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The Development of Constructivist Flipped Classroom Learning Environments on Metaverse to Promote Problem Solving and Reasoning Skills in Mathematics of Secondary Education Grade 10th Students

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Abstract

This study investigates the effectiveness of a constructivist flipped classroom learning environment on Metaverse in promoting problem-solving and reasoning skills in secondary education Grade 10 mathematics students. Utilizing a one-group experimental design, a mixed-methods approach was employed to analyze the results, with a T-test yielding a significant value of .000. Results showed significant improvements in students' problem-solving and reasoning skills, as well as high levels of engagement and motivation in the virtual learning environment. The study suggests that the use of the Constructivist Flipped Classroom Learning Environments on Metaverse is a promising approach to enhance mathematics education, specifically in developing students' problem-solving and reasoning skills in a secondary education setting.

Keywords: Constructivist Flipped Classroom Learning Environments, Metaverse, Problem Solving and Reasoning Skills in Mathematics

1 Introduction

The management of learning in mathematics today emphasizes the importance of mathematical process skills in addition to understanding of mathematical content. According to the Programme for International Student Assessment (PISA) 2018, although students in Thailand have a good understanding of mathematics, they lack proficiency in mathematical process skills [13]. The rapid development of new technologies in recent years has made them more important in our lives, and the necessary skills for the 21st century include computational thinking, which is a problem-solving process involving logical reasoning and analysis, as well as a context that corresponds to the skills required for the 21st century [6]. The PISA 2018 results also showed that 52.2% of Thai students have mathematical literacy skills below Level 2 out of a total of 6 levels, and that the average score in Thailand is lower than the average score of participating countries. These findings reflect the fact that students still face challenges in mathematical process skills and in linking knowledge to real-life problem-solving situations [12].

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The Flipped Classroom is a necessary approach to adjust learning and teaching, focusing on learners and enabling hands-on experiences. It was created by Jonathan and Aaron, chemistry teachers at Woodland Park High School, to address students missing classes frequently. The Flipped Classroom, established in 2007, has become widespread in the United States and globally. It aligns with 21st-century learning principles, emphasizing "Teach Less Learn More" and shifting from teacher-centered to student-centered instruction. It utilizes online learning formats, social media, and information technology to bring activities from home into the classroom, giving learners more time for practice and interaction [8]. Flipped learning integrates teaching and technology, utilizing the Metaverse, a blend of physical reality and digital virtuality, to overcome limitations of 2D e-learning tools in online distance education [9].

2 Theorical Framework

Theorical Framework of The Development of Constructivist Flipped Classroom Learning Environments on Metaverse to Promote Problem Solving and Reasoning Skills in Mathematics of Secondary Education Grade 10th Students

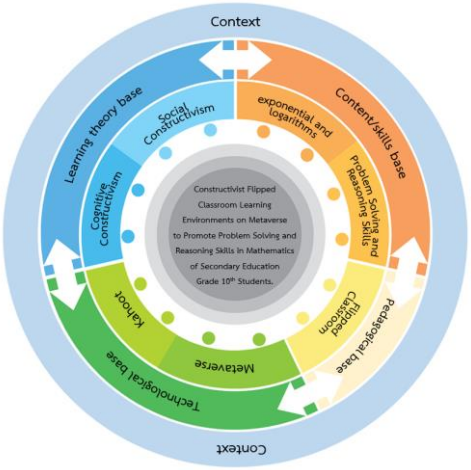


Figure 1: Theorical Framework

Researchers have reviewed literature, studied principles, theories, and research related to the design and development of constructivist flipped classroom learning environments on the metaverse to promote problem-solving and reasoning skills in mathematics for Grade 10th students of secondary education. This forms the basis for creating a theoretical framework, which consists of four key theoretical foundations:

Learning theory base: The researchers have integrated the concepts of Constructivist Learning Environment theory by Issara Kanjug [8], which emphasizes the importance of hands-on experiential learning and the ability to seek problem-solving methods to enhance cognitive structures and create authentic learning situations that are contextually relevant to the learners. They also applied Social Constructivism theory, which emphasizes the social interaction processes of learners and the contextual factors, through collaborative problem-solving and the exchange of learning experiences, resulting in meaningful learning. The design of the learning environment in accordance with the Constructivist Learning Environment theory incorporates the following components and principles: 1) Problem base, 2) Knowledge Bank, 3) Scaffolding, 4) Collaboration, and 5) Coaching.

Technological base: The researchers have incorporated the ideas from the Constructivist Learning Environment theory by Issara Kanjug [8], which is rooted in the Constructivism theory. This theory defines learning as the construction of knowledge, where learning occurs when learners actively construct representations of knowledge in their working memory. This concept emerged in the 1980s and 1990s through the study of human learning in authentic situations. Under this constructivist approach to learning, learners play an active role, while teachers serve as guides using cognitive coaching to provide guidance and act as models in authentic learning tasks. The role of educational technologists or teachers is to create an environment that facilitates meaningful interactions between learners and the content of the lesson, as well as to facilitate processes such as information selection, organization, and integration to enhance learning efficiency. In this research, the researchers utilized modern online learning technologies and platforms, including Metaverse by Mozilla Hubs and Kahoot.

In learning within Metaverse by Mozilla Hubs and Kahoot, students will experience a different learning environment compared to traditional classroom learning. Metaverse by Mozilla Hubs is a platform that allows users to create and participate in virtual classrooms that can be accessed from anywhere in the world. Students can join existing classrooms or create their own as needed. They can learn and share knowledge individually or in groups, utilizing virtual reality technology and standard web browsers. This enables users to easily access and use the platform, making learning convenient and accessible.

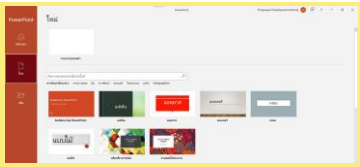
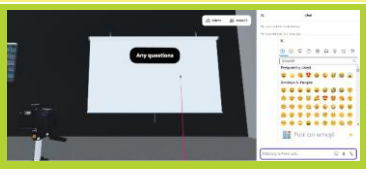
Kahoot is a platform used for game-based learning to increase the fun and engagement of students. Users can create quizzes and surveys related to their own learning topics and allow students to participate in unlimited question-answering games. It involves competitive scoring among players, creating competition and classroom discussions. This creates benefits in learning from various perspectives, such as reviewing students' knowledge through game-based learning, promoting analytical thinking skills and problem-solving abilities, and fostering relationships and interest in learning among students. Additionally, Kahoot features connectivity with players' mobile devices, allowing users to join games anytime and anywhere, not limited to the classroom. This adds convenience and accessibility for users.

Pedagogical base: In this research, the author has employed the flipped classroom theory based on the constructivist theory proposed by Issara Kanjug [8]. This theory is an effective form of flipped classroom learning that utilizes a pedagogical base aligned with constructivist theory, emphasizing students' knowledge construction through experiences and hands-on activities that involve critical thinking processes. It establishes connections between prior experiences, authentic contexts, and creating new knowledge that is personally meaningful. It stimulates problem-based situations that provide opportunities for learners to analyze problems, generate diverse alternatives, make decisions suitable to the context, and produce creative outcomes. Learners are encouraged to seek new knowledge from knowledge bank, collaboration, and problem-solve, exchanging ideas and intellectual processes. The teacher acts as a coach or facilitator, providing guidance and stimulating learners' thinking to construct their own knowledge. Flipped classroom learning is another form of learning environment integration that combines pedagogy and technology. From the application of the aforementioned theory, there are important components used in the design as follows: 1) Problem base & Learning Task: Authentic problems with meaningful tasks. 2) Knowledge Bank: A knowledge repository for students to accomplish their goals. 3) Scaffolding: Scaffolding consists of four types: Problem Solving and Reasoning Scaffolding, Metacognition Scaffolding, Strategic Scaffolding, and Procedural Scaffolding. 4) Collaboration:

A place for collaborative learning and sharing. Tools for manipulating problems and tasks. 5) Coaching: Teachers provide support to help students perform tasks.

And a content/skills base: The researcher aims to investigate problem-solving and reasoning skills in mathematics of the students in the subject of mathematics. These skills align with the skills necessary for the 21st century as emphasized in the PISA 2021, which takes into account the rapid changes brought about by new technologies that play an increasingly important role in life. The development of skills for the 21st century focuses on the ability to reason mathematically and engage in computational thinking, which is a problem-solving process, a logical and analytical thinking process, and includes contexts that align with the skills of the 21st century [10] based on the literature review, principles, theories, and related research on problem-solving and reasoning skills in mathematics [1][2][3][4][5][6][7]. By applying the concepts of the aforementioned theory, there are crucial steps involved in the design: 1) Problem analysis, 2) Making a plan for problem-solving, 3) Problem-solving execution, and 4) Looking back and reflecting on the results.

Table 1: Framework of Constructivist Flipped Classroom Learning Environments on Metaverse

Out of Class	Knowledge acquisition	▪ Problem base & Learning Task ▪ Knowledge Bank ▪ Scaffolding	Metaverse	
During Class	Knowledge transfer	▪ Enabling Context ▪ Problem base	Kahoot	
	Knowledge construction	▪ Learning Task ▪ Collaboration ▪ Coaching	Google app.	
	Knowledge refection	▪ Reflection	Presentation Program	
Out of Class	Knowledge sharing	▪ Collaboration ▪ Coaching	Blog on Metaverse	

3 Methodology

The research aims to develop Constructivist Flipped Classroom Learning Environments on Metaverse to promote problem-solving and reasoning skills in Mathematics of Secondary Education Grade 10th Students. The researchers have designed a research methodology that includes three phases: 1) Product design and development phase: (1) Learner Characteristics (2) Study of Teaching and Learning Context (3) Framework for Designing Learning Environments (4) Learning Environments, 2) Product evaluate phase: (1) Quality and effectiveness of the Environments for learning (2) Criteria for success in utilizing the Environments for learning, and 3) Validation of product phase: (1) External validity of the learning Environments (2) Internal validity of the learning Environments. The methodology is based on the developmental research and instructional innovation design by Richy & Klein [11] and Issara Kanjug [8].

4 Result

Study results of problem-solving and reasoning skills in mathematics.

Table 2: The results of the study of problem-solving and reasoning skills in mathematics.

	N	Mean	Std. Deviation	t	Sig.
Pre-test	38	8.3421	3.87840	11.374	.000
Post-test	38	28.1316	11.90315		

Results of the study indicated that the development of a constructivist flipped classroom learning environment on Metaverse had a significant impact on the problem-solving and reasoning skills of 10th-grade secondary education mathematics students. The one group experimental design with a pretest-posttest measurement revealed a statistically significant improvement in the problem-solving and reasoning skills of the students. The T-test analysis showed a significant difference in the mean scores of pre-test and post-test with a p-value of .000, indicating that the intervention was effective in enhancing the students' problem-solving and reasoning skills. The students also reported high levels of engagement and motivation in the virtual learning environment, suggesting that the constructivist flipped classroom learning environment on Metaverse is an effective approach to promote problem-solving and reasoning skills in mathematics education.

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