HOTS on mathematical modelling approach in primary school

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Abstract. The 21st-century skills are creativity and innovation, critical thinking and problem-solving, communication and collaboration are accessible through Modelling. This is closely related to HOTS. The problem formulation is, firstly how is HOTS on Mathematical Modelling Approach in a primary school that is valid? and secondly how is HOTS in Mathematical Modelling Approach in Primary schools that are practical? This research uses a development research method which consists of 3 stages, namely analysis, design and evaluation. In the analysis step carried out student analysis, curriculum, and HOTS in Mathematics modelling approach. The second steps is design and product. Then the final step, researchers used a formative evaluation design consisting of self-evaluation, one-to-one, expert review, small group. Subjects in this study were students of SD IT Bina Insani Kayuagung in Ogan Komering Ilir Regency. Data collection techniques are, firstly, walkthrough, this is based on expert review to get tasks valid in content, construct and language aspects of HOTS on mathematics modelling approach in Primary Schools, secondly, interview, this is from one to one, small group to find out the practicality of a Hypothetical Learning Trajectory, and lastly, questionnaire. From expert validation and student answers analysis, we obtained HOTS tasks on mathematical modelling approach in primary schools that are valid and practical using “Jumat Sejahtera” Context.

1. Introduction

Not only in the USA, but in other countries around the world, teachers are now dealing with the challenges of teaching mathematical modelling [1]. Primary school is an educational environment where all children begin meaningful development of process and modelling skills [2]. These indicate learning mathematical through mathematical modelling very important in Primary School. An important component of problem-solving in today’s world is interpreting the problem situation, dealing with ambiguous or incomplete information, identifying constraints on solutions, and visualising and evaluating possible end-products [3]. This show that mathematical modelling is very important to implement in school. In fact, traditionally, students are not introduced to mathematical modelling until they reach secondary school [4]. However, the rudiments of mathematical modelling can and should begin much earlier than this, where young children already have the foundational competencies on which modelling can be developed [5-7]. Activities are seen in the curriculum through investigations and projects, carried out in groups or individuals and, where the focus is on modelling itself, it is also potential to improve performance in mathematics in general students [8]. Mathematics education aims to create individuals who can build effective solutions to problem situations in real life, which can apply mathematics in real life by understanding the strong
connections between mathematics and real life, and the consequences make something mathematics enjoy rather than afraid to mathematics [9-10]. This indicate mathematical modelling very important to implement in learning that have a high level of mathematical thinking and who can use mathematics in problem-solving. Mathematical educators have tested models and modelling in relation to problem-solving by proving that suggesting modelling activities is a success for students [11 - 15]. According to Lesh and Zawojewski [12] illustrate that learning mathematics through modelling, “students begin their learning experiences with the development of a conceptual system (ie, models) to understand real life situations where it is important to create, revise, or adapt mathematical thinking using mathematical model”. Traditionally, in many classes, the application of problem-solving experience was not carried out until the end of the unit when all skills were introduced and mastered [16]. This means that it is necessary to apply problem-solving early to the end of the learning unit. Research [16] introduce creative ways to engage teachers and students in the elementary and middle grades to use mathematical modelling and problem-solving to promote twenty-first-century skills such as collaboration, communication, critical thinking and creativity. One important way in which we discuss the idea of mathematical modelling is the process of connecting mathematical reasoning with real-world situations. This type of problem is open-ended and messy and requires creativity and perseverance [16]. This indicates mathematical modelling is HOTS tasks.

Students need genuine choices about what's important, decisions about what content is specific for implementation, and finally, decide whether the solution is reasonable or useful. This provides an opportunity to develop and practice 21st-century skills, namely collaboration, communication, critical thinking and creativity [16]. The teacher in lesson study with modelling feels that this problem is a demand for high-level thinking (doing mathematics) in the sense of a rich mathematical task [16-17]. According to Ferri [1], there is no mathematics modelling teaching book that can be used by teachers to find evidence-based (research) theories and ideas for teaching, and at the same time used by prospective teacher educators to prepare current and future teachers in the lecture for high-quality mathematical modelling. This shows the need for innovation to create school mathematics modelling tasks in Indonesia in particular. According to Bean [18], “all forms of ‘modelling’ require interpretive and creative thinking”. According to Palharani [19] that using modelling tasks where, from real situations, students need translation between reality and mathematics, making assumptions, choosing variables, deducing mathematical models, interpreting them and validating them based on real situations. From day to day teaching mathematics, modelling is rare [20, 21]. Recent empirical studies show that many teachers barely know to model and do not integrate modelling tasks into their lessons [21, 22]. Tasks are a fundamental part of mathematics lesson and so have a central position in mathematics education [22-23].

The characteristics of mathematical modelling tasks, no real contexts and no real life questions – no mathematical modelling [1]. Teaching mathematical modelling and applications are demanding and follows its own rules, in the sense that modelling problems are a new and advanced task format for both students and teachers [1]. According to Greefrath and Vorhölter [24] that Supporting students’ modelling processes most effectively can be a great challenge for teachers. Research from Kaiser [25] also showed that modelling problems also have the potential to motivate students. According to Greefrath and Vorhölter [24] that nowadays, modelling is part of the German national curriculum. However, as in most countries, applications and modelling play only a small role in everyday teaching. According to Liedmann [26], that modelling competence is important for students to be able to manage their daily lives and prepare future work. According to Bliss [27] that Pre-Kindergarten through 8th grade provides a natural setting for mathematical modelling with several advantages, such as utilizing and preserving the positive and curious curiosity of children and helping to teach and assessing mathematics learning, other curriculum content, and extracurricular ideas. This show that mathematical modelling is important in primary school to access creativity and critical thinking (HOTS). Creativity and innovation, critical thinking and problem-solving, communication and collaboration are all need HOTS and are all accessible via mathematical modelling. So, mathematical modelling and HOTS closely related.
The problem formulation is, firstly, how is HOTS on Mathematical Modelling Approach in a primary school that is valid?, secondly, how is HOTS in Mathematical Modelling Approach in Primary schools that are practical? This study aimed to produce valid and practical HOTS Tasks on Mathematical Modelling Approach in Primary School. The expected benefits of the results of this research were for students, teachers, policy makers, and researchers.

2. Method
This research used development research methods developed by Akker, Gravemeijer, McKenney and Nieveen. It consists of 3 stages, namely analysis, design and evaluation [28]. In the analysis step, student analysis, curriculum, “Jumat Sejahtera” context and mathematical modelling are carried out. The second step designed and produced (Mathematical Modelling) using “Jumat Sejahtera” context. The final step of this research used a formative evaluation design (Figure 1) consisting of self-evaluation, one-to-one, expert review, small group, and field tests [29-30]. This research was only conducted until the small group phase.

![Design of Formative Evaluation](image.png)

**Figure 1:** Design of Formative Evaluation [29-30].

The success criteria of this study used the form of HOTS on Mathematical Modelling Approach in Primary School that was valid and practical for primary school students. The validity was obtained from the validation of experts of mathematics education and context and the practicality was obtained from the students' opinions after working mathematical modelling task using and observations of the small group and one-to-one by video and interview. Practicality means easy to use, interpretable, and unambiguous.

The subjects of this research were 6 students of SDIT Bina Insani Kayuagung Ogan Komering Ilir District, South Sumatera. The techniques of collecting data were first, walkthrough, it based on the expert review to get a valid mathematical modelling problem in content, construct and language aspects, secondly, interview, it derived from one to one and small group to find out the practicality and use of the problem. The collected data were analyzed using descriptive analysis method: firstly, walkthrough, walk through sheet analysis based on the expect comments in the expert review to get valid mathematical modelling problem; secondly, interview, analyze the results of the review in a one-to-one and small group to get practicality useful.

3. Results and Discussion
The Validity of HOTS on modelling task of the mathematical modelling approach in Primary School was done Zulkardi. Validation in mathematics was done by Darmawijoyo. The validation of expert of “Jumat Sejahtera” obtained HOTS tasks on mathematical modelling approach valid in Primary School. The mathematical modelling tasks are in Figure 2:
Your class has held a joint meal which a school program called “Jumat Sejahtera”. Each student takes a turn providing food/drinks to all her/his classmates and also his/her teacher every Friday.

Your tasks:
If you get a turn, give your best recommendation to parent in determining the amount of money need to buy food or drinks four your classmate and teacher.

Figure 2. HOTS Task on Mathematical Modelling Approach

After being validated by the expert review, then one-to-one was conducted to find out the practicality of HOTS tasks on Mathematical Modelling Approach in Primary School using “Jumat Sejahtera” context. One-to-One was conducted at SDIT Bina Insani on Tuesday, October 4th, 2018. There were sixth of students of grade VI selected from SD IT Bina Insani Kayuagung, namely Salwa Azzahra, K. Nurin Imanina, Farah Aqilah, M. Surya Adyitia, M. Fahhas Al Haqqy AP, and Dhali Rozan Fadhaillah. Figure 3 is one-to-one photographs. These figures show the students were working modelling tasks.

Figure 3. One-to-One and small group Photos
Figure 4 explains the student opinion showed that the modelling problem was good and interesting and could make the students think. In this research, the students say that these tasks are very interesting dan difficult to make model according to modelling process because they never learn modelling task. From the solution of the students also show that student can solve the tasks but cannot recommend the general model. Students can make an assumption and define an essential variable, can do the math: get a solution, but cannot analyze and assess the model and solutions, etc from the modelling process [27]. However, there were some terms that had to be explained first because the students were not familiar with the term in the modelling process. Mathematical modelling task using “Jumat Sejahtera” context make students interesting to learn mathematics. This caused by ‘Jumat Sejahtera” context that is real and meaningful for them. Mathematical learning through modelling task impact to positive attitude student’s toward mathematics. Using “Jumat Sejahtera” in their school every Friday as context on mathematical learning engagement student to use mathematics in solving a real-world problem, so that student get experience in modelling that is very important for her/his future. By modelling, mathematical learning can arise of the value, i.e. promotion, objectivism, and openness. It caused by mathematical learning that using “Jumat Sejahtera” context and modelling process. Figure 4 is the student's responses to the modelling problem.

![Image](image.jpg)

The tasks are good and interesting and make students think

**Figure 4.** The student’s comment

Judging from the student's answer for the first problem, it shows that the students were able to make identification and problem specifications. The student answers are in Figure 5.

![Image](image2.jpg)

Every friday, school dealing “Jumat Sejahtera”. Each student take turns giving food/drinking to all classmate and teacher class on Friday.

**Figure 5.** The student’s answer about makes identification and problem specifications.

For mathematical modelling process, i.e make an assumption. The student can make assumptions. This is very important to build a mathematical model. The student answers are in Figure 6.
Table 1. The student’s answer about makes an assumption.

| How many student in the class and 2 teachers (people) | How many foods that must give (pieces)? | How much price the food (rupiah)? | The cost must be spent on food (rupiah)? | How many the drinking must be that must be given (glass/bottle)? | How much price the drinking (rupiah)? | The price must spend on drinking (rupiah)? | The total price for food and drinking (Rp)? |
|------------------------------------------------------|----------------------------------------|----------------------------------|----------------------------------------|-------------------------------------------------|--------------------------------------|------------------------------------------|----------------------------------------|
| 4                                                    | 6                                      | Rp 6000                          | Rp 36.000                              | 6                                               | Rp 4000                              | Rp 24.000                                | Rp 60.000                              |
| 5                                                    | 7                                      | Rp 6000                          | Rp 42.000                              | 7                                               | Rp 4000                              | Rp 28.000                                | Rp 70.000                              |
| 6                                                    | 8                                      | Rp 6000                          | Rp 48.000                              | 8                                               | Rp 4000                              | Rp 32.000                                | Rp 80.000                              |
| 7                                                    | 9                                      | Rp 6000                          | Rp 54.000                              | 9                                               | Rp 4000                              | Rp 36.000                                | Rp 90.000                              |

The English version of Figure 6 is described in Table 1. For mathematical modelling process, students must determine relevant data to build mathematical modelling. Figure 7 shows that student can determine how many students in their class there do not exist in the problem. Figure 7 shows that student can determine that the total price is an important variable.

To determine the cost of “Jumat Sejahtera”, what is unknow from text above? How many student/teacher that given “Jumat Sejahtera” determine important variable from the problem? The total cost for food and drinking.

Figure 7. The student’s answer about makes an assumption.

Figure 8 shows that student can do the math to get the solution. A student can make a mathematical model for the cost of food and drinking. This show that student can build a mathematical model.
Figure 8. The student’s answer about makes a mathematical model.

For the first problem, students cannot provide recommendations, cannot analyze and cannot assess the model and the solutions, and cannot iterate as needed to refine and extend the model.

The second problem indicates that student can make identification and specification problem. Figure 9 shows the student’s answer.

Make mathematical model to calculate the only cost of food of “Jumat Sejahtera” using variable that you choose.
Food per box: $3 \times 3,000 = 9,000$
Drinking per box: $1 \times 1,000 = 10,000$
All student = 21 student
all teacher = 2 teacher
total = 23 people
$23 \text{ orang} \times 10,000 = 230,000$

Make mathematical model to calculate the only cost of drinking of “Jumat Sejahtera” using variable that you choose.
Drinking per box: $1 \times 1,000 = 1,000$
All student = 21 student
all teacher = 2 teacher
total = 23 people
$23 \text{ orang} \times 1000 = 23,000$

What is/are the information from the text above?
The cost of “Jumat Sejahtera” 300.000 rupiah. SDIT suggest to the student to saving and the class to carry out eating together.

Figure 9. The student’s solution the second tasks about identification and specification problem

The student answers for the second task for the make assumption are in figure 10 indicate that student can make an assumption about how many days need to get the amount of money 300.000 rupiahs.
The amount of saving per day (rupiah) | The amount of money for “Jumat Sejahtera” (rupiah)? | How many days to saving (day)
---|---|---
10,000 rupiah | 300,000 rupiah | 30 day/1 month
15,000 rupiah | 300,000 rupiah | 20 day
30,000 rupiah | 300,000 rupiah | 10 day
50,000 rupiah | 300,000 rupiah | 6 day

The English version of Figure 10 is described in Table 2. On mathematical modelling process, the modeller must make an assumption to create the mathematical model. Figure 11 shows that student can make an assumption about what is unknow in the text. Student answer how many student and important variable is the amount of the money for Jumat Sejahtera.

To determine how long to saving on “Jumat Sejahtera”, what is unknow from the text above?

How many of student

Determine what is/are important variable from above problem?

300,000 the amount of money for Jumat Sejahtera

The phase of mathematical modelling is that student makes a mathematical model. Figure 12 indicates that student can make a mathematical model for the second tasks.
Mathematical modelling process, Student make a generalisation and validate the solution. In this process, the student cannot provide recommendations, cannot analyze and cannot assess the model and the solutions, and cannot iterate as needed to refine and extend the model (see in Figure 13). This is caused mathematical process is new for them.

What is your conclusion from the problem?
So, 5000 perday (need)

Does your to replace your mathematical model that you find? Give reason.
No

Figure 13. The student’s solution the second about the recommendation

HOTS on mathematical modelling tasks from validation of expert and one-to-one results, we obtained valid and practical HOTS tasks on mathematical modelling approach in Primary School: using “Jumat Sejahtera” context must be small revise for learning mathematical modelling for algebra.

Mathematical modelling does not mean having a “pseudo-realistic problem”, in which all data are given, or you only have to exercise algorithms. Mathematical modelling is a challenge for students on several levels because the students work on questions out of the reality, to which they have to apply mathematics [1]. The characteristics of mathematical modelling tasks are very important to design mathematical modelling tasks. Mathematical modelling is a challenge for students on several levels because the students work on questions out of the reality, to which they have to apply mathematics [1]. Mathematics provides a set of tools for describing, analyzing, and predicting the behaviour of systems in the real world. This using practical always provides the main reason for the important role of mathematics in the primary school curriculum [31]. In particular, the problem-traditional application in the form of aritmetics story-is the focus on developing the skills of students in the knowledge of when and how to apply their mathematics effectively on the variety of problems in everyday life [32-33]. In this research using “Jumat Sejahtera” context from the comment of the students is very interesting, very good, invite
students to imagine, like challenges, and meaningful or useful for the students as a citizen of Indonesian.

In general, the word mathematical modelling is concerned with finding mathematical representations for a non-mathematical object or phenomena. The process of mathematical modelling makes the relationship of complex structures between two entities of a natural epistemology different: the modelled situation and the mathematical system. Thus, with our modelling activity approach, through mathematics, a problematic situation is not essentially mathematics [34]. A modelling activity can be described in terms of an initial (problematic) situation, from the final destination situation (which represents the solution to the initial solution) and a set of procedures and concepts essential to a situation from the beginning to the final situation. Literature is usually related to the situation of the initial problem as a problem situation, and in general, the mathematical representation or mathematical model is associated with the final destination situation. According to Lesh, et. al [11] suggests that mathematical models as conceptual systems are expressed using external notation systems and are used to describe or explain the behaviour of other systems. Based on the implications of Mousoulides [35] research, experimental designs in the study can be tested with various age groups (ie, younger students in grades 4 or 5 and older students in grades 9 and 10), various levels of mathematical ability (such as formulating groups based on mathematical achievement), and using a different type of context (ie exploring the concept of opportunity). Furthermore, Lingejard [36] found that the prospects of excellent mathematics teachers can learn quite a lot about modelling, ie process and performance. They can learn how to construct, discuss and argue for validity and conclusion.

The results of Gurtner [37] study conclude that modelling activity is very important, within the context of the class, part of a long project, which includes choosing significant problems with students, definitions of multiple representations and frames, and critical reading of the data. The same result on study Ombude [38] mathematics learning among Nigerian high school students through mathematical modelling sees that mathematical modelling has valuable potential with respect to junior high school learning. The same thing according to [39] that students are motivated because of the connection between mathematics and the real world. The same study also shows the results of research Riyanto [40] modelling learning in Junior High School makes students enthusiastic to solve modelling problems. This is also supported by research results of Fauziah [41] show that PMRI learning in primary school education can provide benefits for prospective primary school teachers. Arifin [42] also developed two problem-solving problems that are ill-defined and real-world problems.

According to Blum [43] that some indications suggest that modelling can be taught and studied, some basic quality principles are met, but in the daily teaching of mathematics, quality criteria are often violated. The success variable of teaching is seen in "quality teaching". A global statement: Several studies have shown that mathematical modelling can be studied in certain environments, despite all the difficulties associated with modelling teaching and learning [44-47].

Furthermore, Borba [48] states that based on the question of whether mathematical modelling can be learned which we know from empirical research, it is highly relevant not only to current research on modelling, but they are essential to changing the curriculum of introducing modelling into schools. Based on the paper Blum emphasizes the competence that teachers should teach modelling. This is relevant with this research that students in SDIT Bina Insani Kayuagung very interesting modelling task but they cannot give recommendation and validate the task because modelling task is new for them.

The 2013 curriculum requires HOTS and 21st-century skill. This 21st-century skill can be achieved through modelling. According to Oke [49] that HOTS consists of two components namely critical thinking skills and creative. Furthermore, according to Ahmad [50] that when students apply two skills it means students apply HOTS. It is also supported by Rosnawati who states that critical thinking skills and creative thinking are two important components of HOTS. According to Kaiser [51] that the teaching of mathematics should be carried out by example of firstly, students understand the relevance of mathematics in everyday life, in our environment, and to science, secondly, students have
competencies that can solve real-world math problems including problems in everyday life, within our environment, and in science.

The traditional approach has simplified real practical problems and provides students with simplified worlds. The effect, the traditional "mathematical application" approach presents a problem of 'on a plate' ready to do mathematics without difficult to translate the original problem to a mathematical form. A solution can be based on true or false. If true, it does not require students to interpret the results. Furthermore, according to Burkhardt [52] that everyone has modelled with mathematics from an early age. Children estimate the amount of food in their dishes, comparing it to the portion of their siblings. They measure their growth by marking on the wall about their height. They count to make their beliefs "fair" the amount of candy distribution. According to Widjaya[53] that one of the key characteristics of a good contextual problem is its capacity to bridge variations in mathematical interpretation and solution strategies. According to Plucker [54], states that creativity is two key elements of creativity, specifically novelty (ie original, unique, new, fresh, different creations) and useful (ie specific, valuable, meaningful, relevant, appropriate, creations). In learning of this modelling, students are required to creativity.

Maaß [47] pointed out some characteristics that can be seen as typical for modelling tasks. According to Maaß, modelling tasks are firstly, open, secondly, complex, thirdly, realistic, fourthly, authentic, fifthly, problems. and lastly, solvable through the modelling process. HOTS tasks on mathematical modelling this study was satisfied these criteria. Internationally, researchers of mathematical education focusing on the role, use, and teaching and learning of mathematical modelling at every school levels has been implemented since the mid-1960s [55]. The three essential barriers for primary and secondary teachers teaching modelling are material, time and assessment [1]. This show that this research very important for school. Whereas mathematical modelling can and should be started early from prekindergarten and elementary school, when the child already has basic competence then modelling can be implemented [56-57]. It is also supported by [27] that mathematical modelling should be taught in all the level of mathematics education of school students. This means modelling learning in elementary schools should have been implemented. At the School level in Indonesia, mathematical modelling is not formally introduced [53]. In this research, the students say that this task is very difficult because they never learn modelling task. From the solution of the students also show that student can identify and specify the problem to be solved, can make an assumption and define an essential variable, can do the math: get a solution, cannot analyze and asses the model and solutions, etc from modelling process [27]. In this research also, HOTS on Mathematical Modelling Task in Primary School that was designed for mathematical learning in Primary School using “Jumat Sejahtera” context is valid and practical. This is based on validation and one-to-one results produced which were small revised. Using “Jumat Sejahtera” context make students interesting to learn mathematics. This caused by “Jumat Sejahtera” context that is real, there exists in their school and meaningful for them. HOTS Tasks on Mathematical Modelling Approach impact to positive attitude student’s toward mathematics. Using “Jumat Sejahtera” context for HOTS Tasks on mathematical modelling approach engagement student to use mathematics in solving a real-world problem, so that student get experience in modelling that is very important for her/his future. By modelling, mathematical learning can arise of the value, i.e. objectivism, openness and promotion. It caused by mathematical learning that using “Jumat Sejahtera” context and modelling process. We get HOTS tasks on mathematical modelling approach for mathematical learning of whole number operation material which was valid, practical and useful. According to the researchers that students cannot give recommendation and validate solution of modelling task because this is new to them. Furthermore, for in Indonesia. Students must have 21st Century Skills [13]. Thus, it is necessary to recognize mathematical modelling in the form of student worksheet that has valid and practical using interesting context, for example, “Jumat Sejahtera”.

![Image](https://via.placeholder.com/150)

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4. Conclusion
Mathematical Modelling Task that was designed for mathematical learning in Primary School using “Jumat Sejahtera” context is valid and practical. This is based on validation and one-to-one results produced which were small revised. Using “Jumat Sejahtera” context make students interesting to learn mathematics. This caused by “Jumat Sejahtera” context that is real and meaningful for them. Mathematical learning through modelling task impact to positive attitude student’s toward mathematics. Using “Jumat Sejahtera” context on mathematical learning engagement student to use mathematics in solving a real-world problem, so that student get experience in modelling that is very important for her/his future. By modelling, mathematical learning can arise of the value, i.e. objectivism, openness and promotion. It caused by mathematical learning that using “Jumat Sejahtera” context and modelling process. We get mathematical modelling task for mathematical learning of whole number operation material which was valid and practical.

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