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The Designing Framework for Flipped Learning Environment on Metaverse to Enhance Mathematical Conceptual Understanding for Seven Grade Students

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Abstract

The purpose of this research was to synthesize the theoretical framework for Flipped Learning Environment on Metaverse to Enhance Mathematical Conceptual Understanding for Seven Grade Students. The target group consisted of three experts reviewing document and designed framework and 29 students in Grade 7, who study in a school in Khon Kaen province. Documentary and survey research were adopted in this study. This research was conducted in four stages: 1) examining and analyzing the principles and theories, 2) reviewing literature, 3) studying relevant contexts, and 4) synthesizing the designing framework for the Flipped Learning Environment. The research instruments were survey a synthesis record of theoretical framework, a synthesis record of design framework, and evaluation form for experts. Data were analyzed by using descriptive and analytical summary interpretation. The results revealed that the theoretical framework consisted of five foundations: 1) Contextual Basic 2) Fundamentals of Learning Psychology 3) Pedagogical Fundamentals 4) Fundamentals of Mathematical Conceptual Understanding 5) media theory and technology base. And the designing framework consisted of four stages: 1) activating of cognitive structure and enhancing mathematical conceptual understanding, 2) promoting cognitive balance 3) enhancing knowledge construction and mathematical conceptual understanding, and 4) supporting knowledge construction. The Flipped Learning Environment was comprised of seven components as following: 1) problem base, 2) resources, 3) related case 4) mathematical conceptual understanding center 5) collaboration 6) scaffolding and 7) coaching.

Keywords: Flipped Learning Environment, Mathematical Conceptual Understanding, Metaverse

1 Introduction

Currently, the social changes and rapid advancement in science and technology, it has affected the livelihoods of society as a whole [1], Furthermore, the educational challenges in the 21st century, mathematics plays a crucial role in the success of learning in the 21st century because it helps humans think creatively, logically, and analyze problems thoroughly, enabling them to plan problem-solving accurately [2]. Despite the significance of mathematics, the past teaching and learning approaches have not achieved the desired success, as seen in the results of the 2018 PISA test. It revealed that Thai students had an average score of 419 in mathematics, which placed

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them below the OECD average score of 489 [3]. Similarly, the 2015 TIMSS assessment found that Thai students had an average score of 431 in mathematics, indicating a low level of proficiency [4]. The above assessment reflects that Thai students have low mathematical skills. They also lack the ability to apply what they have learned in the classroom to solve problems in other situations. Therefore, it is necessary to develop students' understanding of mathematics so that they have sufficient fundamental knowledge to apply in problem-solving across different contexts. Learning mathematics with understanding is crucial as it helps students succeed in solving problems they have not encountered before [5]. Activities that promote and develop students' conceptual understanding should consider the students' need to construct knowledge themselves. Teachers serve as facilitators who assist students in their learning process by providing various data management techniques or encouraging independent exploration. This leads to the creation of new knowledge that can be applied practically. A corresponding teaching approach that aligns with this is the flipped classroom [6]

The Flipped Classroom is a teaching approach where teachers assign students to study learning materials before class. This enables students to understand, take notes, and ask questions in advance. During the classroom session, teachers facilitate activities that build upon the pre-studied content or engage in discussions related to the pre-studied topics. This method aims to assess students' understanding. It aligns with the learning approach of students in the current era, which heavily involves technology. Researchers have utilized Spatial Metaverse as an outside-classroom learning medium, acting as a Resource Center. This medium has gained popularity in creating virtual worlds for education [7]. It allows people to communicate, perform activities, and interact without boundaries in the digital world. Students can access it through computers, tablets, smartphones, and augmented reality (AR), which has been mentioned to have benefits for education in the Metaverse world, including: 1) Students and teachers can interact with each other in a realistic 3D virtual environment, creating an immersive learning experience in a simulated classroom setting. 2) Students and teachers can access the learning materials without limitations of place and time, eliminating the need to be physically present in a classroom. They can learn according to their own preferences. 3) Students can learn in a realistic situation, gaining practical skills for practical application and fostering collaborative activities [8].

Due to the aforementioned reasons, the researcher is interested in studying the design framework for flipped learning environment on metaverse to enhance mathematical conceptual understanding for seven grade students, the new technology in education necessitates a review of principles, theories, research, and synthesis designing framework for flipped learning environment on metaverse to enhance mathematical conceptual understanding, as well as researching various works to use as a basis for synthesizing theoretical frameworks and design frameworks. This approach should be integrated as a component of the learning environment and applied in designing and developing appropriate learning environments that promote understanding of mathematical concepts for learners in different contexts.

2 Methodology

The research methodology used were document analysis and survey research. The data collection process used in this study aimed for high-quality data and included research on documents, principles, theories, relevant research studies, synthesis of theoretical frameworks, and design frameworks. [12]

2.1 Target group

The target group for this educational initiative consists of three experts: a content expert, a media expert, and a design expert. The content expert is a mathematics teacher who specializes in reviewing documents and conceptual frameworks for environmental design. The media expert and design expert are professors specializing in Educational Technology within the Faculty of Education at Khon Kaen University."

2.2 Researching tools

The tools used for data collection include: (1) Document review form, (2) Conceptual framework synthesis form for theoretical and design frameworks, (3) Assessment form for experts regarding the synthesis of theoretical frameworks and design frameworks, and (4) Survey form for students' opinions on classroom management in the subject of Mathematics.

2.3 Collecting data and Data Analysis

1. Review literature and study principles, theories, and research related to designing the learning environment. Study principles and theories of learning as a foundation for research and record the findings in the document review form.

2. Study the learning context of students in basic Mathematics by examining the learning management. Use a survey form to gather opinions, analyze the data, summarize, and interpret.

3. Synthesize theoretical frameworks from the review of relevant theories and research. Use the conceptual framework synthesis form and present it to the advisor and experts. Then, make improvements based on their suggestions. Analyze the data by summarizing and providing analytical descriptions.

4. Synthesize the design framework based on the theoretical frameworks and analyze the components of the learning environment. Present it to the advisor and experts for examination of the coherence between the principles and theories used as the foundation for designing the learning environment. Make improvements based on their suggestions. Analyze the data by summarizing and providing analytical descriptions.

3 Result

The results of synthesizing the framework for Flipped Learning Environment on Metaverse to Enhance Mathematical Conceptual Understanding for Seven Grade Students include theoretical frameworks and design frameworks for the learning environment. The details are as follows:

3.1 Theoretical framework

Theoretical framework creates a conceptual framework based on study and analysis of theoretical principles, research, variables, linking the relationship between theoretical principles. The results revealed that the theoretical framework consisted of five foundations: 1) Fundamentals of Learning Psychology , which has been used as a foundation for important learning psychology, which includes (1) Cognitive Theory, which focuses on studying the thinking process within the learners' brains, including the Information Processing Theory that emphasizes the process of thinking, categorization, and the sequence of information

processing; (2) Constructivism Theory, which has two important principles: Cognitive Constructivism and Social Constructivism. 2) Pedagogical Fundamentals using constructivism theory as a foundation for design in conjunction with media, it is called the 'flipped classroom learning environment'. This includes the OLEs Model, SOI Model, Situated Learning, and Cognitive Apprenticeship. 3) Contextual Basic, the researcher surveyed the opinions of 29 students regarding the context of teaching and learning according to the core curriculum in the subject "Basic Mathematics" and learning through the flipped classroom. It was found that the students had never experienced a flipped classroom learning environment, especially using the interstellar-friendly classroom. The traditional teaching methods they had been exposed to primarily involved knowledge transmission. As a result, most students only had a conceptual understanding of the perspectives without truly comprehending them. Based on the results of the study, the researcher used this context as a foundation for designing learning tasks on the topic of "applying ratios and percentages," which is a part of the subject " Basic Mathematics." The four learning tasks are as follows: 1) calculating profit and loss percentages, 2) setting product prices, 3) calculating value-added tax, and 4) calculating personal income tax. 4)Fundamentals of Mathematical Conceptual Understanding, the researcher utilized the framework of Channarong Hiangraj [10] which measures the level of understanding of mathematical concepts in three levels. Level 1 is the Action conceptual understanding, which is the ability to carry out a series of steps or actions according to specified conditions. Level 2 is the Process conceptual understanding. Level 3 is the structures conceptual understanding, 5) Fundamentals of media theory and technology in designing a flipped classroom learning environment. The researchers have taken the characteristics of flipped classroom learning and applied them in the design of learning management. They have assigned all 4 tasks for students to self-study prior to classroom sessions. They have also utilized the characteristics of media in designing and developing the learning environment, which consists of two main features: an online virtual classroom and a system of symbols for designing online lessons, to design that can synthesize theoretical framework as follows:

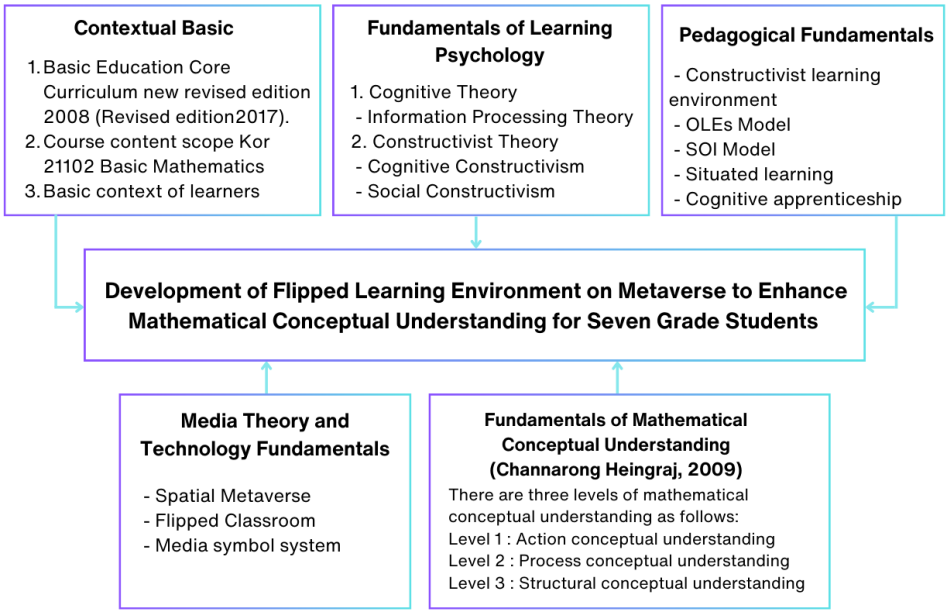

Figure 1: Shows the Theoretical framework for Flipped Learning Environment on Metaverse to Enhance Mathematical Conceptual Understanding for Seven Grade Students

The evaluation results of the theoretical framework for flipped learning Environment on metaverse to enhance mathematical conceptual understanding for seven grade students by three experts show that the overall score is at the level of (the average mean ($\bar{x}$) was 0.87 standard deviation (S.D) was 0.23 and representing 86.68% as shown in Table 1.

Table 1: Shows the results of the evaluation of the theoretical framework of flipped learning environment on metaverse to enhance mathematical conceptual understanding for seven grade students

Assessment Items	Details of the theory	$\bar{x}$	S.D.	Percentage
1) Fundamentals of Learning Psychology	1. Cognitive Theory - Information Processing Theory 2. Constructivist Theory - Cognitive Constructivism - Social Constructivism	1.00	0.00	100
2) Pedagogical Fundamentals	Constructivist learning environment - OLEs Model - SOI Model - Situated learning - Cognitive apprenticeship	1.00	0.00	100
3) Contextual Basic	1. Basic Education Core Curriculum new revised edition 2008 (Revised edition2017). 2. Course content scope Kor 21102 Basic Mathematics 3. Basic context of learners	0.67	0.58	66.7
4) Fundamentals of Mathematical Conceptual Understanding	There are three levels of mathematical conceptual understanding (Channarong Heingraj, 2009) as follows: Level 1 : Action conceptual understanding Level 2 : Process conceptual understanding Level 3 : Structural conceptual understanding	1.00	0.00	100
5) Media Theory and Technology Fundamentals	- Spatial Metaverse - Flipped Classroom - Media symbol system	0.67	0.58	66.7
Summarize		0.87	0.23	86.68

3.2 Designing framework

From synthesizing theoretical frameworks of flipped learning environments on metaverse to enhance mathematical conceptual understanding, it has been used as the basis for creating a framework for designing framework for flipped learning environments on metaverse to enhance mathematical conceptual understanding consisted of four stages.

1. activating of cognitive structure and enhancing mathematical conceptual understanding the researchers design and apply the foundation of Piaget's which believes in stimulating the construction of intellectual structures through problem situations that create cognitive conflicts and lead to learning, emphasizing the importance of situational learning in authentic contexts. In this study, the designed component is called **"problem situations"** [11], according to the principles of Situated Learning [12] to make learners feel like they are part of the problem situation.

2. promoting cognitive balance when learners encounter problem and task-based situations, they must seek ways to solve the problems they face by utilizing resources from the principles of the open learning environment design of Hannafin, which collects information and data that learners will use to solve the problem situation and find answers. Therefore, the researchers designed it to be a **"Resource"** [13] by applying the principles of Information Processing Theory and the SOI model as the foundation for designing the selection and processing of information that is linked to the content, particularly for short-term memory processes. This includes text-based information with highlighted important keywords, categorizing content to enable learners to connect content and select information that aligns with short-term memory and integrates with prior knowledge from long-term memory. Additionally, utilizing the principles of CLEs to create relevant scenarios, allowing learners to access relevant experiences for problem-solving.. The researchers used the term **"Related case"**

3. enhancing knowledge construction and mathematical conceptual understanding it promotes the highest level of knowledge and understanding of mathematical concepts by balancing intellectual factors, using the principles of OLEs [14] In order to develop and support the learning process, which serves as a central platform to facilitate and expand collaborative thinking, enabling learners to cooperate in problem-solving. This support encourages learners to exchange experiences with others and broaden their perspectives. The researchers have named this approach **"Collaboration"** And to promote understanding of the mathematical concept, the researchers used the term **"Mathematical Conceptual Understanding Center"**

4. supporting knowledge construction the researcher relies on the social constructivist theory of Vygotsky. If the learner is below the Zone of Proximal Development, it is necessary to receive a support called Scaffolding, in which the support base supports the learner. As well as the basic principle of Cognitive Apprenticeship that serves to transfer knowledge or knowledge to be a coach that provides assistance and advice for learners. In the design, the researcher has used the name **"Scaffolding"** and **"Coaching"** The Flipped Learning Environment was comprised of seven components as following: 1) problem base, 2) resources, 3) related case 4) mathematical conceptual understanding center 5) collaboration 6) scaffolding and 7) coaching, as shown in Figures 2

Figures 2**:** Shows Designing framework for Flipped Learning Environment on Metaverse to Enhance Mathematical Conceptual Understanding for Seven Grade Students

The result of the assessment for the Designing framework for Flipped Learning Environment on Metaverse to En-hance Mathematical Conceptual Understanding for Seven Grade Students by three experts found that overall score was at the level of (the average mean ($\bar{x}$) was 0.86 standard deviation (S.D) was 0.25 and representing 85.73% as shown in Table 2.

Table 2: Shows the results of the assessment for the designing framework for Flipped Learning Environment on Metaverse to Enhance Mathematical Conceptual Un-derstanding for Seven Grade Students

Assessment Items	Detailed of flipped learning environment	$\bar{x}$	S.D.	Percentage
1) Problem base  Figures 3: Problem base	The problem situation center is designed to stimulate learning and monitor problem solving until a deep understanding of the mathematical structure is achieved, and the problem-solving process can be applied effectively in daily life.	1.00	0.00	100
2) Resources  Figures 4: Resources	The resources center can help support learners in discovering answers or knowledge that can be used to solve problems effectively	0.67	0.58	66.7
3) Related case  Figures 5: Related case	The Related Center can help promote and explain various problem-solving methods and rationale, as well as provide cases that closely resemble real-life problems for effective application.	1.00	0.00	100
4) Mathematical Conceptual Understanding Center  Figures 6: Mathematical Conceptual Understanding Center	The center for mathematical conceptual understanding can help promote students' learning of correct mathematical concepts from the level of understanding to the process level, and up to the level of structural understanding	1.00	0.00	100
5) Collaboration  Figures 7: Collaboration	The collaboration can help promote learners to exchange experiences with others. It provides opportunities for learners to converse and express their own opinions to others. They can also contact teachers when problems arise and misunderstandings occur.	0.67	0.58	66.7
6) Scaffolding  Figures 8: Scaffolding	The scaffolding can help promote problem-solving skills for learners, enabling them to gain a correct understanding of mathematical concepts and have a correct problem-solving process.	0.67	0.58	66.7
7) Coaching	The Coaching, which can support and help students find various answers and	1.00	0.00	100

 Figures 8: Coaching	provide guidance			
Summarize		0.86	0.25	85.73

4 Summary and Discussion

4.1 Discussion

The synthesis of theoretical framework for flipped learning environment on metaverse to enhance mathematical conceptual understanding for seven grade students was analyzed based on research findings and studies of theoretical principles related to designing learning environments and scientific explanation. This was used as the foundation for developing a theoretical framework. The study found that the theoretical framework consists of five foundations: 1) Contextual Basic 2) Fundamentals of Learning Psychology 3) Pedagogical Fundamentals 4) Fundamentals of Mathematical Conceptual Understanding 5) media theory and technology base, which is consistent with Nutthakarn Moeikao studying The Development of Constructivist Learning Environments Model to Enhancing Programming Problem Solving on Internet of Things (IoT) [15]. The research of Issara Kanjung studying Development and Implement Model of Social Media - Based Learning Environment (SMBLE) to enhance Mental Model in Knowledge Construction for Basic Level Education Students [16]. From this below research, which shows that these theories and principles are used as components in synthesizing the theoretical framework of the learning environment design. The results show that the designed and developed learning environment is of high quality. In addition, the research has also designed flipped learning environment on metaverse to enhance mathematical conceptual under-standing for seven grade students, which consist of seven components: 1) problem base, 2) resources, 3) related case 4) mathematical conceptual understanding center 5) collaboration 6) scaffolding and 7) coaching. In this research, there is a difference from previous research in that, this means it is the application of virtual reality technology spatial metaverse in the design of flipped learning environment to enhance mathematical conceptual understanding for seven grade students. The synthesis of the design concept framework for the flipped learning environment to enhance mathematical conceptual understanding for seven grade students are in accordance with principles and theories in all components. This study focuses on synthesizing theoretical frameworks and designing of flipped learning environment that are important factors for use in designing and developing of flipped learning environment to enhance mathematical conceptual understanding for seven grade students, based on a clear and systematic study for future effectiveness. This can be used for designing and developing of simulation learning environment in the future.

4.2 Summary

From research to synthesis of theoretical frameworks for flipped learning Environment on metaverse to enhance mathematical conceptual understanding for seven grade students importantly the results revealed that the theoretical framework consisted of five foundations: 1) Contextual Basic 2) Fundamentals of Learning Psychology 3) Pedagogical Fundamentals 4)

Fundamentals of Mathematical Conceptual Understanding 5) media theory and technology base. And the designing framework consisted of four stages: 1) activating of cognitive structure and enhancing mathematical conceptual understanding, 2) promoting cognitive balance 3) enhancing knowledge construction and mathematical conceptual understanding, and 4) supporting knowledge construction. The Flipped Learning Environment was comprised of seven components as following: 1) problem base, 2) resources, 3) related case 4) mathematical conceptual understanding center 5) collaboration 6) scaffolding and 7) coaching.

5 Suggestion

The principles and theories should be a basic for designing educational interventions that respond to the learning needs of students in different contexts.

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References

[1] H. Sumattana and K. Panapong, "Management of elementary mathematical learning to develop problem solving ability," July. 2021; http:// https://jeal.snru.ac.th/

[2] Ministry of Education, Basic Education Core Curriculum, B.E. 2551 (A.D. 2008), p. 62.

[3] OECD, "Thailand - Country Note - PISA 2018 Results (PISA)," July. 2019; http:// https://www.oecd.org/pisa/publications/PISA2018_CN_THA.pdf

[4] TIMSS THAILAND, "Research Report of the TIMSS 2015 Project Mathematics," 2017; http://http://timssthailand.ipst.ac.th/timss/reports

[5] Houghton Mifflin, Mathematics Grade 3 teacher's Edition, Houghton Mifflin Company, p. 506.

[6] C. Metpattarahiran. "Flipped Classroom and Mathematics Teaching", 15 Feb. 2022; https://www.scimath.org/article-mathematics/item/12484-flipped-classroom.

[7] K. Lertbumroongchai, "Spatial Metaverse In Information Technology", 16 Feb 2022; https://touchpoint.in.th/spatial-metaverse/

[8] RMUTT, "Metaverse go to school," 2022; https://www.metaverse-gts.com/

[9] C. Richey and D. Klein, Design and Development Research. Lawrence Erlbaum Associates, New Jersey, 2007.

[10] P. Sengdao and H. Channarong, "An Investigation of Souphanouvong University Students' Mathematical Conceptual understanding on Vector Using The Geometer's Sketchpad as

a Learning Tool in Lao People Democratic Republic", Journal of Education Graduate Studies Research, Khon Kaen University, Vol.4, 2010

[11] J. Piaget, "Cognitive Development in Children: Development and Learning," Journal of Research in Science Teaching, vol. 2, 1964, pp. 176-186.

[12] A. Collins and P. Duguid, "Situated cognition and the culture of learning," Educational Researcher, vol. 18, no. 1, 1989, pp. 32–42.

[13] M. J. Hannafin, "Open-ended learning environment: Foundation, assumptions, and implications for automated design," New York: Springer-Verlag, 1999, pp. 101-129.

[14] L. S. Vygotsky, "Mind in society: The development of higher psychological processes," Cambridge, MA: Harvard University Press, 1978.

[15] N. Moeikao, The Development of Constructivist Learning Environments Model to Enhancing Programming Problem Solving on Internet of Things (IoT) Programming, Faculty of Education, Khon Kaen University, 2020.

[16] I.Kanjung, Development and Implement Model of Social Media - Based Learning Environment (SMBLE) to enhance Mental Model in Knowledge Construction for Basic Level Education Students, Faculty of Education, Khon Kaen University, 2018.