A Study on Flipped Classroom based on Donald and Maki's Approach for Developing Mathematical Connection In Exponential and Logarithmic Functions to Real-Life Situations for Grade 10 Students

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Abstract

The objective of this research is to develop real-life mathematical connection ability in exponential and logarithmic functions. The population used for this research was two classrooms of grade 10 students, semester 2 in the 2020 academic year of Suksanari School, with 77 students. The researcher used the cluster random sampling method to select a sample of one classroom of 31 students. The research instruments include pre-test and post-test for real-life mathematical connection ability and eight "Flipped Classroom" lesson plans based on Donald and Maki's approach (consist of six steps; Revisit, Real World, Real Model, Classroom Model, Mathematical Model, and Conclusion.) The results of the instrument quality test showed that the reliability of the pre-test and post-test for real-life mathematical connection ability from five experts with the Alpha Cronbach coefficient was 0.84, a difficulty levels of 0.36 to 0.68, a discrimination power value was from 0.23 to 0.50, and content validity score of 0.95. The statistics used to analyze the data were reliability, content validity, and relative gain score. Furthermore, we analyze the report after implementation of each lesson plan for showing their mathematical connection abilities as the qualitative data. The results revealed that all students had improved the mathematical connection ability to real-life.

Keywords: *Donald and Maki's Approach, Exponential and Logarithmic Functions, Flipped Classroom, Mathematical Connection Ability to Real-Life.*

1. Introduction

The National Council of Teachers of Mathematics defines mathematical connection skill, a necessary and vital skill for learners to integrate their mathematical knowledge with maths concepts. It is an application of mathematics to solve real-life problems, and mathematical models can be used to explain conclusions from mathematical problems [1]. "Mathematical Connection Skills" is the ability to relate knowledge in mathematical content of the learners to solve problems in real life [2]. From the past to the present, teachers often convey mathematical concepts in abstraction, making students unable to apply that knowledge to solve problems. It also greatly affected the Thai education system because it could not establish a relationship between abstract mathematical concepts and actual learning. Therefore, teachers should conduct a learning process for learners to understand maths through real-world concepts from their experiences, which combine maths process skills and mathematical knowledge that go hand in hand to solve real-life problems [3]. Due to the global coronavirus disease (COVID-19) since 2019, the current teaching model is being adapted to more online learning or asynchronous learning [4]. An online learning management model that fosters real-life mathematical connections of learners is Flipped Classroom. Flipped Classroom is a learning process that consists of two main activities: self-learning and discussion session. Students can study important content flexibly [5]. They can learn from online learning resources anytime and anywhere. Each week there will be a special 55 minutes discussion session where investigators will provide students with the opportunity to engage in activities together to develop real-life mathematical connections based on Donald and Maki's approach. It consists of 5 steps: real world, real model, classroom model, mathematical model, and conclusion [6]. In order to observe the students' learning intention, the knowledge from the provided online material should be examined to show how well they can manage to understand through the materials or how much prior knowledge the students had beforehand. As a result, one more step has been added to the process of Donald and Maki's approach, namely the "revisit step." Exponential and logarithmic functions, like this concept, are essential and connected with other sciences. If students can connect mathematical knowledge on this topic with real-life situations in different contexts, it will make students appreciate the lesson's content and result in their ability to better mathematics learning [7].

1.1 Research Question
Research question is leading to the research objective: “How can students develop real-life mathematical connections?”

1.2 Objective of Research
This research aimed to develop mathematical connection ability in real-life exponential and logarithmic functions for grade 10 students at Suksanari School.

2. Methodology
We used the mixed method i.e., the quantitative and qualitative data were both used in this research to collect and analyze the results.

2.1 Population, Sample and Sampling Method
The population used in this study was grade 10 students in the second semester of the academic year 2020 at the Suksanari School. There are two classrooms, 77 students. In this research, the homogeneity of variance and the equality of means of grade 10 students’ two classes were tested. The variance for the two classes is equal (.15>.05), and the mean difference was not different statistically significant the .05 level. (.80>.05). Grade 10 two classes are not different, so using a cluster random sampling technique was available.

2.2 Instrumentation
The research instruments consisted of eight lesson plans for the flipped classroom based on Donald and Maki's approach in exponential and logarithmic functions for grade 10 students, and data collection instruments that included pre-test and post-test for real-life mathematical connection ability. The process of instruments construction follows Fig. 1. as follows:

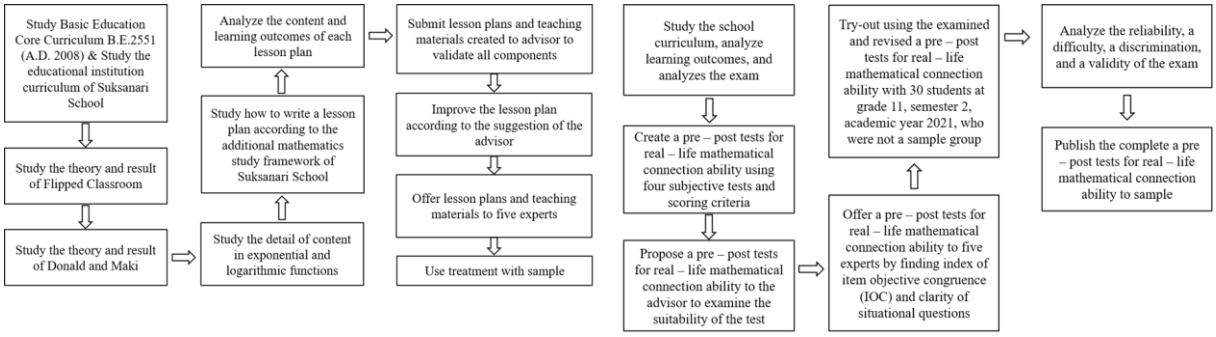


Fig. 1. The process of instruments construction

The quality of the real-life mathematical connection ability test was measured by five experts, with a content validity score of 0.95. From the quality measuring of instruments, the Alpha Cronbach coefficient of 0.84, difficulty levels of 0.36 to 0.68, and a discrimination power value was from 0.23 to 0.50.

3. Results and Discussion

Table 1. A Number of students who received the Relative Gain Score at each development level [Adjusted from Ahlee-Ae, 2014] [8]

Relative Gain Score (%)	Student Development Level	Number of students
more than 75-100	Very High Development	26
more than 50-75	High Development	4
more than 25-50	Medium Development	1
0-25	Low Development	0

In Table 1, the relative gain score of each student was compared with the criteria, showing that each student had at least a 50 percent. Due to Flipped Classroom is a student-centered learning

management process in which there are applications of technology that focus on critical thinking skills, and applications for students to acquire mathematical skills [9]. The flipped classroom is also a way of allowing students to do practical activities that will allow them to complete the learning process according to Bloom's revised taxonomy [10]. Moreover, Srichaipanya [11] said, "Mathematical Connection ability is important for students to build their understanding of mathematical comprehension. Therefore, teachers should conduct learning activities in which students perceive the usefulness, importance of mathematics and mathematical application in daily life, in line with Donald and Maki's approach." For all reasons, Flipped Classroom based on Donald and Maki's approach, provides students with the opportunity to apply their prior knowledge and connect to problems or situations in various real-life contexts. Therefore, teaching in this way encourages students to develop real-life mathematical connections. It also makes students appreciate learning and learn with meaning [12].

Furthermore, we obtained the qualitative data from analyzing the report after the implementation of each lesson plan. In this paper, the reports of lessons 2 and 6 were mentioned to observe students' behavior and develop students' ability to real-life mathematical connection abilities, as shown in Fig. 2. and Fig. 3.

Steps	Student Behavior
Revisit	All students cooperated in answering class questions on "Graphs of Exponential Functions," which could be observed from the response of students answered the class questions; twenty-four students can explain and answer questions correctly in Kahoot, such as "Which of these is the same type of function as $y = 2^x + 1$?"
Real World	All students exchanged opinions in the "Solar Energy" and "Internet of Things (IoT)" brainstorming activity, which can be observed from discussions in each group. Seven groups could explain situations accurately. One group of students left could not explain these real situations because they were unfamiliar with certain words, such as "Cumulative power generation from solar energy," resulting in misunderstandings of their meanings, which caused the teacher to spend much time explaining these they genuinely understand the situations. However, all of them can explain Activity Sheet 2, which one of the fundamental competencies that will help them develop real-life mathematical connections.
Real Model	All students attempted to analyze the conditions required for "Solar Energy" and "Internet of Things (IoT)" scenarios. However, they were still unable to accurately analyze the situation themselves, as evidenced by the fact that they answered irrelevant questions in Activity 2 and did not see the importance of the conditions necessary for those situations. They need additional explanations from their teachers, affecting the connection of their mathematical knowledge with real-context situations.
Classroom Model	All students were able to choose the correct data set for the situation, but they still did not clearly explain the reasons. Only five student groups were able to observe the graph trends of the question correctly. Each group of students was confused about choosing an equation that corresponds to the real situation because each number is an approximation. They should also practice estimating answers because sometimes cannot find an exact solution.
Mathematical Model	All students could choose the correct data set for the situation, but they still did not clearly explain the reasons. Only five student groups were able to observe the graph trends of the question correctly. Each group of students was confused about choosing an equation corresponding to the actual situation because each number is an approximation. They should also practice estimating answers because sometimes they cannot find an exact solution.
Conclusion	All students participated in summarizing the knowledge of "Graphs of Exponential Functions." In addition, they were able to summarize the answers from Activity Sheet 2 based on their knowledge of "Graphs of Exponential Functions," describe the characteristics of graphs, data, and equations concerning the actual situation in the activity.

Fig. 2. The report after implementation of 2nd lesson plan

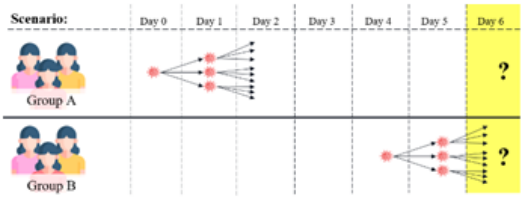
Steps	Student Behavior
Revisit	All students cooperate in answering class questions on "Solving Exponential Inequalities (Increasing Function)," which could be observed from the response of students answered the class questions; 24 students can answer questions correctly such as "What is the video material the teacher assigns students to study?" (Solving Exponential Inequalities: Increasing function).
Real World	All students brainstorm about the Bacterial Fission situation but still cannot accurately describe the bacterial fission characteristics because they misunderstood the nature of this fission bacteria, resulting in an inaccurate explanation of the situation and affecting individual students' real-life mathematical development connection abilities.
Real Model	Twenty-four students were able to accurately and thoroughly analyze the necessary conditions for a Bacterial Fission situation. As a result, they have improved their real-life mathematical connection abilities, as observed by answering Activity 6's essential questions. They could answer that "one cell of this bacteria can fission, three new cells at a time," and "the fission of this bacteria is fission indefinitely." The remaining students were unable to analyze the necessary conditions because they were still unable to explain the bacterial fission characteristics, and they did not prioritize the infinite fission of bacteria.
Classroom Model	Twenty-four students can use the necessary conditions to accurately the bacterial fission of group A and group B students as follows:  From the picture, participation in building the classroom model of students. The rest of the students were confused about the different bacterial fission characteristics and the different bacterial culture periods of groups A, and B.
Mathematical Model	Each student was able to create a mathematical model to accurately show the fission of this bacterium, but only 24 of the 31 students could describe the number of days of culturing this bacterium by the students of groups A and B correctly. However, once all students have been correctly described by peers and teachers, all students can substitute values in the mathematical model with different variables such as x_1, x_2. Afterwards, each student was able to predict that "By day 6, Group A students had more bacterial cell amount than group B students," thus enabling them to apply their knowledge of Exponential Inequalities with what they correctly predicted. Finally, they were all able to explain the mathematical reason and real situational reason to support what they correctly predicted, indicating that they were able to connect their math knowledge to real situations.
Conclusion	All students participated in summarizing the knowledge of "The principle of solving exponential inequality (Increasing Function)," observed by students' responses to key questions.

Fig. 3. The report after implementation of 3rd lesson plan

From Fig. 2. and Fig. 3., there are real-world situations, but they were not the everyday situations of the students, making them unable to attract students' attention. According to a study of the field theory of Kurt Lewin in Muangpatom's [13] research that explains "Applying Lewin's field theory can be done as follows: 1. In the teaching and learning for students to learn, it is necessary to understand the "life space" of the learners how they are interested. Because the teaching and learning management and the physical and psychological environment that is suitable for the learners contribute to the learning well. 2. Motivating learners to concentrate on learning and lessons will lead to learning."

5. Conclusion

The results of the development of real-life mathematical connection ability on exponential and logarithmic functions for grade 10 students found that the post-test score of all students were higher than the pre-test score. Moreover, the mathematical connection abilities levels of students were at the medium development level at least. Moreover, the progress of students' real-life mathematical connection abilities can be observed from the students' performance in each activity in the lesson

plans. It can be noticed that the students understood the situation better and answered the key questions clearer, which can be seen in the step Real World, Real Model, and Classroom Model of Donald and Maki's approach.

6. Suggestion

A flipped classroom based on Donald and Maki's approach should be taken while the student is ready to learn. It should apply to other topics in mathematics with a variety of activities. In addition, students' study behavior or participation should be observed individually, such as answering questions in class, analyzing the conditions of the situation, making worksheets for the effectiveness of learning management, and formative assessment.

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References

[1] Puri, E.R. et al. “Relationship Between Self-Regulated Learning and Mathematical Connection Ability in Junior High School”, AIP Conference Proceedings, Surakarta, Indonesia, 2019, pp. 1-2.
[2] Chaiyawan, H. et al. “The Effects of Using Problem Based Learning Supplemented with Kwdl Technique and Skill Exercise Book on Mathematics Problem Solving Ability and Mathematics Connect Ability of Mathayomsuksa 1 Students”, The 7th NEU National Conference 2020, Khon Kaen, Thailand, 2020, pp. 368-371.
[3] Dongpali, M. “Learning activity provision connecting between mathematics and real-life on relationships among two and three dimensional geometric figures for Mathayom Suksa 1”, Chiang Mai University, 2014, p.1.
[4] Zhang, Z. et al. “Global sensitivity analysis of COVID-19 mathematical model”, Alexandria Engineering Journal, Vol. 60, 2021, pp. 565-566.
[5] Stohr, C. and Adawi, T. “Flipped Classroom Research: From “Black Box” to “White Box” Evaluation”, Education Sciences, Vol. 8, 2018, pp. 1-4.
[6] Sengsri, S. and Panna, W. “The Result of QSCCS Learning Process and Learning Resources in the Community to Promote three Ability of Mathematical for Secondary Student”, Journal of Education Naresuan University, Vol. 20, 2018, pp. 253-265.
[7] Makgaga, S. and Sepeng, P. “Teaching and Learning the Mathematical Exponential and Logarithmic Functions: A Transformation Approach, Mediterranean Journal of Social Sciences”, Vol. 4, 2013, pp. 177-179.
[8] Ahlee-Ae, S. “Effects of Science, Technology, Society and Environment Approach on Chemistry Achievement, Problem Solving Ability and Instructional Satisfaction of Grade 12 Students”, Songkla University, 2014, pp. 61-63.
[9] Bergmann, J. and Sams, A. “Flip your classroom: Reach every student in every class every day”, International Society for Technology in Education, 2012, pp. 13-17.
[10] Bloom, B. ““The Nature and Development of the Taxonomy”, in TAXONOMY OF EDUCATIONAL OBJECTIVES: The Classification of Educational Goals”, the United States of America, 1956, pp. 10-17.
[11] Srichaipanya, M. “Effects of Organizing learning activities emphasizing the connection of mathematics and real-world situations on mathematics learning achievement and attitude toward mathematics learning of eighth grade students in schools under the office of the basic education commission”, Chulalongkorn University, 2007, pp.3-5.
[12] Khongngern, P. et al. “Development of Mathematical Skills and Processes of Matthayom Suksa 1 students at Tessaban Takli (Khuntaklikanakit) School, Nakhon Sawan Province using Flipped Classroom and Formative Assessment Techniques”, Kasetsart University, 2017, pp. 42-53.
[13] Muangpatom, C. “Teaching theory”, UdonThani Rajabhat University, 2014, pp. 37.