

The Micro-Learning Activities via Metaverse Platform: The Outcomes of Students' at Pakse Teacher Training College, Lao PDR

Aphinanh Suvandy¹, Pinanta Chatwattana², Prachyanun Nilsook²

¹ Pakse Teacher Training College, Champasack, Laos

² King Mongkut's University of Technology North Bangkok, Bangkok, Thailand

Abstract – The micro-learning activities via metaverse platform, or MICRO-META platform, is a research tool designated to promote learning that focuses mainly on small units of contents and learning activities that can be accomplished in a short period of time. Thereby, the micro-learning activities are facilitated by means of the so-called micro-steps under digital learning environments via metaverse. The activities of this kind are capable of providing realistic learning experiences along with ability to interact with others in the virtual world, which shall result in the exchange of information and access to varied resources. In addition, these activities are believed to increase confidence in practical skills related to the use of digital technologies. The research results show that the micro-learning activities via metaverse platform to enhance digital literacy and digital empathy can be used practically as a learning tool, and it is efficient enough to promote both digital literacy and digital empathy. Once integrated with immersive learning technologies under the virtual world, the MICRO-META platform can also encourage learners to learn by experiences and acquire new bodies of knowledge according to their own abilities.

Keywords – Micro-learning activities, metaverse, digital literacy, digital empathy.

DOI: 10.18421/TEM132-80

<https://doi.org/10.18421/TEM132-80>


Corresponding author: Aphinanh Suvandy,
Pakse Teacher Training College, Champasack, Lao PDR
Email: aphinanh1717@gmail.com

Received: 26 January 2024.

Revised: 28 April 2024.

Accepted: 14 May 2024.

Published: 28 May 2024.

 © 2024 Aphinanh Suvandy, Pinanta Chatwattana & Prachyanun Nilsook; published by UIKTEN. This work is licensed under the Creative Commons Attribution-NonCommercial-NoDerivs 4.0 License.

The article is published with Open Access at <https://www.temjournal.com/>

1. Introduction

The 8th Five-Year National Socio-Economic Development Plan for 2016-2020 of Lao People's Revolutionary Party and the Government of the Lao People's Democratic Republic has emphasized the improvement on the instruction quality and the efficiency of instructors, equipment, curriculum, as well as laboratories, with an intention to reduce the theory-based teaching while focusing more on practices. Teaching innovations in digital universities are so highly important that instructors must pay cautious attention to them. In addition, instructors must be able to apply them in compliance with the world's current situations in order to promote self-learning and raise the quality of social services, particularly the services in the area of education. This is due to the fact that the exchange of knowledge and interaction with one another through online social networks are believed to enable people to have unlimited access to information. All of the aforementioned are also in line with the National Economic and Social Development Plan [1], which states that human resources must be developed and well equipped with knowledge and competencies in the areas of science and technology so that they can become intellectual forces for national development. The plan also places an emphasis on the creation of convenience, speed, and safety of communication and data transmission, including the development of high-speed communication technology and information networks, which can result in quality services [2].

Technological and social changes in the 21st century have resulted in necessity of skills required for adaptation and self-development in various fields. As one of the indispensable skills in such digital age, digital literacy has become a major issue for all levels of instruction management for new generation education [3].

Integrating technologies about virtual world with instruction was more evident and concrete during the crisis caused by COVID-19 since this method is recognized as a means to encourage creation of knowledge, exchange of knowledge, and collaboration via virtual technology or metaverse [4]. This leads to the enhancement in quality of social services through network system, especially those related to education, while enabling people to have unlimited access to information.

Micro learning is a concept of learning process that emphasizes small units of contents and learning activities that can be accomplished in a very short period of time. The learning in this style is intended to enhance knowledge and it can be adapted according to the needs of learners. The contents in this learning style are usually those that can be applied effectively in daily life. With the steps predetermined in the micro-learning process, it is said that micro learning helps learners acquire new knowledge and enables them to adjust their learning styles as to their own needs quickly and conveniently. In addition, micro learning enables learners to develop their knowledge and skills more effectively while facilitating the learning styles that respond to their needs and interest at every step [5].

The micro-learning process [5] consists of four steps as follows.

- Defining the objectives: The learning objectives are set to focus mainly on a specific subject for clarity and targets of learning.
- Studying the contents: Learners are allowed to study the learning contents by their own as to the specified objectives through learning activities.
- Doing the learning activities via metaverse: Learners are allowed to do the learning activities which are set to focus mainly on a specific subject.
- Evaluation after learning: This step is related to the evaluation after completing the micro-learning process in order to measure the learning achievement of learners.

Metaverse is a virtual reality platform that allows learners to create and interact with virtual environments. Metaverse provides unique and creative learning experiences that can help increase learners' engagement and motivation [6]. For this reason, metaverse is considered a new technology in educational that provides more access to learning resources by exchanging information through the 3D virtual world, that help learners achieve deep learning [7]. Due to its rapid growth and evolution, metaverse has become a technology applied in the new-normal education management [8] with an aim to promote continuous learning.

Digital literacy refers to knowledge and understanding of how to use digital technologies. Digital literacy is highly significant because it increases ability to work, communicate, learn, and solve problems, all of which contribute to the effective learning and use of digital technologies [9]. Therefore, digital literacy is also regarded as the ability to create a variety of contents by means of varied digital tools [10]. Not only does digital literacy involve the learning about using tools, but it also involves skills in data analysis, problem solving, and adaptation to technological changes.

Digital empathy refers to understanding and responsibility for emotions and feelings of others in online world [11]. Digital empathy also encompasses the use of technologies in an ethical way, communication, and interaction with other users with good manners [12], [13], which shall pave ways to a learning and sharing society based on the utilization of information technology.

This research is related mainly to the examination of perspectives towards the design and the development after having the participants use the micro-learning activities via metaverse platform (MICRO-META platform) to enhance digital literacy and digital empathy. This is to verify whether the MICRO-META platform is efficient enough and can be employed to enhance digital literacy and digital empathy or not. Thus, this research consists of the following objectives:

OB1: To synthesize the micro-learning activities via metaverse platform to enhance digital literacy and digital empathy at Pakse Teacher Training College, Lao PDR.

OB2: To develop the micro-learning activities via metaverse model (MICRO-META model) to enhance digital literacy and digital empathy at Pakse Teacher Training College, Lao PDR.

OB3: To develop the micro-learning activities via metaverse platform, or MICRO-META platform, to enhance digital literacy and digital empathy at Pakse Teacher Training College, Lao PDR.

OB4: To study the results after using the micro-learning activities via metaverse platform, or MICRO-META platform, to enhance digital literacy and digital empathy at Pakse Teacher Training College, Lao PDR.

2. Methodology

This research is related to design and development of the MICRO-META platform to enhance digital literacy and digital empathy and the details thereof are as follows.

2.1. Research Design

This research is concerning the development of the micro-learning activities via metaverse platform, or MICRO-META platform to enhance digital literacy and digital empathy at Pakse Teacher Training College, Lao PDR, using pre-experimental research method with one group pretest-posttest design. The following hypotheses are associated with the study of results after using the MICRO-META platform.

H₁: The suitability of the micro-learning activities via metaverse model (MICRO-META model) to enhance digital literacy and digital empathy at Pakse Teacher Training College, Lao PDR, is at high level.

H₂: The efficiency of the micro-learning activities via metaverse platform (MICRO-META platform) to enhance digital literacy and digital empathy at Pakse Teacher Training College, Lao PDR at high level.

H₃: The learning achievement scores after learning with the said MICRO-META platform are higher than those before learning with a significance level of .05

2.2. Participants

The research participants in this study are (1) 10 experts from different higher education institutions specialized in the design and development of instruction systems, all of whom were chosen by means of purposive sampling, and (2) 30 undergraduate students obtained by means of cluster sampling, all of whom are the freshmen of Pakse Teacher Training College, Lao PDR, enrolled in Basic Computer Course 1, Semester 1, academic year 2023. All participants above were well protected under the policy of confidentiality and anonymity.

2.3. Research Instruments and Data Collection

The research instruments consist of (1) the micro-learning activities via metaverse model (MICRO-META model), (2) the micro-learning activities via metaverse platform (MICRO-META platform), (3) the evaluation form on the suitability of the MICRO-META model, and (4) the evaluation form on the quality and efficiency of the MICRO-META platform. The data analyses are mean and standard deviation (SD). In reference to the data collection, the researchers employed the evaluation form, which had already been proved for index of item objective congruence by experts. Before doing voluntary assessment on this form, the participants had been informed that they had freedom to make decisions and accept this participation.

Above all, they were assured that their identity shall not be revealed.

2.4. Method

To design and develop the MICRO-META platform, the researchers adhered to the concepts of systems approach [14], [15] along with software development life cycle (SDLC) theories [16], which can represent the steps and the process of system development. Thus, the methodology of this research can be concluded into four stages as below.

Stage 1: Synthesis the documents and researches relevant to micro learning, activity-based learning, metaverse, digital literacy, and digital empathy, in order to find out the conceptual framework of the MICRO-META platform.

Stage 2: Develop the MICRO-META model. The researchers applied the principles of systems approach [14], [15] as guidelines for the design and the development.

Stage 3: Develop the MICRO-META platform. The researchers employed the SDLC [16] to illustrate the steps and the process of system development. Also, the MICRO-META platform was developed on the Spatial.io platform, which is compatible with various interactive screens (Responsive Web Design).

Stage 4: Study the results after having the participants use the MICRO-META platform. Whereby, all of the participants gave their consent to complete the evaluation form and they were all protected under the policy of confidentiality and anonymity. The criteria of mean score and interpretation [17] were studied at this stage.

3. Results

The results of the design and the development of the micro-learning activities via metaverse platform (MICRO-META platform) to enhance digital literacy and digital empathy can be concluded as follows:

3.1. Conceptual Framework of the MICRO-META Platform

After the synthesis of the documents and researches relevant to instruction system, micro learning, activity-based learning, metaverse, digital literacy, and digital empathy, the researchers acquired the conceptual framework of the micro-learning activities via metaverse platform to enhance digital literacy and digital empathy as seen below.

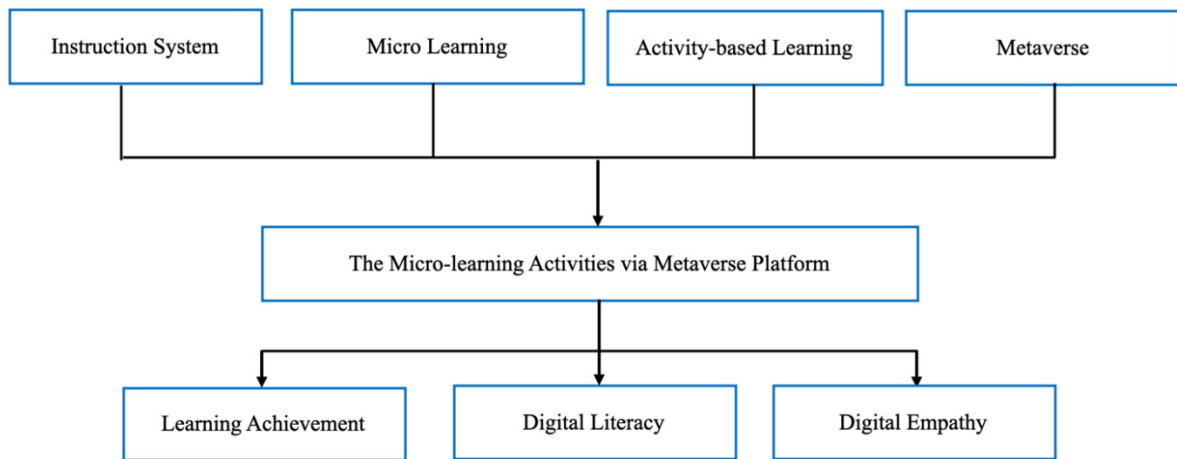


Figure 1. Conceptual framework of the MICRO-META platform

3.2. Design of the MICRO-META model

The micro-learning activities via metaverse model (MICRO-META model) used to enhance digital literacy and digital empathy are research tools that can facilitate the learner-centered instruction management, in which the micro-learning activities are organized by means of the so-called micro-steps under digital learning environments. Based on the concept “Less is More”, the instruction design emphasizes smaller units of contents but more

learning. It is expected that it enables learners to control what they are learning on their own in a flexible manner. Learners are able to learn lessons from instructional videos and other forms of learning materials. Meanwhile, they are encouraged to think and do analysis by themselves before coming to do activities with friends in class. At the meantime, instructors are required to give advice and facilitate the learning management that can urge learners to develop digital literacy and digital empathy.

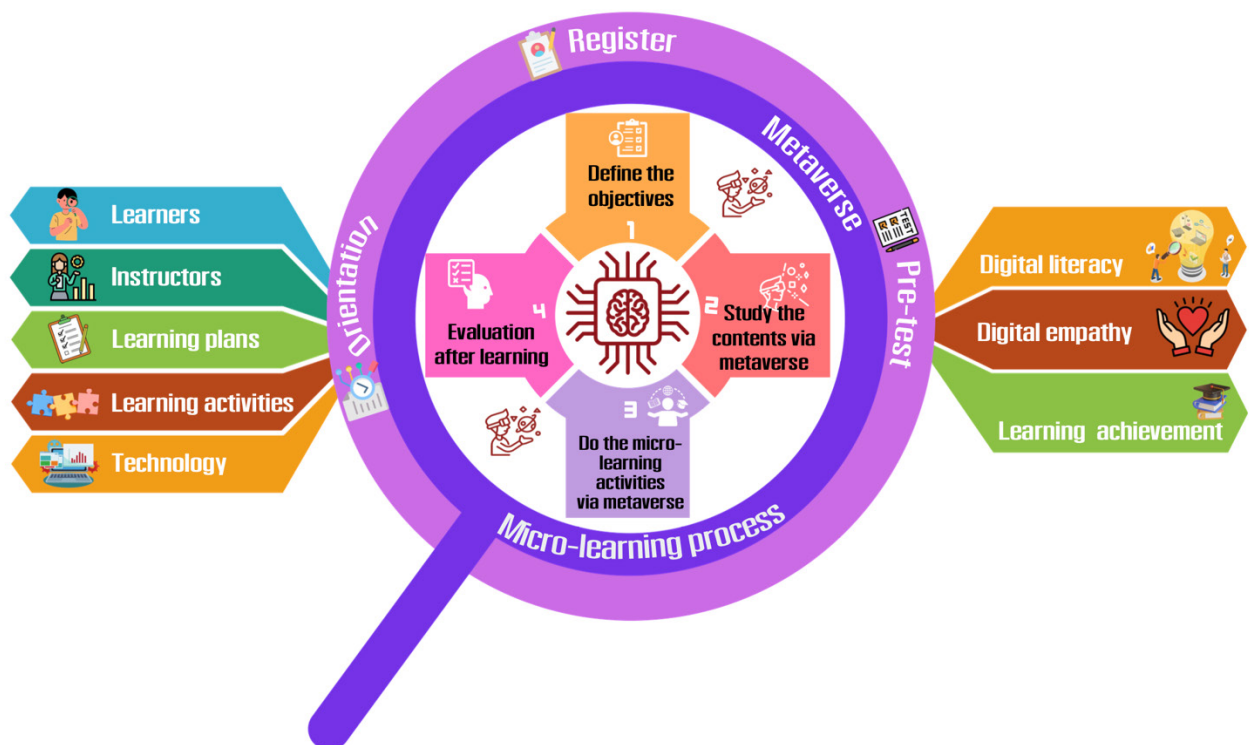


Figure 2. The MICRO-META model to enhance digital literacy and digital empathy

According to Figure 2, the details of the MICRO-META model to enhance digital literacy and digital empathy are as follows:

1. Input factor: This section represents all the elements related to the design of MICRO-META model, including learners, instructors, learning plans, learning activities, and technologies.
2. Micro-learning process via metaverse: This element is the learning process designated in the MICRO-META model, which is the learning in a virtual environment, or online learning, combined with classroom learning. Learners shall take the tests through the computer system and study the contents through the micro-learning process [5], [18], [19], [20], [21]. Thereby, the micro-learning process comprises the steps of (1) defining the objectives, (2) studying the contents via metaverse, (3) doing the micro-learning activities via metaverse, and (4) evaluation after learning. The tools used to support such learning include: (1) the learning management system, which is the classroom instruction system, (2) metaverse, which is employed to promote learning; whereby learners must simulate themselves into 3D avatars in order to learn in such a simulated world, (3) micro-learning activities, prepared in small units, through which learners can do both group and individual activities, and (4) the pre-class and post-class tests which learners can take in the classroom. Furthermore, with these micro-learning activities, learners can also do the practices about digital literacy and digital empathy so as to measure their behaviors in using technologies.
3. Output: These are the results acquired from the learning process; in other words, it refers to the abilities related to digital literacy and digital empathy. In summary, digital literacy and digital empathy are essential for engagement in the modern world in terms of both personal competencies and profession because technologies have become important parts of everyday life, e.g., communication, education, work, etc. In this study, the researchers had done synthesis on the relevant documents and researches [12], [13], [22] and then received the guidelines for use in this study. It can be concluded that digital literacy and digital empathy consist of the following abilities, i.e., access to technology, use of technology, understanding of technology, creation of technology, communication literacy, and collaboration.

Table 1. Synthesis of the abilities related to digital literacy and digital empathy

Digital literacy and digital empathy	Desired characteristics
Access to technology	Accessibility to technology along with understanding and ability to communicate ideas effectively
Use of technology	Ability to use technology to search information, select appropriate information, and use information to search data
Understanding of technology	Ability to understand, interpret, learn, and show opinions about what is found
Creation of technology	Proficiency to use technology to create learning materials, and then summarize and present the acquired knowledge through worksheets
Communication literacy	Ability to exchange and share bodies of knowledge with others in the society
Collaboration	Ability to work with others in order to achieve the goals

4. Feedback: This part is about the data received from the output, which will be used as feedback to enhance the learning process. The feedback comprises the results of evaluation on digital literacy, digital empathy, and learning achievement.

Table 2. The overall elements of evaluation of the MICRO-META model

Items for evaluation	Mean	SD
1. Concepts and theories used in the design	4.80	0.45
2. Elements of the MICRO-META model		
2.1 Input factor	5.00	0.00
2.2 Micro-learning process via metaverse	5.00	0.00
2.3 Output	5.00	0.00
2.4 Feedback	4.80	0.45
3. Suitability of the sequence of steps in the learning process of the MICRO-META model	5.00	0.00
4. Overall elements in the design of the MICRO-META model	4.80	0.45
Total average score	4.91	0.28

Referring to the results of suitability evaluation in Table 2, it is found that the average score of overall elements in the MICRO-META model is at very high level (mean = 4.91, SD = 0.28).

It can be clearly seen that the MICRO-META model has proper elements and it can be employed as a guideline to develop other learning tools in order to enhance digital literacy and digital empathy, both of

which are the characteristics for learners in the digital era as both can lead to the creation of new knowledge or new innovations.

Table 3. The separate elements of evaluation of the MICRO-META model

Items for evaluation		Mean	SD
1. Input factor	1.1 Learners	5.00	0.00
	1.2 Instructors	5.00	0.00
	1.3 Learning plans	5.00	0.00
	1.4 Learning activities	5.00	0.00
	1.5 Technology	5.00	0.00
2. Micro-learning process via metaverse			
2.1 Preparation	2.1.1 Orientation	4.80	0.45
	2.1.2 Register	5.00	0.00
	2.1.3 Pre-test	5.00	0.00
2.2 Instruction	2.2.1 Define the objectives	5.00	0.00
	2.2.2 Study the contents via metaverse	5.00	0.00
	2.2.3 Do the micro-learning activities via metaverse	5.00	0.00
	2.2.4 Evaluation after learning	5.00	0.00
3. Output			
3.1 Learning achievement	3.1 Learning achievement	5.00	0.00
	3.2 Digital literacy	5.00	0.00
	3.3 Digital empathy	4.60	0.55
4. Feedback			
4.1 Learning achievement score	4.1 Learning achievement score	5.00	0.00
	4.2 Digital literacy score	5.00	0.00
	4.3 Digital empathy score	4.80	0.45
Total average score		4.95	0.22

According to the results of suitability evaluation in Table 3, it is found that the average score of the MICRO-META model is at very high level (mean = 4.95, SD = 0.22). It is obvious that the MICRO-META model is composed of all essential elements and it can be employed as a guideline to further develop the practical and effective learning tools to enhance digital literacy and digital empathy. Both of these characteristics are necessary for learners in the digital era because they can encourage them to conduct self-learning with the aid of technologies. This is in accordance with the research whose author [23] stated that the application of principles, concepts, theories, and new technology can help learners gain learning experiences on their own. Additionally, this can enhance their digital literacy and learning achievement as well.

3.3. Development of the MICRO-META Platform

The micro-learning activities via metaverse platform (MICRO-META platform) to enhance digital literacy and digital empathy is considered a learning tool that can be put in practical use as it is operating on the Spatial.io platform, compatible with various interactive screens (Responsive Web Design). This study is intended to present the MICRO-META platform of which the user interface was designed in correspondence to users' demand. Besides, the researchers incorporated the learning technologies via metaverse in the development with an effort to equip learners with new experiences while giving them the opportunities to perform self-learning.

Table 4. Results after using the MICRO-META platform to enhance digital literacy and digital empathy

Items for evaluation		Mean	SD
Quality	1. The MICRO-META platform is convenient and easy to understand	4.40	0.55
	2. Images and languages	4.40	0.55
	3. Fonts and colours	4.80	0.45
	4. Design of classroom elements	4.80	0.45
	5. Design of classroom via metaverse	4.60	0.55
	6. The virtual classroom is complete and easy to understand	4.40	0.55
	7. The platform can promote micro-learning activities	4.40	0.55
	8. The learning tools are suitable	4.40	0.55
	9. Design of learning tools to enhance digital literacy and digital empathy	4.60	0.55
	10. Referring to overall quality, the MICRO-META platform covers all demands.	4.40	0.55
Efficiency	11. System capabilities	4.60	0.55
	12. Functionality	4.60	0.55
	13. Usability	4.40	0.55
	14. Work performance	4.40	0.55
	15. Referring to overall efficiency, the MICRO-META platform covers all demands.	4.60	0.55
Practical use	16. The MICRO-META platform can enhance digital literacy.	4.80	0.45
	17. The MICRO-META platform can enhance digital empathy.	4.60	0.55
	18. The MICRO-META platform can be used as a tool to promote instruction.	4.60	0.55
	19. The MICRO-META platform is likely to be applied for practical use.	4.40	0.55
Total average score		4.54	0.50

Table 4 represents the results after using the MICRO-META platform to enhance digital literacy and digital empathy. The average score in all 3 aspects (quality, efficiency, and practical use) is at very high level (mean = 4.54, SD = 0.50). It is evident that the MICRO-META platform to enhance digital literacy and digital empathy is considered a learning tool that can be applied for practical use. Not only that, the platform is efficient enough to be used as a tool to enhance digital literacy and digital empathy since the micro-learning activities contained in this platform are managed by means of the so-called micro-steps under digital learning environments, which are supported by modern technologies and digital tools. This can facilitate the learning styles according to the needs of learners. This is in compliance with the research whose authors mentioned that the use of technologies to create interactions and provide realistic learning experience as well as immersive learning experience can increase learners' interest and enthusiasm to learn; and at the meantime, it is said to also increase their self-confidence related to their practical skills [24].

Table 5. Comparative of learning achievement before and after using the MICRO-META platform

learning achievement	Full score	Mean	SD	t-test	Sig.
Pre-test	50	31.43	3.71	20.02	.00*
Post-test	50	44.30	2.87		

* Significant at the level of .05 ($\alpha = .05$, $df = 49$)

In reference to the results of comparison of learning achievement scores before and after using the MICRO-META platform in Table 5, it is found that the students of one-group pretest-posttest design, who had learned with the MICRO-META platform, received higher learning achievement scores. Once considering the average scores of learning achievement, it is found that the average scores after learning with the platform (mean = 44.30, SD = 2.87) are higher than those before learning with the platform (mean = 31.43, SD = 3.71).

The results show that the students have better learning achievement with the significance level of .05 after learning through the MICRO-META platform.

In pursuant to the said results, it can be concluded that the MICRO-META platform can increase the learning achievement of these students, which is in compliance to the hypothesis 3. The results are in line with the research [25] where the concepts related to information technology and online instruction are integrated together to generate new ideas and innovations, which results in the online lessons that can promote the learning among the new-generation learners and correspond directly to their experiences.

4. Conclusion

Once considering education management for modern learners, the main point that instructors must take into account is the education format that is appropriate for the era, can be adapted to the current situations, and can lead to continuous learning. In addition, it is also very significant that instructors ought to choose the learning styles that are consistent with the learners' behaviors today, who are usually

fond of challenges, freedom to learn, and self-learning.

The MICRO-META platform to enhance digital literacy and digital empathy was developed with the principles and the concepts of instruction management that focuses mainly on the learning of small units of contents and learning activities that can be accomplished in a short period of time. Thereby, the micro-learning activities are facilitated by means of the so-called micro-steps under digital learning environments. Also, the MICRO-META platform was developed on the Spatial.io platform, which is compatible with various interactive screens (Responsive Web Design), so that learners can acquire new bodies of knowledge and change their learning styles as to their needs in a quick and convenient manner. It is expected that this platform will help learners develop their knowledge and skills more effectively with the learning styles that are corresponding to their needs and interest.

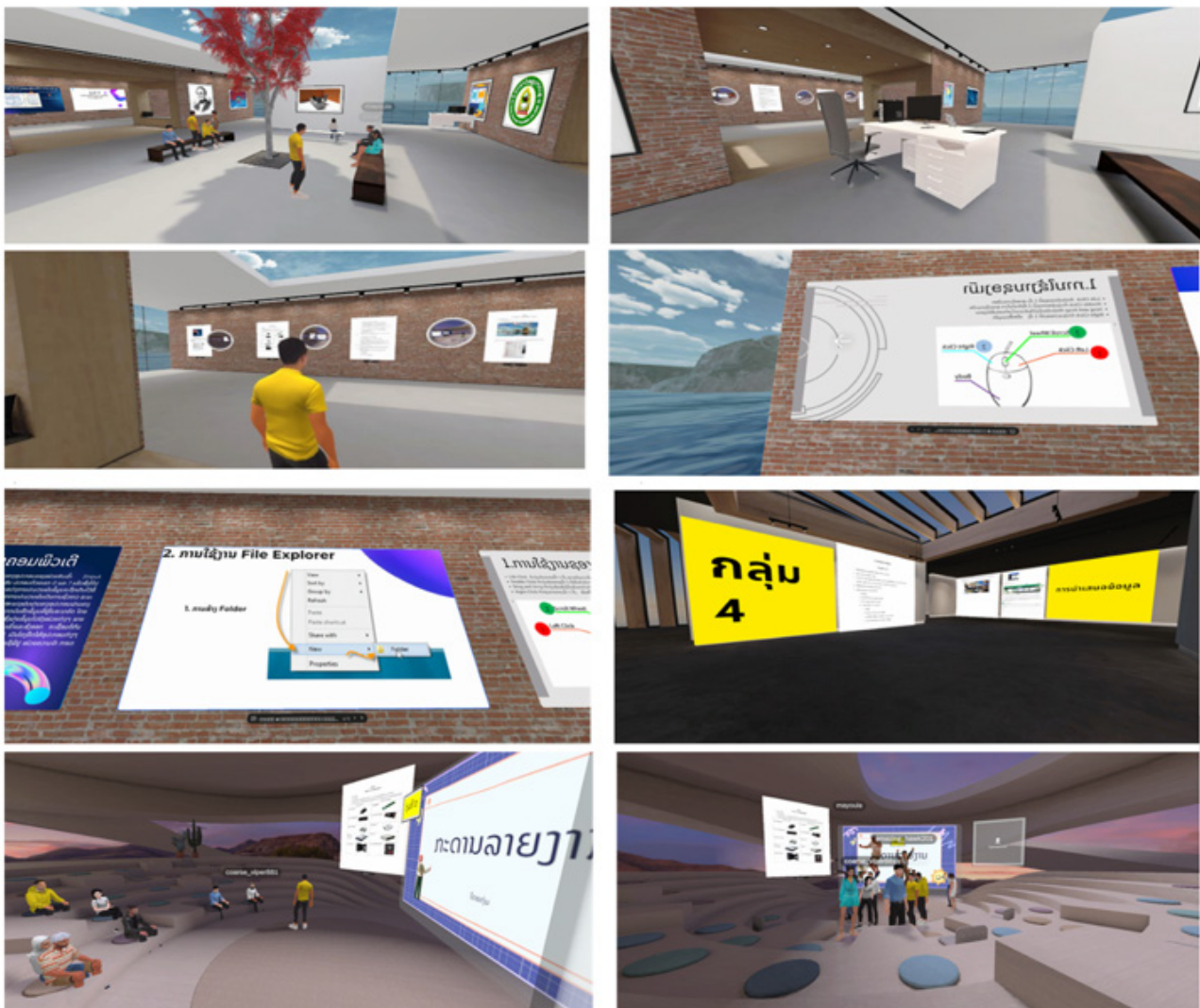


Figure 3. The MICRO-META platform to enhance digital literacy and digital empathy at Pakse Teacher Training College, Lao PDR

This research contributes to the development of learners' digital literacy and digital empathy through self-learning (Figure 3). Both digital literacy and

digital empathy are said to promote lifelong learning since learners with these competencies are capable of making the ultimate use of digital technology,

especially when facilitating the instruction management at higher education level. However, this research still has some limitations due to the small size of participants and it is only a study on a specific group. Therefore, to acquire the more valid and more evident results, there should be a study on the more diverse research participants so as to confirm the suitability of the research. Regarding the suggestions for future research, the researchers would like to propose that there should be the exploration on the broader scope of use with the broader population and educational environments in order to monitor the effectiveness of the MICRO-META platform development as well as the skills that have influence on the use of education technology and other relevant contexts.

References:

- [1]. Ministry of Planning and Investment. *Vision to 2030 and 10-Year Economic and Social Development Strategic Plan (2016-2020)*. Ministry of Planning and Investment, Lao PDR.
- [2]. Ministry of Education and Sports. (2015). *Education and Sports Sector Development Plan (2016-2020)*. Vientiane: Ministry of Education and Sports.
- [3]. Chatwattana, P. (2018). The concept of creative innovation skills for enhancement of Thailand 4.0. *Journal of Industrial Education*, 17(3), 222-229.
- [4]. Sapliyan, S., Chatwattana, P., & Nilsook, P. (2023). A constructionist, imagineering learning system with the metaverse: a study of learning outcomes at secondary schools in Thailand. *Global Journal of Engineering Education*, 25(2), 90-98.
- [5]. Leela, S., Chookaew, S., & Nilsook, P. (2019). An Effective Microlearning Approach Using Living Book to Promote Vocational Students' Computational Thinking. *ICDTE '19: Proceedings of the 3rd International Conference on Digital Technology in Education*, 25–29. Doi: 10.1145/3369199.3369200
- [6]. Kongpha, R., & Chatwattana, P. (2023). The Virtual Interactive Learning Model using Imagineering Process via Metaverse. *Higher Education Studies*, 13(1), 35-40. Doi: 10.5539/hes.v13n1p35
- [7]. Wannapiroon, P. (2022). *Innovation and intelligent technology for next normal education*. Bangkok: MAC Education.
- [8]. Abanikanda, M. O., & Ezechinyere, C. I. (2021). Interest of undergraduate students in virtual learning modes occasioned by the new normal. *Zambia Journal of Education (Online ISSN 2664-3170: Print ISSN 1996-3645)*, 6(1), 99-108.
- [9]. Haruehansapong, K. (2019). Digital Literacy of Undergraduate Students at Walailak University. *Walailak Journal of Learning Innovations*, 5(2), 27-40. Doi: 10.14456/jli.2019.8
- [10]. Onah, D. F., Pang, E. L., Sinclair, J. E., & Uhomoiibhi, J. (2021). An innovative MOOC platform: the implications of self-directed learning abilities to improve motivation in learning and to support self-regulation. *The International Journal of Information and Learning Technology*, 38(3), 283-298.
- [11]. Chookusol, C., & Wannapiroon, P. (2021). Virtual Learning Environment via Smart Coworking Space. *Journal of Education and Innovative Learning*, 1(1), 97-110.
- [12]. Chatwattana, P., Piriya-surawong, P., Nilsook, P., & Wannapiroon, P. (2022). Total learning experience (TLE) on the cloud with an intellectual repository to enhance digital empathy and literacy skills. *Global Journal of Engineering Education*, 24(3), 193-201.
- [13]. Friesem, Y. (2016). Empathy for the digital age: Using video production to enhance social, emotional, and cognitive skills. In *Emotions, technology, and behaviors*, 21-45. Academic Press. Doi: 10.1016/B978-0-12-801873-6.00002-9
- [14]. Khemmani, T. (2010). *Science of Teaching: Knowledge of Efficient Learning Process Management*. Bangkok: Chulalongkorn University Press.
- [15]. Utranan, S. (1982). *Systematic Instructional Management*. Bangkok: Chulalongkorn University.
- [16]. Roberta, M.R., Alan, D., & Barbara, H.W. (2013). *System Analysis and Design*. Hoboken: John Wiley & Sons.
- [17]. Kanasutra, P. (1995). *Statistics for Research in the Behavioral Sciences*. Bangkok: Chulalongkorn University Press.
- [18]. Nikou, S. A., & Economides, A. A. (2018). Mobile-Based micro-Learning and Assessment: Impact on learning performance and motivation of high school students. *Journal of Computer Assisted Learning*, 34(3), 269–278. Doi: 10.1111/jcal.12240
- [19]. Busse, J., & Schumann, M. (2021). Towards a Pedagogical Pattern Language for Micro Learning in Enterprises. *EuroPLoP'21: 26th European Conference on Pattern Languages of Programs*, 2, 1-8. Doi: 10.1145/3489449.3489973
- [20]. Yan, Y., Wang, Y., & Lei, Y. (2022). Micro Learning Support Vector Machine for Pattern Classification: A High-Speed Algorithm. *Computational Intelligence and Neuroscience*, 2022. Doi: 10.1155/2022/4707637
- [21]. Arnab, S., Walaszczyk, L., Lewis, M., Kernaghan-Andrews, S., Loizou, M., Masters, A., Calderwood, J., & Clarke, S. (2021). Designing Mini-Games as Micro-Learning Resources for Professional Development in Multi-Cultural Organisations. *The Electronic Journal of E-Learning*, 19(2), 44–58.
- [22]. Law, N. W. Y., Woo, D. J., De la Torre, J., & Wong, K. W. G. (2018). *A global framework of reference on digital literacy skills for indicator 4.4*. 2.UNESCO.
- [23]. Chatwattana, P. (2021). Massive open online courses model with self-directed learning to enhance digital literacy skills. *International Journal of Engineering Pedagogy*, 11(5), 122–137. Doi: 10.3991/ijep.v11i5.22461
- [24]. Iasha, V., Japar, M., Maksum, A., & Setiawan, B. (2023). Let's Go On A Virtual Reality Trip!: The Effect on the Students' Literacy, Interest, and Satisfaction in Cultural Learning. *TEM Journal*, 12(4), 2488. Doi: 10.18421/TEM124-61
- [25]. Phunaploy, N., Chatwattana, P., & Piriya-surawong, P. (2021). The Results of Development of the Online Instruction with Design-based Thinking for the Construction of Creative Products. *TEM Journal*, 10(4), 1715-1720. Doi: 10.18421/TEM104-30