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Development Metaverse Learning Environment Base on Station Rotation Model to Promote Scientific Literacy and Self-Directed Learning on Topic Sequence of Geological Event for 10th Grade Students

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Abstract

This study investigated the effects of a Metaverse learning environment based on the Station Rotation Model on scientific literacy and self-directed learning. The participants were divided into experimental and control groups, with the experimental group receiving the intervention while the control group received traditional instruction. The results showed that the scientific literacy scores of the experimental group significantly improved after the study, with a higher average score than the control group. Similarly, the experimental group showed significantly higher scores in self-directed learning compared to the control group after the intervention. These findings suggest that a Metaverse learning environment based on the Station Rotation Model can enhance students' scientific literacy and self-directed learning.

Keywords: Metaverse, Scientific literacy, Self-directed learning, Station rotation model.

1 Introduction

In the 21st century, rapid advancements in science and technology have brought about rapid changes. New knowledge emerges at an unprecedented pace, and communication is now borderless and easily accessible across the globe. Social media has become an increasingly integral part of daily life, providing a public space without gender, age, nationality, religion, education level, or occupation limitations for the production and dissemination of information [1]. In this context, developing lifelong learning skills is crucial for personnel to adapt to changes in the digital age, aligned with the key global educational goals in the 2030 Sustainable Development Agenda that emphasizes the importance of quality education and promoting lifelong learning opportunities for all. Self-directed learning is a fundamental foundation for lifelong continuous learning, as it focuses on developing the ability to learn independently and become a self-directed learner. Self-motivation to learn is essential for success [6].

According to PNAS (2019), false information disseminated online can lead to misunderstandings. The dissemination of online information may also be influenced by unreliable principles, biases, and misunderstandings from data creators, which can lead to a lack of credibility in

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analytical thinking [7]. The Office of the Education Council (2017) found that data utilization among Thai people still lacks synthesis, screening, and comprehensive evaluation, particularly with regard to scientific data. This underscores the importance of scientific literacy in today's digital world, where a wide range of information is available. Scientific literacy is a skill that enables individuals to connect scientific concepts with critical thinking and apply them to scientific-related issues. A scientifically literate person can communicate and argue rationally about scientific and technological issues. The Organization for Economic Co-operation and Development (OECD) aims to assess international science literacy through the Program for International Student Assessment, which evaluates students at the age of 15 every three years. Despite participating in the PISA assessment since 2000, Thailand's science literacy scores have consistently been below the OECD average.

Educational institutions often overlook the importance of teaching earth science, astronomy, and space, despite the fact that these subjects integrate scientific knowledge from physics, chemistry, biology, and other related sciences to explain and understand various natural phenomena, including changes on the earth's surface, within the world, and in weather. All of these processes are interconnected and have an impact on living things Ministry of Education, Thailand. The sequence of geological events used to describe the hierarchy of rocks is particularly crucial, as it can help determine the geological age of fossils, which many people struggle to explain logically and scientifically. This struggle often leads to the association of beliefs with scientific facts and the spread of scientific misinformation [7] Institute for the Promotion of Teaching Science and Technology: IPST, Thailand, 2017. Such misconceptions and misunderstandings can be reduced through the development of science literacy, which enables individuals to connect scientific concepts with critical thinking and apply them to scientific-related issues. A scientifically literate person can communicate and argue rationally about scientific and technological issues.

The researcher aims to create a metaverse learning environment using the station rotation model, specifically for 4th-grade students studying the sequence of geological events. This approach offers learners a variety of authentic and flexible learning experiences, promoting self-directed learning and enhancing scientific literacy [14]. By utilizing the Metaverse's simulation capabilities, students can explore various locations and times, past and present, and connect with others through avatars, fostering communication skills and overcoming social barriers. Additionally, the Station rotation model's rotation between classroom and online learning, combined with other forms of learning such as small-group instruction or individual tutoring, provides learners with diverse learning experiences that can help build their knowledge from their experiences and environment [2]. The result is a learning environment that encourages active and personalized learning, creating a solid cognitive structure that students can use to acquire new knowledge and connect it with existing understanding. The classroom environment should also be designed to stimulate self-directed learning by filling it with interesting materials and encouraging learners to explore naturally [6].

2 Theorical Framework

The researcher conducted a literature review and studied principles, theories, and research related to the design and development of a Metaverse learning environment base on station rotation model to promote scientific literacy and self-directed learning on Topic sequence of geological event for 10th grade students. From this, the researcher synthesized a conceptual framework for synthetic design based on 5 fundamental theories, including the Fundamentals of Learning Psychological base, Pedagogical base, Technological base, Contextual base, and Scientific literacy base as shown in Figure 1, which contains important components of the framework.

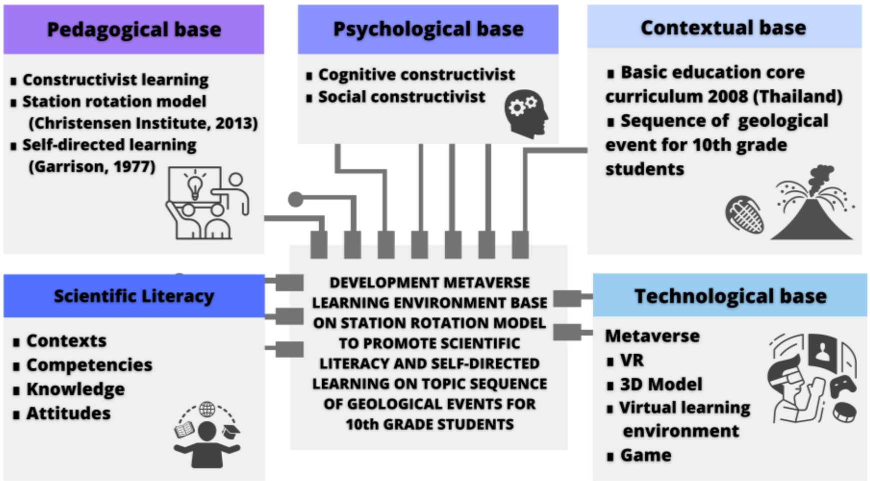

Figure 1: Theorical Framework

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3 Methodology

3.1 Framework of the developmental research and instructional innovation design

This study applies guidelines from Richy & Klein [15] and Issara Kanjug [6] to develop a metaverse learning environment based on the station rotation model. The research aims to promote scientific literacy and self-directed learning among 10th-grade students in the topic sequence of geological events. The research process consists of three phases: (1) product design and development, including analysis, synthesis, and expert interviews; (2) product evaluation to assess the quality and effectiveness of the innovative metaverse learning environment; and (3) validation of the product's effectiveness in enhancing scientific literacy and self-directed learning. The research process is depicted in Figure 2.

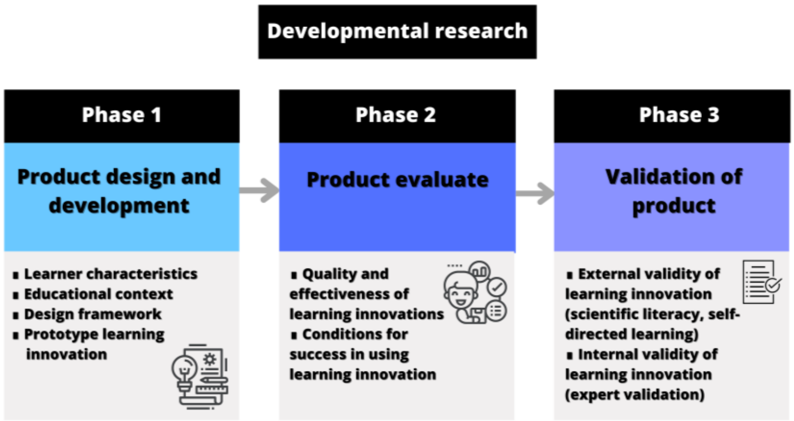

Figure2: Framework of the developmental research and instructional innovation design

3.2 Station rotation model

The station rotation model, as described by the Christensen Institute (2013), involves students rotating between different learning modalities within a specific course or subject. This rotation can occur on a fixed schedule or at the teacher's discretion. At least one station is dedicated to online learning, while other stations may include activities such as small-group or full-class instruction, group projects, individual tutoring, and pencil-and-paper assignments (refer to figure 3). This model provides students with the opportunity to experience and benefit from both face-to-face instruction and online learning, as well as carefully chosen collaborative learning situations facilitated by their teacher [2].

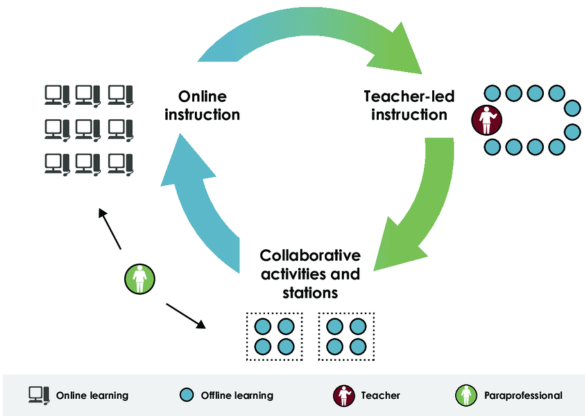

Figure 3: The Station Rotation Model

3.3 Metaverse

Metaverse is a platform for creating virtual worlds and avatars. Users can interact through avatars and engage in real-life-like activities [5]. It utilizes Hubs and Spoke for collaborative work and scene editing. Users can access and share content through various devices and communicate using spatialized audio. The Metaverse has potential for educational research, enabling immersive learning experiences and simulations. It also fosters social learning and cultural exchange. However, challenges regarding privacy and inclusivity need to be addressed. The Metaverse transforms education and knowledge accessibility.

4 Result

4.1 The results of the design and development metaverse learning environment base on station rotation model to promote scientific literacy and self-directed learning on topic sequence of geological event for 10th grade students

From the theoretical framework, the researchers used it as a basis for creating and developing metaverse learning environment base on station rotation model to promote scientific literacy and self-directed learning on topic sequence of geological events for 10th grade students as shown in Figure 4.

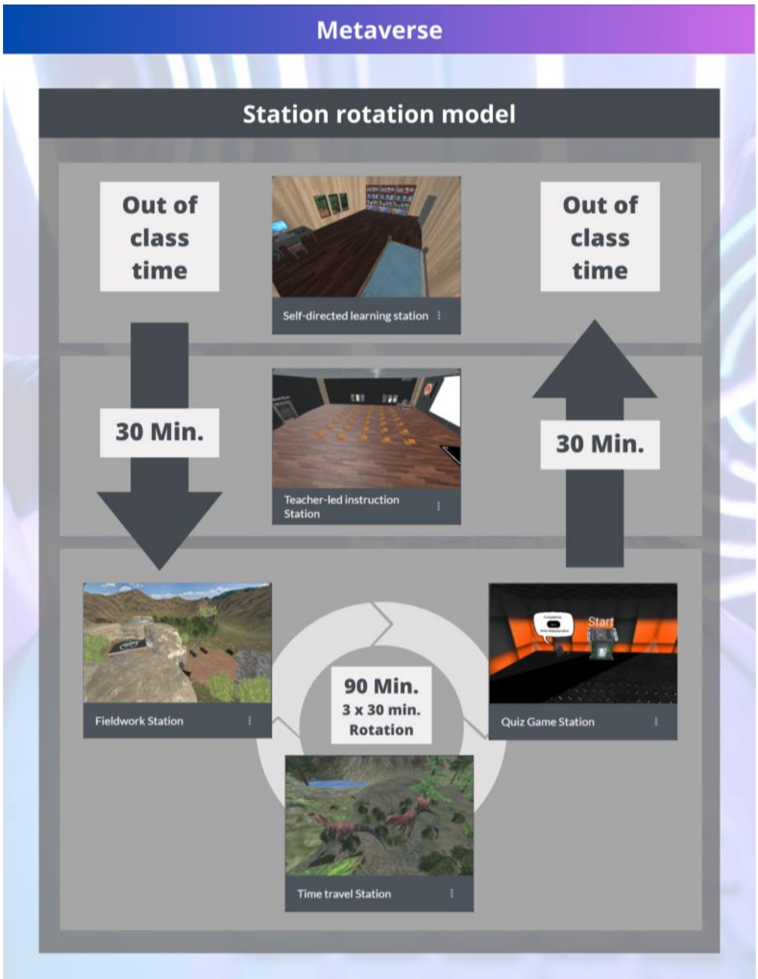

Figure 4: development metaverse learning environment base on station rotation model to promote scientific literacy and self-directed learning on topic sequence of geological events for 10th grade students

4.2 The Comparison of Scientific Literacy of the Experimental and Control Group

Table 1: Paired sample t-test result on scientific literacy of the experimental group students and control group students

Group	Pre-test			Post-test			t	p
	$\bar{x}$	S.D.	%	$\bar{x}$	S.D.	%		
Experimental group (n=33)	5.33	1.99	26.65	11.24	3.15	56.20	10.224	.000*
Control group (n=31)	4.97	1.89	24.85	7.56	2.23	37.80	7.024	.000*

*p < .05

According to Table 1, it was found that the scientific literacy scores of the experimental group were significantly higher on post-test ($\bar{x}$ = 11.24, S.D = 3.15) than pre-test ($\bar{x}$ = 5.33, S.D = 1.99) at the .05 level of statistical significance and scientific literacy scores of the control group were significantly higher on post-test ($\bar{x}$ = 7.56, S.D = 2.23) than pre-test ($\bar{x}$ = 4.97, S.D = 1.89) at the .05 level of statistical significance.

Table 2: Independent samples t-test result on scientific literacy of the experimental group students and control group students

Group	Pre-test			t	p	Post-test			t	p
	$\bar{x}$	S.D.	%			$\bar{x}$	S.D.	%		
experimental group (n=33)	5.33	1.99	26.65	0.752	.455	11.24	3.15	56.20	5.434	.000*
Control group (n=31)	4.97	1.89	24.85			7.56	2.23	37.80		

*p < .05

According to Table 2, the scientific literacy pre-test scores of the experimental group ($\bar{x}$ = 5.33, S.D = 1.99) and control group ($\bar{x}$ = 4.97, S.D = 1.89) were not significantly different (p > .05). and the scientific literacy post-test scores of the experimental group ($\bar{x}$ = 11.24, S.D = 3.15 was significantly higher than control group ($\bar{x}$ = 7.56, S.D = 2.23)

4.3 The Comparison of Self-directed Learning of the Experimental and Control Group

Table 3: Paired sample t-test result on Self-directed Learning of the experimental group students and control group students

Group	Pre-test			Post-test			t	p
	$\bar{x}$	S.D.	%	$\bar{x}$	S.D.	%		
Experimental group (n=33)	76.76	22.70	59.05	99.67	14.53	76.67	5.227	.000*
Control group (n=31)	87.71	11.67	67.47	91.94	10.79	70.72	1.598	.121*

*p < .05

According to Table 3, it was found that the self-directed learning scores of the experimental group were significantly higher on post-test ($\bar{x}$ = 99.67, S.D = 14.53) than pre-test ($\bar{x}$ = 76.76, S.D = 22.70) at the .05 level of statistical significance and self-directed learning scores of the control group ($\bar{x}$ = 87.71, S.D = 11.67) and control group ($\bar{x}$ = 4.97, S.D = 1.89) were not significantly different ($p > .05$).

Table 4: Independent samples t-test result on Self-directed Learning of the experimental group students and control group students

Group	**Pre-test**			**t**	**p**	**Post-test**			**t**	**p**
	$\bar{x}$	**S.D.**	**%**			**$\bar{x}$**	**S.D.**	**%**		
experimental group (n=33)	76.76	22.70	59.05	2.448	.018*	99.67	14.53	76.67	2.404	.019*
Control group (n=31)	87.71	11.67	67.47			91.94	10.79	70.72		

*p < .05

According to Table 4, the self-directed learning pre-test scores of the control group ($\bar{x}$ = 87.71, S.D = 11.67) was significantly higher than experimental group ($\bar{x}$ = 76.76, S.D = 22.70). and the self-directed learning post-test scores of the experimental group ($\bar{x}$ = 99.67, S.D = 14.53) was significantly higher than control group ($\bar{x}$ = 91.94, S.D = 10.79).

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