity that promotes systematic thinking and creativity. The hypothesis of this research: The metaverse learning ecosystem for Hyflex learning Snoopathon used to enhance systematic and innovative thinking demonstrates a high level of suitability.

II. Methodology of Research

The research comprised 11 participants chosen through purposive sampling. These individuals were carefully selected based on their expertise in designing and developing teaching systems, as well as their academic positions within various educational institutions. Notably, all participants possessed a wealth of experience, with each having accrued a minimum of five years in their respective fields of work.

The development of this research study involved the design, development, and evaluation of an MLES and used the following data collection, analysis, and methods.

Phase 1: Study and synthesize the MLES to enhance systematic thinking and innovative thinking.

Collection of information: The researcher used the following research tools: 1) an MLES designed to enhance systematic and innovative thinking. 2) A suitability assessment of this model. The statistics used in the data analysis included the mean and standard deviation of the data. Semi-structured interview questions were used as a data collection tool. The opinions of experts were sought in relation to the interview design and information related to the teaching and learning management process. This included learning to use the MLES, including learning content conducive to promoting systematic thinking and innovation among students, which can result in students being able to create innovative works. Sample questions included the following:

1) In organizing past teaching activities, were there any problems and needs regarding the teaching and learning process?
2) What are the current guidelines or formats for organizing activities for your students?
3) The Hyflex learning process consists of three elements: learning at the same time, online learning, and online and offline bidirectional communication. Do you think these elements are appropriate or not?
4) The process of marathon inquiry consists of five steps, consisting of (i) seeking knowledge, including (a) seeking knowledge quickly and (b) searching for information quickly; (ii) searching for information, including (a) searching for information quickly and (b) training the mind creatively; (iii) data analysis; (iv) summarizing data; and (v) presentation and discussion of results. Do you think these steps are appropriate and how are they appropriate?
5) Do you think that the MLES enhances systematic thinking and innovative thinking?
6) Do you think that using the MLES to enhance systematic and innovative thinking will affect the promotion of systematic thinking among students or not?
7) Do you think that the MLES can be used to enhance systematic and innovative thinking? How will it promote student innovation?
8) In what areas do you think adopting such a metaverse learning ecosystem causes students to develop or change? Why?
9) The adoption of the model metaverse learning ecosystem is integrated with teaching in Computational Science, Mathayom 5. Do you think it will affect the adjustment of your teaching? Why?
10) How likely do you think it will be possible to implement a flexible blended learning model with Marathon Inquiry using the Creative Universe learning ecosystem to promote systematic thinking and innovation in educational institutions?
11) If you will use the above learning management model and process in an educational institution, what suggestions do you have?

The design and development of this methodological study can be summarized into the following four phases, as shown in Fig 1.

Fig. 1. Research methodology.

Phase 2: Designing the MLES to enhance systematic and innovative thinking.

The design of the components of the metaverse MLES are shown in Fig. 2.

MLES were divided into three roles: students, teachers, and administrators. All three roles were able to access the MLES through various applications, including smartphones, tablets, and computers. The user had to enable the system via an internet connection, apply for membership, and log into

the system every time before using the MLES.

The architectural design of the Metaverse Learning Ecosystem with Snoopathon (MLES) is shown in Fig. 3.

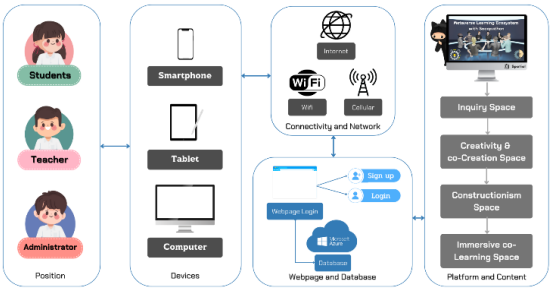

Fig. 2. The components of the MLES.

Fig. 3 depicts the system architecture of the MLES. It consists of the following parts:

1) The term "user" refers to the roles within the system, including students, teachers, and administrators. Students are high school-level learners, while teachers instruct in computer and information technology.
2) The term "devices" refers to any equipment used to access the MLES, such as PCs, laptops, tablets, and cell phones.
3) A firewall is a hardware or software solution that guards the MLES against several types of cyber-attack.
4) The system for determining user IDs and associated rights or responsibilities is called Active Directory and Identity and Access Management, which is employed to control access.
5) The term "Metaverse Platform" describes content in the metaverse learning ecosystem that has been collaboratively produced using information and data obtained from the MLES system.
6) A database is a sizable data repository that compiles relevant data, methodically having effective access to and utilization of information.
7) A computer device that processes data and offers the MLES system a number of functions is referred to as a server. In order to facilitate rapid and effective access to information, servers are in charge of storing a variety of data, including emails, databases, webpages, and numerous files.
8) Storage uses cutting-edge data storage technology to store information and data acquired by the MLES system to have rapid access to knowledge and information.

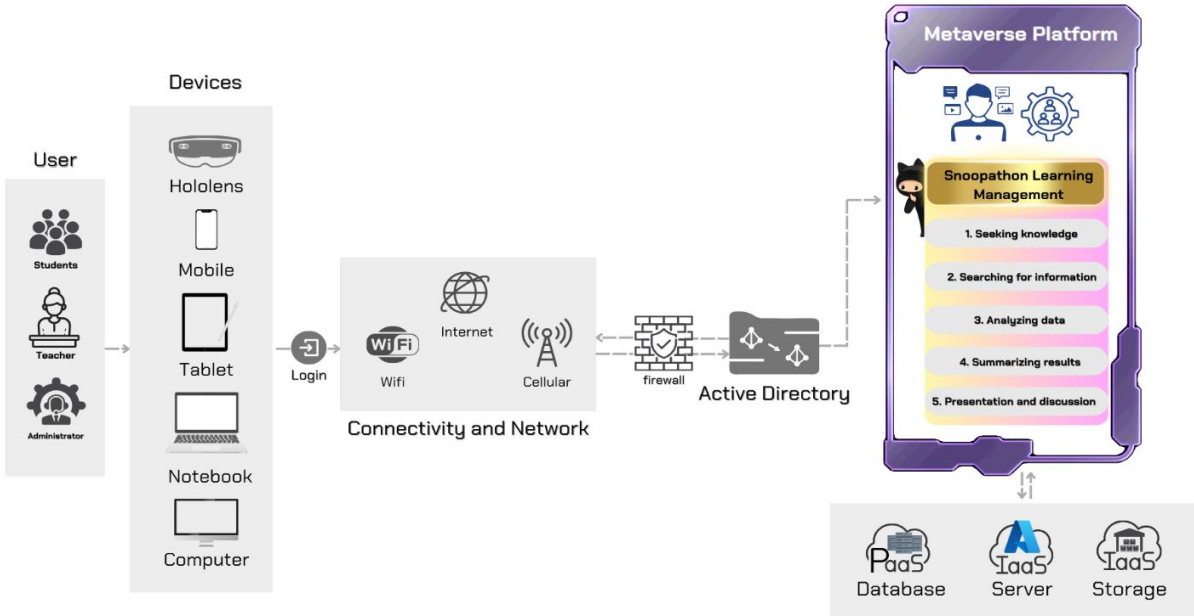

Fig. 3. The architectural design of the Metaverse Learning Ecosystem with Snoopathon (MLES).

Phase 3: The development of the MLES to be used as a tool to promote appropriate qualities in systematic thinking and innovation.

Phase 4: The results of evaluating the appropriateness of the developed model.

The criteria for data analysis were based on rank interpretation [9, 10] and details are given in Table 1.

Table 1. Score range and interpretation

Average score	Interpretation
4.50–5.00	Very high level
3.50–4.49	High level
2.50–3.49	Moderate level
1.50–2.49	Low level
1.00–1.49	Very low level

Metaverse learning ecosystem model for Hyflex learning Snoopathon to enhance systematic thinking and innovative thinking is designed to promote limitless learning and encourages students have real learning experiences. The process and steps are shown in Fig. 4.

The MLEs designed to enhance systematic and innovative thinking was composed as follows:

1) The Hyflex learning process encompasses three main components: in-person synchronous sessions, online synchronous sessions, and online asynchronous activities.
2) Snoopathon involves five distinct steps: knowledge seeking, information searching, data analysis, result

summarization, and presentation along with discussion.

3) The Metaverse learning ecosystem comprises seven essential components: hardware, software, individuals, content, technology, data, and administration.

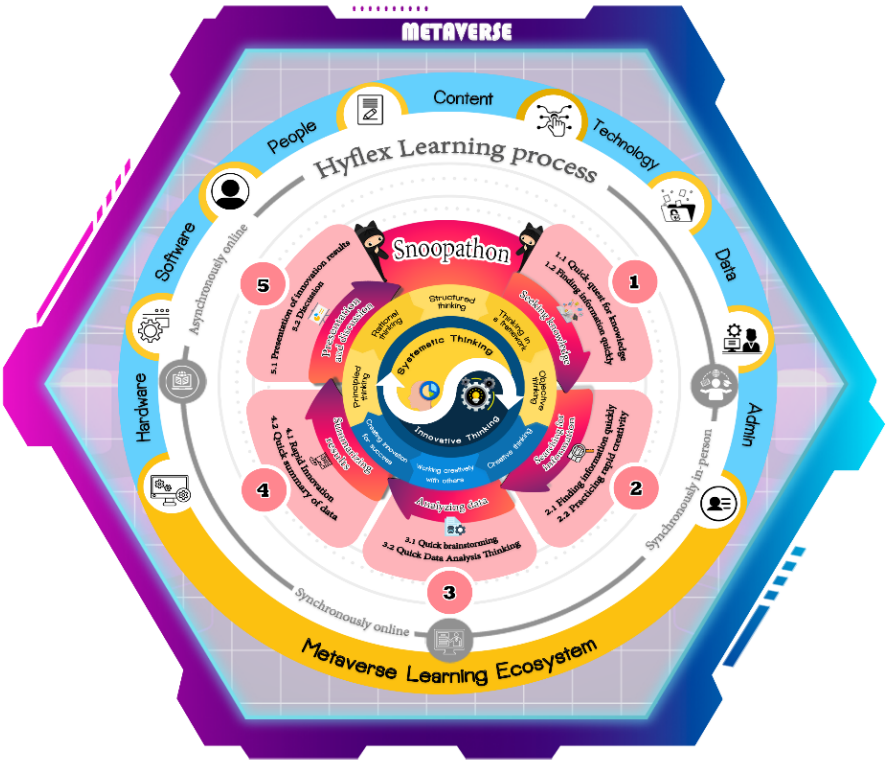

Fig. 4. Metaverse learning ecosystem model for Hyflex learning Snoopathon to enhance systematic thinking and innovative thinking.

Table 2. Synthesizing the dynamic MLES to enhance systematic thinking and innovative thinking

Snoopathon	Hyflex learning Snoopathon	Metaverse	Content	Learning outcomes
Seeking knowledge	1) Quick quest for knowledge 2) Finding information quickly	Explain the thought process through the Metaverse	Design thinking	Systematic thinking
Searching for information	1) Finding information quickly 2) Practicing rapid creativity	Analyze study problems and related documents through the Metaverse	Collection of information	
Analysis data	1) Quick brainstorming 2) Quick Data Analysis Thinking	Create knowledge through the Metaverse	Data analysis	
Summary of data	1) Rapid Innovation 2) Quick summary of data	Creating innovation through the Metaverse	Project development and innovation	Innovative thinking
Presentation and Discussion	1) Presentation of innovation results 2) Discussion	Present the results of the project report through the Metaverse	Project report	

III. Results and Discussion

The results of developing the Metaverse Learning Ecosystem (MLES) will be presented in Figs. 5–8. These numbers will display various data of MLES such as the login page, platform homepage, entry area into the Marathon Discovery Learning Ecosystem (MLES), and examples of classrooms, as follows: Inquiry Space is an area for fostering ideas among group members using this space allows for discussions, expressing opinions, and assisting each other in rapidly acquiring knowledge and retrieving information swiftly. Creativity & co-Creation Space serves as a venue for quick research and fostering rapid creative thinking. Constructionism Space is an area for rapid idea generation and quick data analysis. Immersive co-learning is a space for presenting innovative works and discussing outcomes.

Fig. 5. Login page.

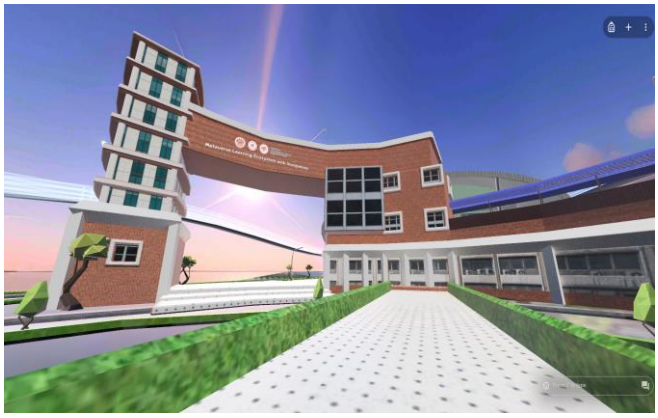

Fig. 6. Platform home page.

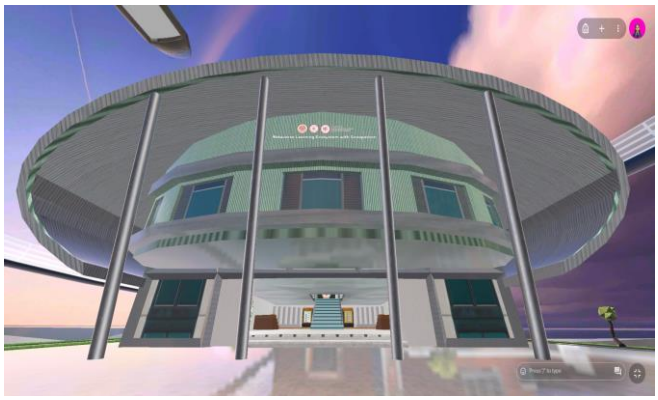

Fig. 7. At the entrance to the Metaverse Learning Ecosystem with Snoopathon (MLES).

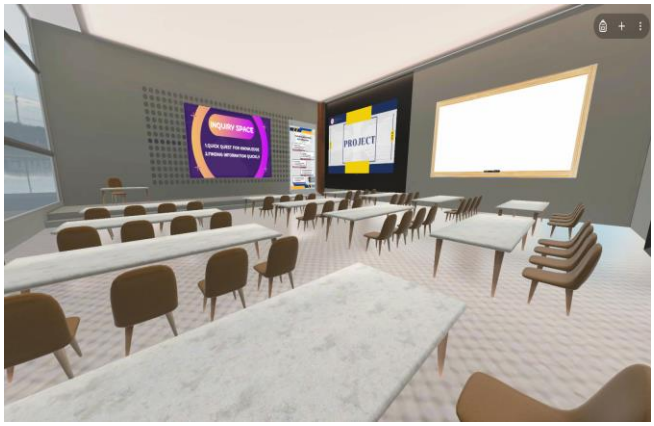

Fig. 8. Example of a classroom.

An "inquiry space" is a space for brainstorming within group members who can use this area to talk and express opinions and help each other find knowledge and information quickly.

A "creativity & co-creation space" is a space for quick research and where creativity can be practised quickly.

A "constructionism space" is a space for quick brainstorming, thinking, and analysing information quickly.

An "immersive co-learning space" is a space for presenting innovative work and discussing results.

The results of evaluating the appropriateness of the components of the MLES can be divided into two parts: 1) the suitability of the components of the Hyflex learning with the Snoopathon process, and 2) the appropriateness of the metaverse learning ecosystem. Details of the evaluation are shown in Tables 3 and 4.

According to Table 3, it can be inferred that the Metaverse Learning Ecosystem (MLES) significantly contributed to the improvement of systematic and innovative thinking skills among participants. The mean value of 4.80 suggests that the level of enhancement in these skills was very high. Additionally, with a standard deviation (SD) of 0.40, we can understand that the responses regarding this enhancement were quite consistent among the participants. This indicates a strong consensus among the respondents regarding the effectiveness of the MLES in fostering systematic and innovative thinking.

Table 3. Results of the evaluation of the appropriateness of the elements of the metaverse learning ecosystem model

Hyflex learning with snoopathon	Assessment results		Appropriateness
	Mean	SD	
Hyflex learning	4.82	0.40	Very high level
1. Synchronously in-person	4.82	0.40	Very high level
2. Synchronously online	4.82	0.40	Very high level
3. Asynchronously online	4.91	0.30	Very high level
Snoopathon	4.64	0.50	Very high level
1. The pursuit of knowledge	4.91	0.30	Very high level
1.1 Quick quest for knowledge	4.64	0.50	Very high level
1.2 Finding information quickly	4.82	0.40	Very high level
2. Searching for information	4.82	0.40	Very high level
2.1 Finding information quickly	4.82	0.40	Very high level
2.2 Practicing rapid creativity	4.64	0.50	Very high level
3. Data analysis	4.82	0.40	Very high level
3.1 Quick brainstorming	4.82	0.40	Very high level
3.2 Quick Data Analysis Thinking	4.82	0.40	Very high level
4. Summary of data	4.82	0.40	Very high level
4.1 Rapid Innovation	4.64	0.50	Very high level
4.2 Quick summary of data	4.82	0.40	Very high level
5. Presentation and Discussion	4.91	0.30	Very high level
5.1 Presentation of innovation results	4.91	0.30	Very high level
5.2 Discussion	4.82	0.40	Very high level
Overall	**4.80**	**0.40**	**Very high level**

According to Table 4, the evaluation of the Metaverse Learning Ecosystem (MLES) concerning its role in fostering systematic and innovative thinking. The mean score of 4.80 indicates that the effectiveness of the MLES in enhancing these cognitive skills is at the highest level. This high mean score suggests that most participants perceived significant improvement in their systematic and innovative thinking abilities because of utilizing the MLES. Moreover, the standard deviation (S.D.) value of 0.42 indicates the degree of variability in responses among participants. With a relatively low standard deviation, it suggests that the opinions regarding the effectiveness of the MLES for enhancing systematic and innovative thinking are consistent among the respondents.

Creating a metaverse learning environment has profound impacts on systemic thinking and creativity, as it can create experiences that are highly realistic and closely resemble the real world. It can generate environments rich in realism and reflective of diverse learning experiences. In the metaverse, learners can create avatars representing themselves and communicate with others in a virtual space. This can be a

great opportunity to integrate various knowledge and skills in situations that help learners understand and comprehend content more efficiently. Experimenting with the metaverse provides learners with opportunities to experiment and innovate without limits. This is because creating a feasible virtual environment can provide an appropriate setting for creativity and experimentation. The metaverse environment greatly enhances collaborative learning as students can collaborate with other learners or teams simultaneously and share experiences full of realism. Students can use their creativity to develop new things and experiment with various methods. Systematic thinking in the metaverse environment helps students learn how to collaborate to solve problems or create new things, with engagement and interest, resulting in intriguing outcomes. Utilizing the metaverse for learning not only adds fun and interest to the learning process, but also opens up opportunities for learners to create, innovate, and enhance a wide range of skills without the constraints of imagination and understanding in various aspects of learning and personal development.

Table 4. Results of the evaluation of the MLES designed to enhance systematic and innovative thinking

Metaverse learning ecosystem model	Assessment results		Appropriateness
	Mean	SD	
1. Metaverse learning ecosystem process for Hyflex learning snoopathon can foster systematic thinking and innovation	4.91	0.30	Very high level
2. The steps of the metaverse learning ecosystem for Hyflex learning snoopathon can foster systematic thinking and innovation	4.73	0.47	Very high level
3. Guidelines for using the metaverse learning ecosystem for Hyflex learning snoopathon can foster systematic thinking and innovation.	4.73	0.47	Very high level
4. Metaverse learning ecosystem for Hyflex learning snoopathon can strengthen the systematic thinking and innovative thinking	4.82	0.40	Very high level
5. Metaverse learning ecosystem for Hyflex learning snoopathon to enhance systematic thinking and innovative thinking can strengthen the ability to create innovative works	4.73	0.47	Very high level
Overall	**4.80**	**0.42**	**Very high level**

The research found that 1) the results of the evaluation of the Hyflex learning with Snoopathon process found that it was appropriate at a very high level. 2) The results of the evaluation of the suitability of the MLES to enhance systematic and innovative thinking was appropriate at a very high level. These results are consistent with Maneehaet and Wannapiroon's research, which suggests that a digital learning ecosystem with Artificial Intelligence (AI) for intelligent learning organizes learning spaces and learning content. The application of AI in the teaching process can be used to support teachers, support learners, and respond to the needs of many different learners at the same time using personalized assistance, automatic grading, and identifying weaknesses in the classroom [11]. Hyflex learning comprises three components: 1) synchronous learning, 2) online learning, and 3) two-way online and offline communication. This aligns with the research of Phonphanthin *et al.* [12], which suggests that blending and flexibility are comprehensive approaches to managing three learning formats. These include 1) managing traditional classroom learning for students simultaneously in the same place and at the same time, 2) conducting online learning for learners, and 3) managing learning for groups of students who do not follow either format. This Hyflex learning approach adapts to the suitability and readiness of learners, allowing them to study anywhere and anytime.

Teachers need to prepare teaching materials, manage instruction, and consistently assess the learning outcomes of the students. The research of Nguyen *et al.* [13] indicates that research has been undertaken on the development of a Hyflex learning model for undergraduate students. The results of the research found that 1) the Hyflex model for undergraduate students can be used through certification by experts. This has three components: the teacher, the dimension of flexibility in learning, and the learner. 2) The quality of flexible learning media is at a very good level. 3) Academic achievement scores are significantly higher than pre-test scores at the 0.05 level. The quality of learning outcomes according to the actual conditions of students is at a good level and 4) student satisfaction with flexible learning is at a high level because such teaching and learning can create new knowledge from self-learning through digital technology [14].

The learning activity of a Metaverse-based learning environment is highly suitable overall, aligning with Seng's research [15] on developing virtual classrooms with the metaverse to facilitate inquiry-based learning for enhancing technological literacy among sixth-grade students at an innovative educational institution. The development and effectiveness testing of the virtual classroom with the metaverse indicated the highest level of effectiveness, meeting the criteria. This is attributed to the researchers' systematic approach in designing and developing the virtual classroom with the metaverse, involving steps such as analysing student profiles, learning management, lesson content, relevant documents, and research materials. The data collected served as the foundation for the efficient design and development of the metaverse-enabled virtual classroom, consistent with Kasetiam *et al.*'s study [16] on developing virtual classrooms using Metaverse Spatial for first-year high school students studying the unit on living organisms in science, showing significant implications at the 0.05 level.

The spatial application within the metaverse learning environment, along with Snoopathon participation, increased learner engagement with the learning content, improved information retention, and developed analytical skills. In particular, results were seen in the following areas. Accessibility: Learners can access learning content from anywhere, anytime. Safety: Learners can practise skills in a safe virtual environment. Collaboration: Learners can work together with other students and instructors. Snoopathon offers a variety of tools and resources to assist creators in

developing spatial learning applications. The Metaverse learning environment with Snoopathon presents exciting new opportunities for creators to develop diverse and collaborative spatial learning applications. Snoopathon helps creators to develop memorable and effective metaverse learning experiences.

IV. Conclusion

To develop the MLES to enhance systematic and innovative thinking, the researcher used learning platforms that are aligned with new learning models, incorporating digital learning through technology that is appropriate for the new generation, to facilitate direct learning that leads to the future of learning. The model developed consisted of the following main components: 1. The Hyflex learning process, which can be summarized into three components as follows: (i) synchronously in-person; (ii) synchronously online; and (iii) asynchronously online. 2. Snoopathon, which can be summarized into five steps as follows: (i) seeking knowledge; (ii) searching for information; (iii) analysing data; (iv) summarizing results; and (v) presentation and discussion. 3. The Metaverse learning ecosystem, which consisted of seven components: hardware, software, people, content, technology, data, and Administrator. The Metaverse Learning Ecosystem (MLES) demonstrates its effectiveness in fostering systematic and innovative thinking. This high mean score suggests widespread perception among participants of substantial improvement in systematic and innovative thinking due to MLES utilization. Additionally, the low standard deviation suggests consistent opinions among respondents regarding the MLES effectiveness in enhancing these skills, indicating a high level of agreement.

Current teaching and learning are learner-centred, and learners play an important role in their learning. Digital technology can also help to make learning effective. It also facilitates the exchange of knowledge through social networks leading to a learning society that will equip students with the creativity and skills needed for the 21st century.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Agree to research the metaverse learning ecosystem for Hyflex learning Snoopathon to enhance systematic thinking and innovative thinking. Jaruwan Karapakdee conducted research. analyze data, write articles, review and edit language. Panita Wannapiroon and Prachyanun Nilsook reviews and makes recommendations for presenting the results of data processing and conclusions. All authors have approved the final version.

Acknowledgment

The researcher would like to thank Educational Research Development and Demonstration Institute, Srinakharinwirot University, And Special thanks to the Innovation and Technology Management Research Center, King Mongkut's University of Technology North Bangkok which supported this research.

References

[1] J. Bengoechea and A. Bell, "Metaverse as a form of reality and the impact of metaverse in higher education," *Journal of Educational and Pedagogical Sciences*, vol. 16, no. 9, pp. 531–535, 2022.

[2] Q. Yang, Y. Zhao, H. Huang, Z. Xiong, J. Kang, and Z. Zheng, "Fusing blockchain and AI with metaverse: A survey," *IEEE Open Journal of the Computer Society*, vol. 3, pp. 122–136, Jul. 2022. doi: 10.1109/ojcs.2022.3188249

[3] 21CLEO Research Team. (2022). 30. working learners in an workplace learning ecosystem. *21CLEO Research Project Blog Posts*. 30. [Online]. Available: https://pdxscholar.library.pdx.edu/cleo_blog/30

[4] W. López-Ojeda and R. A. Hurley, "The medical metaverse, part 1: Introduction, definitions, and new horizons for neuropsychiatry," *J. Neuropsychiatry Clin Neurosci.*, vol. 35, 1, 2023. doi: 10.1176/appi

[5] L. Jacka, "Successful integration of virtual worlds in learning environments: A Case study of a supportive learning ecosystem," *Interdiscip. J. Virtual Learn. Med. Sci.*, vol. 12, no. 3, pp. 169–176, 2021. doi: 10.30476/IJVLMS.2021.90912.1091

[6] W. D. Redmond and L. P. Macfadyen, "A framework to leverage and mature learning ecosystems," *International Journal of Emerging Technologies in Learning*, vol. 15, no. 5, pp. 75–99, 2020. doi: 10.3991/IJET.V15I05.11898

[7] J. Karapakdee, P. Wannapiroon, and P. Nilsook, "Hyflex Learning with Snoopathon for Metaverse," in *Proc. 4th Research, Invention, and Innovation Congress: Innovative Electricals and Electronics: Innovation for Better Life, RI2C 2023*, Institute of Electrical and Electronics Engineers Inc., 2023, pp. 77–82. doi: 10.1109/RI2C60382.2023.10356005

[8] M. Miura and T. Higuchi, "IMS-LMS: A learning management system integrated with idea-marathon system activities," *F Intelligent Informatics and Smart Technology*, vol. 7, 2022.

[9] N. Wannapiroon and S. Petsangsri, "Effects of steamification model in flipped classroom learning environment on creative thinking and creative innovation," *TEM Journal*, vol. 9, no. 4, pp. 1647–1655, Nov. 2020. doi: 10.18421/TEM94-42

[10] K. Carper and C. Friedel, "Systems thinking and hybrid learning: Systems thinking and hybrid learning: Findings for improving teaching in the findings for improving teaching in the COVID-19 Era COVID-19 Era 1 1," *NACTA Journal*, vol. 65, pp. 144–155, 2021.

[11] S. Maneehaet and P. Wannapiroon, "A digital learning ecosystem with artificial intelligence for smart learning," *Journal of Education Naresuan University*, vol. 21, no. 2, pp. 359–373, 2019.

[12] S. Phonphanthin, S. Chalayasap, J. Jitsupa, and W. Sakulhom, "Hyflex learning active learning in learning loss," *Journal of Teacher Professional Development*, vol. 3, no. 2, pp. 18–29, 2022.

[13] L. T. Nguyen *et al.*, "Digital learning ecosystem for classroom teaching in Thailand high schools," *Sage Open*, vol. 13, no. 1, Jan. 2023. doi: 10.1177/21582440231158303

[14] B. Gourneau and K. Smart. (2022). Using the Hyflex Model in teacher education: Faculty reflections and insight. [Online]. Available: http://nssa.us

[15] R. Seng. (Jun. 2023). The Development of virtual classroom with a metaverse by using inquiry-based process to promote competency-based learning in technology on computing science course for Grade 6 students of the education sandbox schools. [Online]. Available: https://wb.yru.ac.th/handle/yru/6859

[16] N. Kasetiam, P. Roungrong, and T. Roungbundit, "Development of an online metaverse lesson using with active learning approach titled 'technology for solving problems' in design and technology course, of 9th grade students," *Journal of Education and Innovation*, vol. 26, no. 1, pp. 152–162, 2023.

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