Designing Mathematical Modeling Tasks for Learning Mathematics

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ABSTRACT
Planning and implementing a lesson is not an easy thing to do. Also, it is not an easy task to find good and relevant context for all mathematical concepts. The results of the International PIAAC and PISA studies show that people and students have low competence when solving problems with context. The formulation of problem of this study is how to design mathematical Modeling tasks for learning mathematics using water faucet damage contexts in vocational high school which is valid?. This research used development research methods developed by Akker, Gravemeijer, McKenney and Nieveen. This development research consists of 3 stages, namely analysis, design and evaluation. In the analysis step, student analysis, curriculum, mathematical modeling and real-world problems are conducted. The second step, design and product. The last step, the researcher used a formative evaluation design consisting of self-evaluation, one-to-one, expert review, small group, and field tests. After being collected, the data are analyzed using descriptive analysis method: (1) walk through, analysis based on expert comments in expert review to get mathematical modeling tasks for mathematical modeling learning which was valid; (2) Analyze the results of the review in one to one. Based on two expert validation, i.e. an expert in numeracy (education) and an expert in pure mathematics and applications and modeling. Mathematician commented that the problem of modeling was good and challenging but needed a little revision, such as Mathematician commented that there was water that did not enter the tub because it dripped on the ceramics. Expert of numeration commented that The problem is based on a very good idea, and I really like the way it is set up in an Indonesian bathroom, a nice cultural influence. Students' answers show they could not make assumptions but could make variables. Student comment that these modeling tasks are difficult but good or interesting. So, it was obtained mathematical modeling tasks using water faucet damage was valid for learning mathematics. Based on this research, it is recommended to use modeling tasks using water faucet damage in mathematics teaching and learning.

Keywords: *Designing, Modeling Tasks, Learning Mathematics.*

1. INTRODUCTION

Planning and implementing a lesson is not an easy thing to do [1]. Also, it is not an easy task to find good and relevant context for all mathematical concepts [2]. So, it is important to do research on designing tasks/problems for mathematics lessons or learning.

The results of the International PIAAC and PISA studies show that people and students have low competence when solving problems with context [3], but the reasons for this low competence are not well identified [4]. This indicates the importance of using context-based tasks in learning mathematics. One of the mathematics learning that uses context-based tasks is mathematics learning using mathematical modeling questions. The characteristics of mathematical modeling problems are using real/realistic, authentic, open-ended, complex, problems, solved by the modeling process [5].

Research results reported that learning mathematical modeling has a potential effect on mathematical modeling literacy [5]. In fact, learning mathematical modeling makes students interested and motivated to learn mathematics [6,7,8,9,10,11]. This is also supported by the statement that mathematical modeling is an example of an interdisciplinary area that brings together mathematics and technology to solve real-world problems [12]. Thus, learning mathematics through mathematical modeling problems is very crucial to do to prevent a lack of interest/interest and enable students to face complex problems [13]. Other research,

learning the effects of COVID-19 on PISAComat in the form of pictures allows most students with high reasoning to understand problems and find solutions by identifying relevant information and using the context of COVID-19 as a learning resource helps students integrate other topics with problem solving [14].

Research [15] reported that through the development of mathematical modeling activities, students' enthusiasm for learning mathematics and participating in mathematical modeling activities was greatly raised, and SMK students had difficulties because they did not know what mathematics to use and when to use it, so they were less enthusiastic about learning mathematics. This indicateds that this research is a solution to the problem of learning in vocational high schools. Thus, research and learning of mathematical modeling is very crucial to be carried out, especially at the vocational high school level.

1.1 The Formulation of the Problem

The formulation of problem of this study is how to design mathematical Modeling tasks for learning mathematics using water faucet damage contexts in vocational high school which is valid?

1.2 The Purpose of this Study

This study aims to produce valid mathematical modeling tasks using the context of water faucet damage for mathematics learning in vocational high schools.

1.3 Benefits of This Research

The research is expected to be useful for teachers, researchers, government, curriculum designers, textbook writers, and ICT designers.

2. RESEARCH METHOD

This study used the approach of design research the type development research that developed by Akker, Gravemeijer, McKenney and Nieveen. This approach used 3 stage, i.e, analysis, design and evaluation [16]. The first stage are student analysis, curriculum, vocational needs, real-world problem, and mathematical modeling tasks nature were implemented. The second stage are designed and produced of mathematical modeling tasks using water faucet damage contexts. The ending stage is formative evaluation which consist of self-evaluation, one-to-one, expert review, small group, and field tests [17,18]. Figure 1 show formative evaluation. This study was only implemented. self-evaluation, expert review, and the one-to-one.

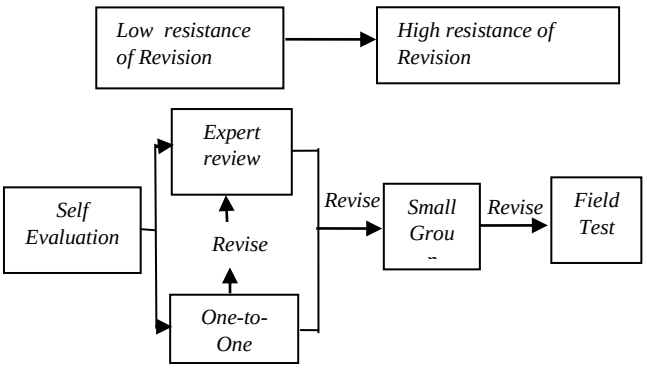


Figure 1 Design of formative evaluation [17,18]

The succes criteria of this study, this study produced valid mathematical modeling tasks using water faucet damage contexts for mathematical learning in vocational high school. This research only reached the one-to-one stage or only tested the validity of the problem. The validity was resulted from the experts review of numeration expert, mathematics education expert, mathematical modeling expert or student's solution and comment on one-to-one.

The subject of research were only one student of SMK Negeri 1 Sungai Menang, Ogan Komering Ilir, South Sumatera, Indonesia. The collected of data were analyzed by conducting descriptive analysis method, firstly, walk through, walk through by worksheet analysis based on the comments of review of expert to produce valid mathematical modeling tasks using water faucet damage; (2) interview and student's solution, the analyze the results of one-to-one.

3. RESULT AND DISCUSSION

This research implemented analyzing, design and assessment. In assessment, researcher only implemented self-evaluation, expert review and one-to-one.

3.1. The Analyzing Step

This study start with analyzing the curriculum, students condition, real world problems and mathematical modeling tasks nature, students' vocational needs. In this step, researcher implemented analyzing of curriculum (competence of basic), real world-problem that contain rich mathematically/ mathematics concept, teacher and student needed, and mathematical modeling tasks natures. This study used Riyanto's [5] natures of mathematical modeling tasks.

3.2. The Design Step

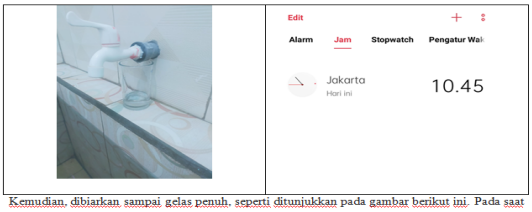
Researcher searched the real world problem that have mathematics concept and it can be used for modeling learning in SMK. Then researcher designed the problem of water faucet damage as a context for

learning mathematics. Because, this context contains rich mathematically, so, reseacher used this problem for learning mathematics. Thus, the researchers designed mathematical modeling tasks using water faucet damage according to the characteristics of Riyanto's research results. [5] The problem of modeling with the context of water faucet damage is given in Figure 2 below.

Berikut adalah Masalah kerusakan karet kran air pada bak air pada suatu rumah tangga

Kerusakan Kran Air

Sebuah keran yang sambungan karetnya putus meneteskan air. Untuk mengatasi agar air tidak terbuang. Dilakukan pengukuran tingkat debit air yang keluar dari kebocoran. Pemilik rumah meletakkan gelas kosong untuk menadah air yang menetes. Pada saat awal (gelas kosong) waktu menunjukkan pukul 10.45, seperti ditunjukkan gambar berikut ini.

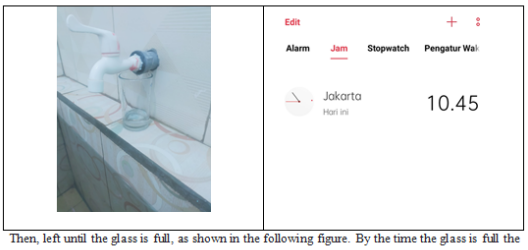


Kemudian, dibiarkan sampai gelas penuh, seperti ditunjukkan pada gambar berikut ini. Pada saat gelas penuh pukul menunjukkan 10.49.

Translate

The following is the problem of damage to water faucet rubber in a water bath in a household Water Faucet Damage

A faucet with a broken rubber plug dripped with water. To prevent water from being wasted. Measure the level of water discharge coming out of the leak. The owner of the house put an empty glass to catch the dripping water. At the beginning (empty glass) the time is 10:45, as shown in the following figure.



Then, left until the glass is full, as shown in the following figure. By the time the glass is full the clock shows 10:49.

Kemudian, dibiarkan sampai gelas penuh, seperti ditunjukkan pada gambar berikut ini. Pada saat gelas penuh pukul menunjukkan 10.49.

Translate

Then, left until the glass is full, as shown in the following figure. By the time the glass is full the clock shows 10:49.

Pemilik rumah belum berencana memperbaiki kran yang karetnya rusak ini karena terlalu sibuk atau belum ada waktu untuk menggantinya/memperbaikinya. Pemilik rumah tidak mau ada air yang terbuang sia-sia. Ia perlu saran dari orang lain, agar bak air ini tidak penuh (air tidak keluar/terbuang sia-sia).

Tugas Anda.

Agar harapan pemilik rumah bisa terpenuhi, tugas Anda memberikan rekomendasi kepada pemilik rumah agar harapan bisa optimal. Bagaimana strategi Anda. Berikan rekomendasi Anda!

Translate

The owner of the house has not planned to repair the faucet with the broken rubber because it is too busy or there is no time to replace/repair it. Homeowners don't want any water to be wasted. He needs advice from other people, so that the water tank is not full (water doesn't come out/wasted).

Your task.

So that the expectations of homeowners can be met, your job is to provide recommendations to homeowners so that expectations can be optimal. What is your strategy. Give your recommendation!

Solusi

1. Informasi Apa yang terdapat pada teks bacaan di atas?

Translate

Solution

1. What information is contained in the text above?

2. Apa masalah yang akan Anda selesaikan berdasarkan teks di atas?

3. Data/Informasi apa saja yang diperlukan atau yang menentukan untuk menyelesaikan masalah yang Anda tetapkan?

Translate

2. What problem would you solve based on the text above?

3. What data/Information is needed or decisive to solve the problem you define?

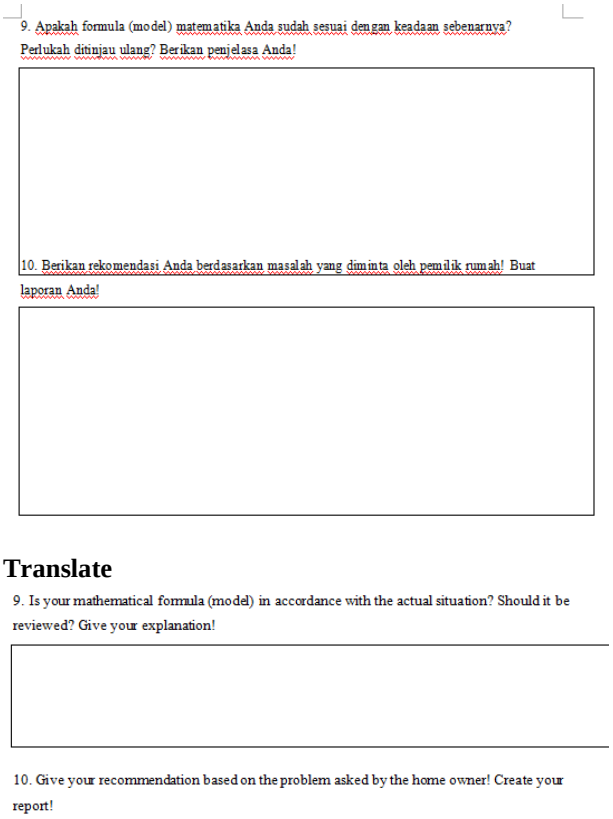


Figure 2 Mathematical modeling tasks using water faucet damage in the analysis and design step

The problem of mathematical modeling in the context of water faucet damage is suitable to natures of the mathematical modeling problem of Riyanto's research [5].

3.3. The Assessment Step

This research implemented only self-evaluation, experts review, and one-to-one. The research has only carried out a validity assessment (expert and one-to-one review) or has not conducted an assessment of practicality (small group) and potential effects (field test) regarding the context of water faucet damage. After implementing the analysis and design, the researcher implemented a formative evaluation to examine the validity of mathematical modeling tasks. The first, researcher implemented self-evaluation the mathematical modeling using water faucet damage that had developed. In this step, researcher used Riyanto's [5] mathematical modeling nature. Based on self-evaluation, this mathematical modeling tasks using water faucet damage was suitable to Riyanto's [5]. Then, researcher impelemented expert review. There are two expert reviews, namely numeration expert. The other one is Expert of pure, applied and modeling. Numeration expert said that "the problem is based on a very good idea!! And I really like the way it is set up in an Indonesian bathroom. A nice cultural influence. Depending on the experience of the learner, that is, how much modelling they have done previously, I would be inclined to provide less scaffolding. The problem, as it stands, is quite structured with relatively few decisions for students to make. This is fine if they are beginning modellers but less interesting if they are more experienced. If this was your house and you were discussing this problem with a plumber, what would be the once question you would ask them?". Figure 3 show the Riyan's comments. So, in this phase, researchers make revisions based on expert's comment. This describe that mathematical modeling tasks using water faucet damage that has designed was good for learning mathematics.

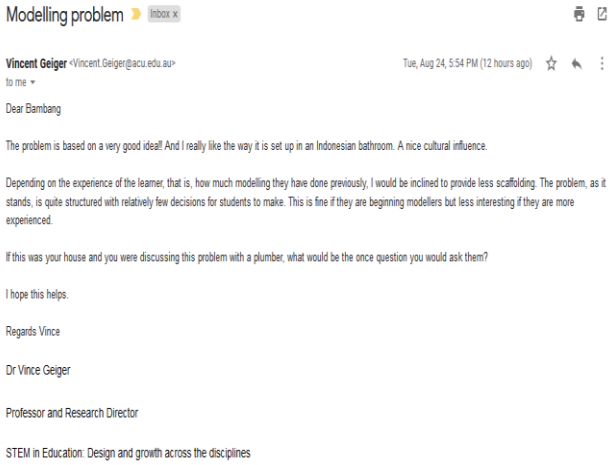


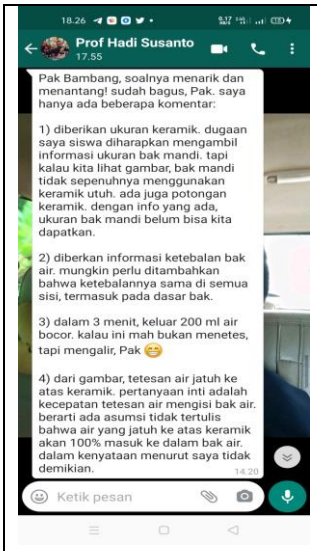
Figure 3 Numeration expert's comment on Experts Review

Based on the results of Numeration's comments, the researcher views that the students of SMK Negeri 1 Sungai Menang are still novice modelers. Because they have never done modeling lessons before, they need to be given more detailed scaffolding. Advice from Vince, need to add what questions to ask the plumber. But this research focuses on strategies so that water is not wasted.

Mathematician commented that the mathematical modeling tasks were interesting and challenging! Already good. The size of the tiles is given to determine the size of the bath, but the bath does not completely use whole ceramics. In this comment, the researcher expects students to make assumptions by estimating. Bath thickness information, it should be added that the thickness of the bath is the same. Thus, the researchers revised the modeling problem. Leak too fast (flow not drip). According to the researcher, this is important for students in strategy. From the picture, not all will fall into the tub because it falls on the ceramic. Here, the researcher hopes that students will make assumptions. Figure 4 shows Mathematician's comment.

Mathematician's comments match to the characteristics of Riyanto's [5] problem modeling, i.e., modeling problems are authentic and complex, so students must look for relevant data in solving real-world problems.

Based on the results of Hadi's comments, researchers must revise the mathematical modeling tasks that have been designed.



Translate

Mr. Bambang, because it's interesting and challenging! it's been good, sir. I just have a few comments:
1) given the size of the ceramic. My guess is that students are expected to take bathtub size information. but if we look at the picture, the bathtub does not completely use whole ceramics. there are also ceramic pieces. with the available info, we can't get the size of the bathtub.
2) given information on the thickness of the water bath. it may be worth adding that the thickness is the same on all sides, including the bottom of the tub.
3) in 3 minutes, out 200 ml of leaking water. if this isn't dripping, it's flowing, sir
4) from the picture, water droplets fall on the ceramic. the core question is the speed at which the water droplets fill the water bath. This means that there is an unwritten assumption that water that falls on the ceramic will 100% enter the water bath. In reality I don't think so.

Figure 4 Mathematician's comment on Experts Review

Revised by adding that the thickness of the tub is the same on all sides. Figure 5 shows after the revision.

Translate

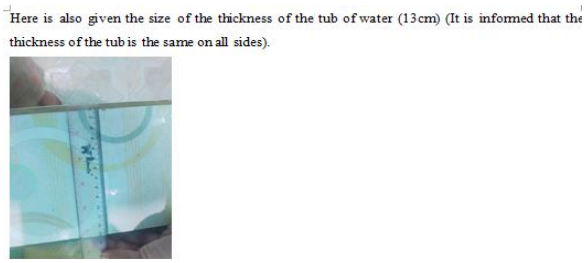
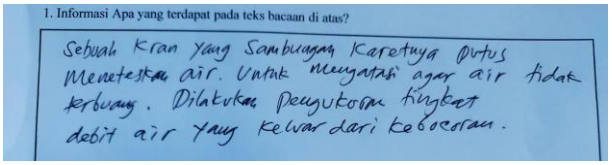


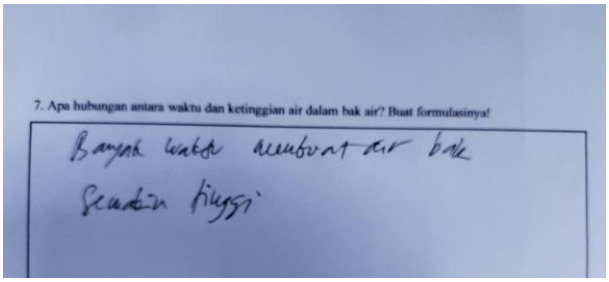
Figure 5 Revision result from expert review

Researcher conducted a one-to-one test to examine the validity of mathematical modeling tasks from expert review prototype. Vicky Darlian Paulanta in one-to-one is subject research and he is student of Grade XII TKJ of SMKN 1 Sungai Menang. The solution of the Vicky indicated by figure 6. Vicky only could understand modeling problems, could not make assumptions, could not work mathematically, and have not been able to validate modeling results. But, Vicky could thinking informal, he conclude informally that the longer the time, making the water bath is higher. This indicates that modeling learning is new for SMKN 1 Sungai Menang because the student could not make assumption in the mathematical modeling process and could not work mathematically. This shows that he does not perform mathematization. So, it requires innovation. It takes innovation to familiarize students with transforming real-world problems into mathematical form [19]. This mathematizing activity is also very suitable with PMRI (*Pendidikan Matematika Realistik Indonesia*). Also, mathematical modeling tasks is suitable to theory of PMRI (*Pendidikan Matematika Realistik Indonesia*). Activities related to PMRI support stakeholders such as teachers, prospective teacher students, students, teacher educators, researchers, and book writers in reforming mathematics education in Indonesia, so that PMRI is an innovation in sustainable mathematics education [20]. So, this indicated that this research is an innovation in mathematics learning. PMRI is not much different from learning mathematical modeling [21]. This result is very compatible with the research results of [9, 10] who reported that students could not make assumptions and could not validate the results of mathematical modeling. This indicate that learning mathematics using mathematical modeling tasks is promising at SMKN 1 Sungai Menang to be further designed. Because students already have informal math thinking. This is also suitable to the studied results of [11] that students could not make assumptions in modeling process which works to simplify the problem because modeling tasks is new for the student in Indonesian. This indicated that mathematical modeling is problematics to be introduced in schools in Indonesia based on the government program on national assessment.

This is also in line with the government's policy on prototype curriculum that will be implemented in the future. It is also very important for teachers of SMKN 1 Sungai Menang in preparing to implement the new curriculum through learning mathematical modeling.



Translate:
1. What information is contained in the text above?
A faucet with a broken rubber plug dripped with water. To prevent water from being wasted. Measure the level of water discharge coming out of the leak



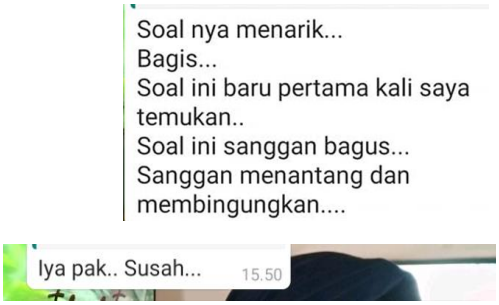
Translate:
2. What problem would you solve based on the text above?

A lot of time makes the tub water higher

Figure 6 Student's solution on one-to-one step

Based on students opinion, Vicky said that this question is difficult, interesting, challenging and good. This fits perfectly with the results of previous research that Doing modeling problems is seen as a difficult activity for students because of the cognitive complexity of the taks ([22], [23]). The integration of mathematical modeling problems in the classroom can pose several challenges; in particular, when students are expected to produce knowledge, various reasons can be put forward by teachers to avoid it, three of which may be more influential when the teacher gives up, namely: difficulty in creating mathematical modeling problems; difficulty in adapting modeling questions to curriculum outcomes; and the long time required to carry out modeling problems [24]. The results of this research indicate that teachers also experience difficulties when designing and implementing modeling problems in mathematics learning. Figure 7 described student's comment in one-to-one step. This indicated that students are not familiar with the mathematical modeling tasks. This also indicates that it is very crucial for teachers, researchers, policy maker, curriculum designer to design and implement mathematical modleing tasks to improve students' capabilities in mathematical modeling and learning quality. This also shows that learning mathematical modeling is promising at SMKN 1 Sungai Menang particularly and schools in Indonesia generally. Also, it is crucial for teachers to design mathematical modeling tasks for learning mathematics. This research suggest the need for teachers to innovate to continue to look for other real problem problem extra-mathematics, especially the world of vocational or industry to design mathematical modeling tasks for mathematical learning in Vocational school, so that it is interesting, joyfull, meaningfull for students and students are motivated to learn mathematics.

In particular, modeling learning at Sungai Menang Vocational School is very crucial to do because the learning carried out so far is still dominated by conventional learning. This is in accordance with the results of research conducted by Riyanto [29] that learning mathematical modeling is still new at SMKN 1 Sungai Menang.



Translate
Because it's interesting, good. This is the first time I have come across this issue. This question is challenging and confusing.

Figure 7 Student's opinion on one-to-one step

The modeling approach in mathematics education arises because traditional mathematics teaching does not develop students' abilities to think and apply in different contexts. This shows that it is important to shift from traditional learning to innovative learning [25]. This give information that teacher, researcher, book writer, curriculum designer, ICT designer should designing mathematical modeling tasks for learning mathematics.

Research result [26] concluded that the objectives of the real-world project are in line with the two main findings of STEM that (a) it is important to expand STEM engagement and achievement, and (b) schools should promote inquiry, reasoning, and creativity and design in STEM curricula, where this project addresses (a) by developing problems that place mathematics learning in real-world scenarios that are relevant and interesting to students and (b) by supporting teachers to identify and present students with open-ended problems stemming from real-world phenomena that require new thinking and using their math resources in a creative way. This statement show that this researsch is crucial

to implement. This also implies the importance of learning mathematical modeling at the school level. Thus, this research is a step towards this expert opinion. In fact, teaching modeling is a special difficulty that is still little studied in mathematical didactic research [27]

Therefore, research and learning of methematical modeling needs to be continued to improve the quality of learning, especially mathematics learning. This is also in line with the suggestion that mathematics teachers should design teaching materials that can guide students in learning mathematical concepts from informal mathematics to formal mathematics [28].

4. CONCLUSION AND SUGGESTION

This study has resulted valid mathematical modeling tasks using the water faucet damage for mathematics learning in vocational high school. This conclusion is based on an analysis of the characteristics of the Riyanto (2020) modeling problem, the results of an expert review which said that this modeling question was good, challenging and suitable and was revised by providing information (assuming) that the thickness of the water tank on all sides was the same. Also, according to the numerator's comments, it also shows that the modeling questions are designed to suit the novice modeler. Based on one-to-one that students stated this question was good and challenging. In the one-to-one stage, no revisions were made. This research also has a weakness, which is that it only takes only one student as a research subject

Based on this conclusion, the researcher provided suggestions for developing and conducting mathematical modeling problems/tasks using interesting, joyfull and meaningful real-world problem for learning mathematics. So that the learning process engagement students more and students' abilities in mathematical modeling are increased. Also, further study, it is crusial/problematic to conduct learning and researching mathematical modeling in mathematics learning. The results of this research also strongly support the government's policy on the new curriculum (prototype curriculum). To implement this prototype curriculum, learning mathematical modeling can be used as an alternative tool. Thus, the context of this water faucet damage can be used as teaching material in mathematics learning because this context has been tested for validity. Finally, it is problematics to conduct education transformation through changing the role of teacher and using problem extra-mathematics.

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