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Developing mathematical modelling competence for students in Vietnam through teaching practical problems on the topic of exponential and logarithmic inequalities

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ABSTRACT: *Mathematical modeling in teaching is getting more and more attention. That is reflected in the new General Education program, which considers mathematical modeling one of the core mathematical competencies. Many researchers around the world have given their views on mathematical modeling and the mathematical modeling process. Our research aims to build a teaching process to resolve practical problems on exponential and logarithmic inequalities to develop mathematical modeling competence for students in Vietnam. By the method of theoretical research, survey, and descriptive statistics method, the results showed that mathematical modeling of practical problems under exponential and logarithmic inequalities has a positive impact on students. By surveying 82 students, it is found that students showed more interest in class and actively participated in lessons. Students would rather solve problems on their own than constantly ask for help from the teacher. Students, through practical activities, showed remarkable progress. Students know how to come up with solutions to a real-world problem involving exponential and logarithmic inequalities. These facts demonstrate the importance of teaching modeling of actual issues on exponential and logarithmic inequalities for students.*

KEYWORDS: **mathematical modeling; competence; exponential and logarithmic inequalities; practical problem; process**

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1. Introduction

Mathematical modeling is essential in teaching mathematics. Through mathematical modeling of practical problems, students see the role of mathematics in their lives, thereby creating interest in mathematics and evoking a need to learn. Teaching students mathematical modeling helps them know how to apply mathematics to solve practical problems in life. Students might be able to see that math knowledge is not purely academic or educational knowledge, but math is significant in everyday life. Students build their knowledge through the teacher's pedagogical activities. Teachers ask questions that stimulate curiosity and a passion for discovery, helping students develop awareness. Students in modeling teaching do not play a passive role in how the teacher dictates their students, but they actively participate in the learning process. Students grow through learning activities. In addition, teaching mathematical modeling of practical problems will also help students develop mathematical competencies such as mathematical modeling ability, problem-solving ability, mathematical thinking and reasoning ability. Teaching is oriented towards developing the ability to assess students according to the whole process, not just the 15-minute or 45-minute tests as before. As a result, students are comfortable in the way they learn and experience. Modeling teaching is a learner-centered teaching method. Students are able to reveal their advantages in the process of learning. In the math program for high schoolers in Vietnam, exponential and logarithmic inequalities problems play an important role. These mathematical matters have applications in practice.

According to Blum and Borromeo (2009), mathematical modeling is the transition between the real world and mathematics in both directions. As a result, it has been one of the most intensely discussed and propagated topics in math education over the past few decades. In a study on mathematical modeling in education, Erbaş et al. (2014) presented different researchers' views on mathematical modeling. Specifically, Haines and Crouch (2007) describe mathematical modeling as a cyclical process in which real-life problems are translated into mathematical language, expressed through a system of symbols; and solutions are then proposed and tested. Verschaffel, Greer, and De Corte (2002) further argued that mathematical modeling is a process in which real problems and the relationships between these problems are expressed in mathematical language. Lesh and Doerr (2003) described mathematical modeling as a process in which existing conceptual systems and mathematical models are used to create and develop new mathematical models in a new context. Gravemeijer and Stephan (2002) stated that mathematical modeling is limited to expressing real-world situations in mathematical language using deterministic models. It also involves associating phenomena in real-life situations with mathematical concepts and objects by reinterpreting them. Finally, Lehrer and Schauble (2003) argued that students must have a higher level of mathematical competence in addition to numeracy and arithmetic skills, such as spatial inference, interpretation, and estimation, to express a real-life concern in the language of mathematics effectively.

There are also many other perspectives on mathematical modeling. For example, Cheng (2001) stated that mathematical modeling is a process of representing real-world problems in mathematical terms to find solutions to these real-world problems. According to Arseven (2015), mathematical modeling is defined as transforming any problem situation into a mathematical model. However, the more common definition of mathematical modeling is the process that includes all the steps of structuring math, working with math, and explaining or verifying. According to Neumaier (2003), mathematical modeling is the art of translating problems from an application domain into mathematical formulas to provide helpful insights, answers, and guidance to the initial application.

In Vietnam, there are a number of studies on mathematical modeling. For example, Nguyen and Nguyen (2020) gives the applications of mathematical modeling in teaching the topic "The second order function". Le and Dinh (2019) also conducted research on the applications of the process of mathematical modeling at primary school. As mentioned above, practical problems on exponential and logarithmic inequalities are important to be using mathematical modeling competence. From the above characteristics, this paper focuses on answering the following three questions:

Research question 1. What are the views on mathematical modeling?

Research question 2. What is the mathematical modeling process like?

Research question 3. What is a specific example of teaching to develop mathematical modeling competence through practical problems on exponential and logarithmic inequalities?

2. Methods

2.1. Mathematical modeling process

Until the late 1970s, mathematicians often used mathematical modeling in industry, economics, banking, and finance. After that, educators used mathematical modeling as a new approach in teaching mathematics (Voskoglou, 1995). One of the first authors to suggest using mathematical modeling to teach math was Pollak, who introduced a diagram called the modeling circle (*figure 1*). In this diagram, a problem coming from everyday life or from a scientific topic other than mathematics will be transformed into mathematical knowledge. Next, the correct mathematical tools are used to come up with solutions before applying mathematics to other real-world problems. Pollak's modeling circle can be reused multiple times (Voskoglou, 1995).

Voskoglou (1995) described a five-step modeling process as follows: (1) Analyze practical problems – (2) Mathematical modeling

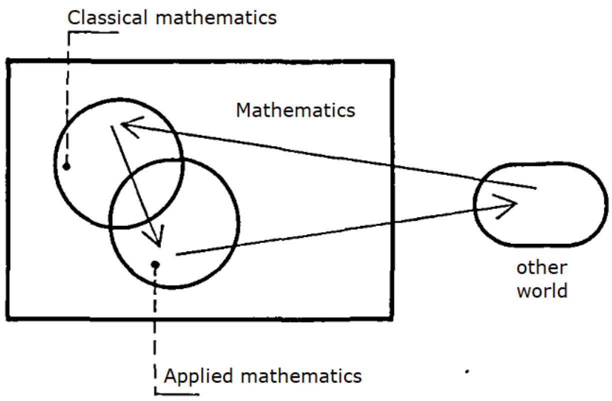

Figure 1. Pollak's modeling circle (Voskoglou, 1995).

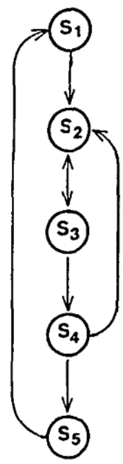

Figure 2. Modeling process (Voskoglou, 1995).

– (3) Draw the conclusion of the mathematical model – (4) Model execution – (5) Apply the solution to a practical problem.

Voskoglou's modeling circle can be repeated once or multiple times from step 2 to step 4 (*figure 2*). According to Tan (2020), mathematical modeling is a cycle of transforming the real world problem into a mathematical problem by using formulas as well as of using proposed mathematical model, interpreting and evaluating solutions to solve in a real-world context. According to Swetz, and Hartzler (1991), and Tan (2020), the process of teaching mathematical modeling is as follows: (1) Observe and identify the object – (2) Predict the relationship between factors and mathematize the real problem – (3) Apply the appropriate mathematical model and (4) Draw conclusions and reinterpret them in real contexts.

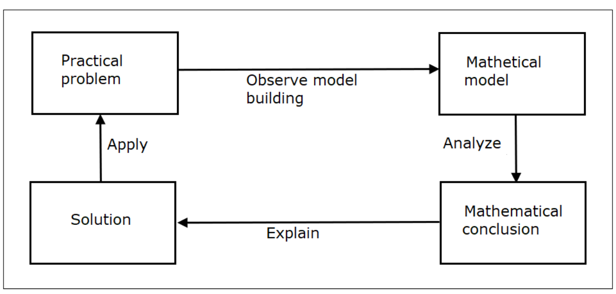

Figure 3. Mathematical modeling process (Tan, 2020).

According to Maaß (2006), the process of mathematical modeling begins with the problem in practice. Then, via simplification and idealization, an actual model is created. Next, by creating abstraction or mathematization, a mathematical model of the actual model is proposed. Mathematical tools are then used to process the mathematical model. From there, mathematical solutions are derived. Lastly, by analyzing the answer, the model can be applied to resolve other true-to-life problems. This process can be repeated many times. In addition to the above processes, there are many processes proposed by other researchers such as Zhang et al. (2013), Blomhøj and Jensen (2003), Galbraith and Holton (2018).

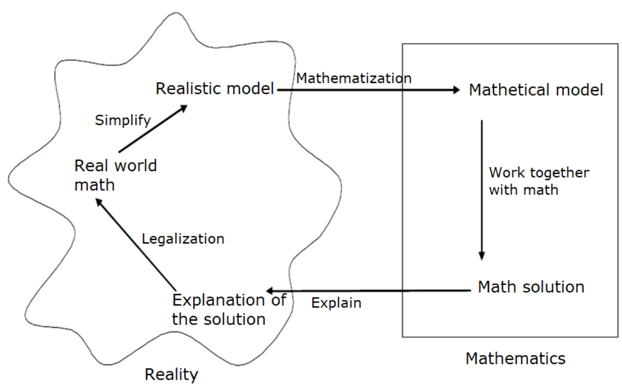

Figure 4. Mathematical modeling process (Maaß, 2006).

2.2. Perspectives on mathematical modeling competence

Mathematical modeling competence is one of the core mathematical competencies that learners need. However, there are different views on mathematical modeling capabilities. Therefore, depending on each field, the researcher in that field would need to define mathematical modeling accordingly. Maaß (2006) argued that mathematical modeling competence includes the skills and ability to perform the modeling process appropriately to achieve the goal as well as the willingness to apply these in practical situations.

For instance, Blum (2015) gives the definition that mathematical modeling competence is the ability to construct, use or apply mathematical models by taking appropriate steps of the mathematical modeling process as well as analyzing or comparing mathematical models with each other. Similarly, Wess (2019) considers mathematical modeling competence as the ability to construct, exploit, or modify mathematical models by performing each step of the modeling process adequately and appropriately for solving practical problems as well as the ability to analyze and compare models. According to Nguyen (2015a), modeling competence is the ability to fully implement all stages of the modeling process in order to solve the problem posed. Ludwig and Xu (2010) divided mathematical modeling competence into 6 levels to evaluate, including

i. Level 0: Students do not understand the actual situation and cannot describe anything about the situation.

ii. Level 1: Students only understand the real situation to a certain extent, cannot structure and simplify the situation, or can not find the connection between the real situation and any mathematical objects.

iii. Level 2: After learning the actual situation, students can understand the situation's structure and develop a real model but do not know how to convert it into a mathematical model.

iv. Level 3: Students can come up with a realistic model and convert it into a suitable problem, but cannot solve this problem with mathematical tools.

v. Level 4: Students can turn a real model into a math problem and solve this problem with mathematical tools to give results for the problem.

vi. Level 5: Students can establish a mathematical modeling process and come up with a mathematical solution for a specific real-life situation.

2.3. The process of teaching mathematical modeling

From the above points of view and studying the works of the authors including Biembengut and Hein (2010), Muthuri (2009), Blomhøj and Carreira (2009), Greefrath & Vorhölter (2016), Le (2005), Duong and Tran (2016), Nguyen (2015b), and Nguyen (2014), this paper offers the following 4-step process to teach mathematical modeling of a real-world problem.

i. Step 1: Build an intermediate model – Identify the important factors in the practical problem, the relationships between those factors, and the requirements to be solved.

ii. Step 2: Build a mathematical model – Describe the elements and relationships in the intermediate model in the form of mathematical language.

iii. Step 3: Solve the math problem – Use mathematical tools and methods to solve the mathematical problem obtained from the mathematical model in Step 2.

iv. Step 4: Answer to the practical problem

For some particular real-life problems, its mathematical model can be generalized to solve bigger problems. It is thus possible to propose Step 5: Generalize the mathematical model.

2.4. Illustrated teaching examples to develop mathematical modeling competence through practical problems on the topic of exponential and logarithmic inequalities

Example 1

The Carbon 14 (^{14}C) dating method assumes that carbon dioxide on Earth today has the same radioactive content as it did centuries ago. If this were true, the amount of ^{14}C absorbed by a tree that grew a few centuries ago would be equal to the amount of ^{14}C absorbed by a large tree today. An ancient piece of coal contains less than 15% of the radioactive carbon compared to a modern piece of coal. At least how long ago was the tree burned to make ancient coal, given the half life of ^{14}C is 5715 years? (Larson et al., 2011).

Table 1. The Carbon 14 Model

Teacher's activities	Students' activities
Step 1. Build an intermediate model	
- Please summarize the facts and requirements of the above problem.	- The amount of ^{14}C absorbed by a tree that grew a few centuries ago would be equal to the amount of ^{14}C absorbed by a large tree today. - An ancient piece of coal contains less than 15% of the amount of ^{14}C compared to a modern piece of coal. The half-life of ^{14}C is 5715 years. - How long ago was the tree burned to make charcoal?
Step 2. Build a mathematical model	
- Which of the above data objects can be set as variables?	- Given that a is the amount of ^{14}C absorbed. T is the half-life. A is the amount of ^{14}C remaining. n is the number of half-lives from the time the tree was burned to the present.
- Find the relationship between the above variables.	- After 1T years, $A=\frac{a}{2}$ - After 2T years, $A=\frac{a}{2^2}$ - After 3T years, $A=\frac{a}{2^3}$ ... After nT years, $A=\frac{a}{2^n}$
- Please state the mathematical model for the above practical problem.	- Given $T=5715$ (years), $A=\frac{a}{2^n}$, and $A<15\%.a.$ Calculate nT.
Step 3. Solve the math problem.	
- Solve the above problem.	We have: $A<15\%.a \Leftrightarrow \frac{a}{2^n}<15\%.a.$ Since $2^n>0$ for every n, the above inequality is equivalent to: $2^n>\frac{1}{15\%}$ $\Leftrightarrow \ln 2^n>\ln\frac{1}{15\%}$ $\Leftrightarrow n>\frac{\ln\frac{1}{15\%}}{\ln 2}$ $\Leftrightarrow nT>\frac{\ln\frac{1}{15\%}}{\ln 2}.5715\simeq 15641.76$
Step 4. Answer to the practical problem	
- Draw a conclusion for the problem.	- The tree was burned at least 15642 years ago.

Example 2

A person monthly deposits an equal amount of VND 3 million in the bank at the beginning of each month at an interest rate of 0.5% per month. After how long will that person have more than VND 50 million? (Hua, 2017)

Table 2. The total amount is more than 50 million.

Teacher's activities	Student activities
Step 1. Build an intermediate model	
Please summarize the facts and requirements of the above problem.	- Monthly deposit amount: 3 million. - Interest rate 0.5%/month. - The total amount is more than 50 million. - Calculate the number of months in which the money has been deposited.
Step 2. Build a mathematical model	
Assuming P(n) is the amount obtained at the end of the nth month, calculate P(1), P(2), P(3), from there, derive the formula for P(n).	- At the end of the first month: $P(1)=3+3.0,5\%=3(1+0,5\%)$ - At the end of the second month: $P(2)=3(1+0,5\%)+3+(3(1+0,5\%)+3)0,5\%$ $=3\left((1+0,5\%)^2+(1+0,5\%)\right)$ - At the end of the third month: $P(3)=3\left((1+0,5\%)^2+(1+0,5\%)\right)+3$ $+\left(3\left((1+0,5\%)^2+(1+0,5\%)\right)+3\right)0,5\%$ $=3\left((1+0,5\%)^3+(1+0,5\%)^2+(1+0,5\%)\right)$ ... - At the end of the nth month: $P(n)=3\left((1+0,5\%)^n+(1+0,5\%)^{n-1}+...+(1+0,5\%)\right)$
Is it possible to simplify the above expression?	The sum $(1+0,5\%)^n+(1+0,5\%)^{n-1}+...+(1+0,5\%)$ takes the form of the sum of n consecutive terms of an exponent whose first term is 1 + 0,5% and the multiplier 1 + 0,5%, so it can be reduced to: $(1+0,5\%)\dfrac{(1+0,5\%)^n-1}{0,5\%}$ So $P(n)=3(1+0,5\%)\dfrac{(1+0,5\%)^n-1}{0,5\%}$
So, which math problem is the above practical problem equivalent to?	- From the data and the problem requirements, we get the inequality: $3(1+0,5\%)\dfrac{(1+0,5\%)^n-1}{0,5\%}>50$
Step 3. Solve the math problem.	
Please solve the above problem.	We have: $3(1+0,5\%)\dfrac{(1+0,5\%)^n-1}{0,5\%}>50 \Leftrightarrow (1+0,5\%)^n-1>\dfrac{50}{603}$

Teacher's activities	Student activities
	$\Leftrightarrow \left(1+0.5\%\right)^n \geq \frac{653}{603}$ $\Leftrightarrow n \geq \frac{\ln\frac{653}{603}}{\ln\left(1+0.5\%\right)} \simeq 15.97$
Step 4. Answer to the practical problem	
Give a conclusion to the problem.	- After 16 months, that person will have over VND 50 million.
Step 5: Generalize the mathematical model	
Please state the general problem for the above problem and the mathematical model for the general problem.	- General problem: Every month, the amount a is deposited into the account with a term of 1 month, the interest rate is r each month. Calculate the amount P after n months. The general mathematical model for this problem is: $P\left(n\right) = a\left(1+r\right)\frac{\left(1+r\right)^n - 1}{r}$

2.5. Time and experimental subjects

The pedagogical experiment was conducted at Ham Thuan Bac High School, (Ham Thuan Bac, Binh Thuan, Vietnam) according to the basic program for the 2020-2021 school year. The study was conducted on two classes of equivalent academic ability, including: (1) experimental class (12A16) includeing 40 students and (2) control class (12A13) including 42 students.

Lesson plans and taught lessons were prepared on the topic "Practicing exponential and logarithmic inequalities" for both classes. Lesson plans provide the core knowledge, skills, and the process of teaching exponential and logarithmic inequalities. In addition, the lesson plans also included the consolidations and homework exercises. For the experimental class, teachers taught according to the lesson plans compiled to develop mathematical modeling competence. For the control class, the teacher taught according to the lesson plans compiled based on the textbook of GT12CB.

2.6. Pedagogical experimental process

The pedagogical process includes a number of stages: (1) select an experimental class and a control class – (2) prepare materials and lectures for experimental lessons – (3) conduct experimental lessons according to the compiled lesson plan – (4) conduct interviews with students and teachers after school to verify data, learn from the unmeasurable aspects of the test and record suggestions from the participating teachers.

After the experimental lessons, a test was given to both experimental class and control class. Data is then collected, analysed and evaluated.

2.7. Experimental evaluation method

Some of the empirical evaluation methods that we use:

I. Observing the classroom: through teaching lessons and interacting with students, the researchers observe students' behaviors and attitudes to assess the level of learning interest, awareness level, and ability to apply knowledge before and after the experimental teaching. In addition, the assessment is also based on the review of students' learning records, including notebooks, exercise notebooks, and scratch paper.

II. Interview: the researchers use the interview method to clarify information, issues that are difficult to determine through observations such as the attractiveness of the measures. These interviews were conducted in the form of conversation or questionnaires with guiding questions, combined with observing the external manifestations of the subject.

III. Essay test: aims to assess the level of students' understanding of knowledge through the lesson. We test the knowledge of each individual in the experimental class and the control class through a test in the form of an essay after teaching the experiment. The content of the test is based on the objectives of the lessons according to the lesson plan, and especially exercises were selected to evaluate the effectiveness of teaching in the direction of developing mathematical modeling competence. The tests are scored on a 10-point scale.

IV. Mathematical and statistical method: After marking the students' tests, the data on the test scores was collected, and SPSS software was used for statistics and data verification.

3. Experimental analysis

A priori analysis

We interviewed the homeroom teacher and the math teacher of the two classes, and the results showed that the two selected classes were equivalent in terms of academic performance, specifically as follows:

An independent T-Test was conducted to assess precisely the similarity or difference between the mean scores of the two experimental and control classes, with the hypothesis H_0: "The average score of the first semester of mathematics of the experimental and control classes is similar." Levene test results (*table 2*) give the value Sig.=0.357>0.05. Using independent T-Test average test results for the case where the equal variances of the two classes are assumed, the value sig. (2-tailed) $p = 0.972 > 0.05$ was created, validating the hypothesis H_0. It is concluded that the difference in the mean scores of the two experimental and control classes is not significant. In conclusion, the two selected classes are equivalent in terms of academic performances.

Table 3. **Summary of information on math performance in the first semester of the control and experimental classes (Personal collection).**

CLASS	MATH PERFORMANCE									
	Good		Fair		Average		Weak		Poor	
	Qty	%	Qty	%	Qty	%	Qty	%	Qty	%
12A16	13	30,95	21	50	5	11,9	3	7,14	0	0
	Arithmetic mean = 7.329									
12A13	11	27.5	24	60.0	5	12.5	0	0	0	0
	Arithmetic mean = 7.320									

Table 4. **Independent T-Test to determine academic equivalence.**

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
T H _ TTD	Equal variances assumed	.859	.357	.035	80	.972	.0086	.2427	-.4744	.4916
	Equal variances not assumed			.035	78.328	.972	.0086	.2415	-.4723	.4894

4. Analyze experimental results

Qualitative assessment

Via experimental teaching and observations in experimental and control classes, interviewing students before and after the experimental teaching process, interviewing teachers and participating teachers, some conclusion was made regarding the effectiveness of the proposed method. The comments stated that:

i. the classroom atmosphere of the experimental class was lively, and students were more active than those of the control class.

ii. the experimental class' students interested in practical problems voluntarily participated in activities and actively exchanged knowledge to build mathematical models for each given practical situation. Thus, the lessons are more effective compared to the control class.

iii. after the experimental lessons, the experimental class students no longer had many difficulties in using mathematically modeling to learn about the topic of exponential and logarithmic inequalities. The researchers have a careful and precise attitude in reasoning to avoid errors in mathematical modeling.

Quantitative assessment

The test results of two experimental and control classes were evaluated and analysed after the experiment (using SPSS software for statistics and data verification) for quantitative data analysis. The results are shown in Table 5, Chart 1, and Chart 2.

Chart 1 and chart 2 suggested that the heights of the score columns and the distribution of students' performances are different are different between two classes. The scores of the experimental class ranged from 5.5 to 10 points, and most achieved from 8 to 9 points. The scores of the control class ranged from 4.0 to 9 points,

Table 5. Statistical indicators of test scores of two experimental and control classes after the experiment

Statistics			
		TN_STD	DC_STD
N	Valid	42	40
	Missing	40	42
Mean		8.052	7.225
Median		8.000	7.250
Mode		8.0a	7.0
Std. Deviation		1.0675	1.1980
Variance		1.140	1.435
Skewness		-.363	-.483
Std. Error of Skewness		.365	.374
Kurtosis		-.145	.113
Std. Error of Kurtosis		.717	.733
Minimum		5.5	4.0
Maximum		10.0	9.0
**Multiple modes exist. The smallest value is shown			

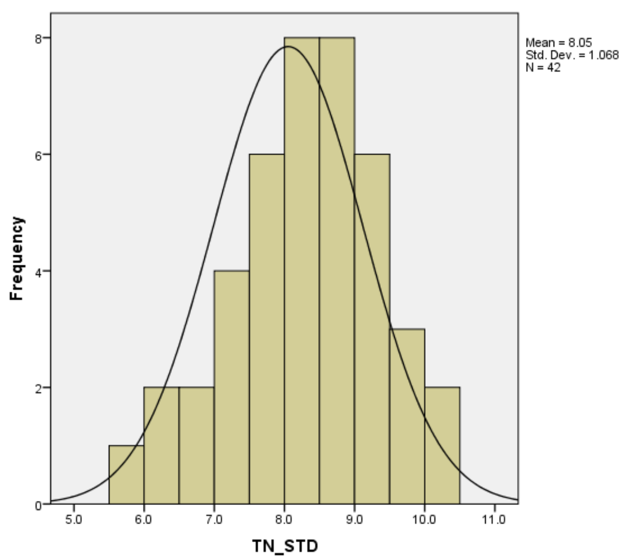

Chart 1. Math test scores of the experimental class after the experiment.

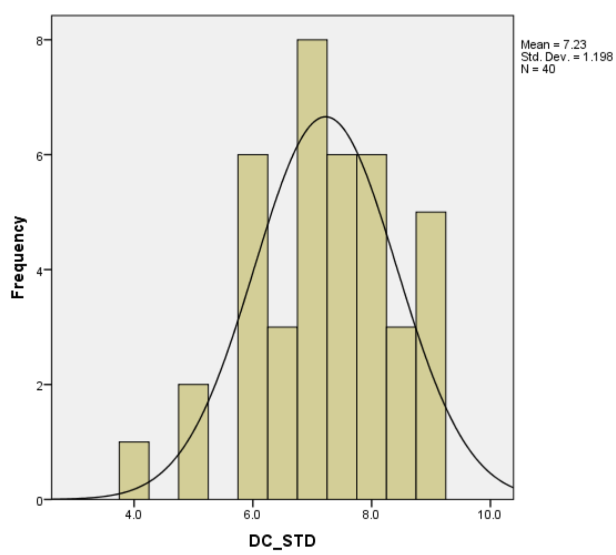

Chart 2. Post-experiment math test scores

and the majority achieved from 6 to 8 points.

The results from table 5 showed that the average score of the experimental class was 8.052, an increase of 0.723 compared to the average score compared to the first semester (before the experiment). On the other hand, the average score of the control class was 7.225, a decrease of 0.095 compared to the average score of the first semester. The variance of the experimental class was 1.140, which is smaller than the variance of the control class of 1.435. That demonstrates that the mean and variance of the two classes had a big difference. The mean score of the experimental class became higher; standard deviation and variance were lower, so the concentration around the mean was higher than the control class. Therefore, it is suggested that the scores of the experimental class were higher than those of the control class, and the test scores of the experimental class had higher levels of normal distribution compared with the control class.

To accurately assess the difference between the mean scores of the two experimental and control classes, an independent T-Test was conducted on the results of the two classes' essay tests, with a significance level $\alpha = 0,05$ and the following two hypotheses:

Hypothesis H_0: "*The mean scores of the experimental and control classes are similar*."

H_1: *"The average score of the experimental class is higher than that of the control class*."

The results from Table 6 showed that the Levene test has the value Sig. = 0.443 > 0.05, so the Independent Sample T-Test results should be used for the case where the equal variances of the two samples are assumed. The independent mean T-Test on the test scores of the two classes shows $p = 0.001 < 0.05$, which allows the rejection of the H_0 hypothesis, and the acceptance of the H_1 hypothesis. There is a big difference between the test scores of the two classes, the mean score of the experimental class was higher than the control class.

Thus, by the test method between two equivalence classes, the results suggested that the experimental class, after being taught the experimental lessons, achieved higher test results and obtained higher average compared to the control class. In other words, experimental measures applied to the experimental class were completely feasible and effective in teaching, and can be used to replace traditional teaching method.

5. Conclusion

The article has analysed mathematical modeling in-depth and clarifed three research questions. Firstly, these are different views on mathematical modeling, the mathematical

Table 6. Table of independent mean T-Test of two experimental and control classes after the experiment

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
TH_STD	Equal variances assumed	.594	.443	3.305	80	.001	.8274	.2503	.3292	1.3255
	Equal variances not assumed			3.296	77.908	.001	.8274	.2510	.3276	1.3272

modeling process, and examples of teaching to develop mathematical modeling competence through real-life problems on the topic of exponential and logarithmic inequalities. Through practical investigation, survey, and experiment with 82 students in Vietnam, it is found that the students showed more enthusiasm and active participation in experimental class compared to traditional teaching. The students were more active and had made remarkable progress compared to the teaching method where the teacher dictates to the students. Especially in terms of learning attitudes, students' skills and knowledge have all become better compared to the pre-test results. There might be weak students in class with knowledge gaps, but now they actively participate in the teaching process. Teachers build lessons inspired by a real problem and then draw out a basic model for solution. Students are expected to realize that mathematics is not purely academic and scholastic but it has a number of practical applications. On the other hand, some students are actively looking for practical applications of mathematics through exponential and logarithmic inequalities problems. Finally, by descriptive statistics method with the help of SPSS software, the evaluation data showed the effectiveness of the teaching and learning application of modeling exponential and logarithmic inequalities problems in Vietnam. It proves that this research direction is suitable and needs more research work. In the future, the research will be applied for other mathematical topics such as the practical extremum problems.

References

Arseven, A. (2015). Mathematical Modeling Approach in Mathematics Education. *Universal Journal of Educational Research,* 3(12), 973–980. https://doi.org/10.13189/ujer.2015.031204

Biembengut, M. S., & Hein, N. (2010). Mathematical Modeling: Implications for Teaching Maria. In *Modeling Students' Mathematical Modeling Competencies* (pp. 481–490). https://doi.org/10.1007/978-1-4419-0561-1_41

Blomhøj, M., & Carreira, S. (2009). Mathematical Applications and Modeling in the Teaching and Learning of Mathematics. In *The Proceedings of the 12th International Congress on Mathematical Education* (pp. 469–473). https://doi.org/10.1007/978-3-319-12688-3_42

Blomhøj, M., & Jensen, T. H. (2003). Developing Mathematical Modeling Competence: Conceptual clarification and educational planning. *Teaching Mathematics and its Applications* 22(3), 123–139. https://doi.org/10.1093/teamat/22.3.123

Blum, W. (2015). Quality Teaching of Mathematical Modeling: What Do We Know, What Can We Do? In *The Proceedings of the 12th International Congress on Mathematical Education* (pp.73-96). https://doi.org/10.1007/978-3-319-12688-3_9

Blum, W., & Borromeo, R. (2009). Mathematical Modeling: Can It Be Taught And Learnt? In *Journal of Mathematical Modeling and Application,* 1(1), 45–58.

Cheng, A. K. (2001). Teaching Mathematical Modeling in Singapore schools. In *The Mathematics Educator,* 6(1), 63-75. https://repository.nie.edu.sg/handle/10497/49

Duong, H. T., & Tran, V. T. (2016). Teaching by Mathematical Modeling: a strategy for teaching logarithmic concepts in high schools. *Can Tho University Science Journal*, 46(3), 62–72. https://doi.org/10.22144/ctu.jvn.2016.58

Erbas, A. K., Kertil, M., Çetinkaya, B., Çakiroglu, E., Alacaci, C., & Bas, S. (2014). Mathematical Modeling in Mathematics Education: Basic Concepts and Approaches. *Educational Sciences: Theory & Practice*. https://doi.org/10.12738/estp.2014.4.2039

Galbraith, P., & Holton, D. (2018). *Mathematical Modeling A guidebook for teachers and teams Peter*. ACER and IM^{2}C.

Gravemeijer, K., & Stephan, M. (2002). Emergent Models as an Instructional Design Heuristic. In *Symbolizing, Modeling, and Tool Use in Mathematics Education* (pp. 145–169). https://doi.org/10.1007/978-94-017-3194-2_10

Greefrath, G., & Vorhölter, K. (2016). *Teaching and Learning Mathematical Modeling Approaches and Developments from German-Speaking Countries*. Springer Open. https://doi.org/10.1007/978-3-319-45004-9

Haines, C., & Crouch, R. (2007). Mathematical Modeling and Applications: Ability and Competency Frameworks. *New ICMI Study Series*, 10(6), 417–424). https://doi.org/10.1007/978-0-387-29822-1_46

Hua, L.P. (2017). *Practice real-world problem-solving skills.* Thanh Hoa Publishing House.

Larson, R., Edwards, B. H., & Falvo, D. C. (2011). *Calculus I with Precalculus - A One-Year Course* (3rd ed.). Brooks/Cole, Cengage Learning.

Le, T. T. H., & Dinh, T. H. L. (2019). The applications of the process of mathematical modeling at primary school. *The Vietnam Journal Education*, 49(2), 28–32.

Le, V. T. (2005). *Methods of teaching Mathematics in high schools.* Ho Chi Minh City University of Pedagogy.

Lehrer, R., & Schauble, L. (2003). Origins and evaluation of model-based reasoning in mathematics and science. In *Beyond constructivism: Models and modeling perspectives on mathematics problem solving, learning, and teaching* (pp. 59–70). Mahwah, NJ: Lawrence Erlbaum.

Lesh, R., & Doerr, H. M. (2003). Foundations of models and modeling perspective on mathematics teaching, learning, and problem-solving. *Beyond Constructivism*, 1(1), 3–33.

Ludwig, M., & Xu, B. (2010). A Comparative Study of Modeling Competencies Among Chinese and German Students. *Journal Für Mathematik-Didaktik*. https://doi.org/10.1007/s13138-010-0005-z

Maaß, K. (2006). What are modeling competencies? *ZDM: The International Journal on Mathematics Education*, *38(2)*, 111-132. https://doi.org/10.1007/BF02655885

Muthuri, C. W. (2009). *Mathematical models*. https://doi.org/10.13140/2.1.2005.0569

Neumaier, A. (2003). *Mathematical Modeling*. Institut fur¨ Mathematik, Universit¨at Wien Strudlhofgasse 4, A-1090 Wien, Austria. https://www.mat.univie.ac.at/~neum/ms/model.pdf

Nguyen D. H., & Nguyen T. T. B (2019). The applications of Mathematical Modeling in teaching the topic "The second order function". *The Vietnam Journal Education*, 27(2), 17–20.

Nguyen, D. N. (2015a). Modeling competence of high school students. *Journal of Science of HNUE*, 60(4), 44–52. https://doi.org/10.18173/2354-1075.2015-0143

Nguyen, D. N. (2015b). Modeling process in teaching Mathematics in high schools. *Hanoi VNU Science Journal: Educational Research*, 3, 1–10.

Nguyen, T. N. (2014). Discuss the problem of teaching mathematical modeling in high schools. Journal of Science of HNUE, 59(3), 69–75.

Raphael Wess, G. G. (2019). *Professional competencies for teaching mathematical modeling – supporting the modeling-specific task competency of prospective teachers in the teaching laboratory*. Eleventh Congress of the European Society for Research in Mathematics Education, Utrecht University, Feb 2019, Utrecht, Netherlands. https://hal.archives-ouvertes.fr/hal-02409039

Tan, J. Y. (2020). Exploring Secondary Students' Modeling Competencies. *The Mathematics Enthusiast*, *17*(1), 85–107. https://www.researchgate.net/publication/337335901%0AExploring

Verschaffel, L., Greer, B., & de Corte, E. (2002). Everyday Knowledge and Mathematical Modeling of School Word Problems. In *Symbolizing, Modeling, and Tool Use in Mathematics Education* (pp. 257–276). https://doi.org/10.1007/978-94-017-3194-2_16

Voskoglou, M. G. (1995). Measuring mathematical model building abilities. *International Journal of Mathematical Education in Science and Technology*, *26*(1), 29–35. https://doi.org/10.1080/0020739950260104

Zhang, S., Jiang, G., Guo, H., Shi, C., & Xia, H. (2013). Apply of synergy drilling fluid system in WeiBei oilfield. In *Drilling Fluid and Completion Fluid*, 30(3), 20-22.