# Designing an Interactive Learning Media Based on Mathematical Modelling Framework

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## ABSTRACT

This article studies designing an interactive learning media based on a mathematical modelling framework. This article only discusses the preliminary stage or the initial stage in developing interactive learning media using design research. The preliminary stage covers two steps; there are analysis and design steps. The analysis step focused on analyzing students' difficulty in solving real-world problems and analyzing the curriculum. The design step focused on the initial design of interactive learning media that use six principles for developing mathematical modelling problem by Catherine Paolucci.

*Keywords: Interactive Learning Media, Mathematics Modelling.*

## 1. INTRODUCTION

Mathematical literacy literacy is the knowledge to find out and apply mathematics in daily life [1,2]. Mathematical literacy defines as a person's ability to formulate, employ, and interpret mathematics in various contexts to describe, explain, and predict a phenomenon [3]. The process in mathematical literacy starts from identifying and formulating real-world problems, after obtaining the appropriate mathematical form, then using mathematical procedures to solve the problems after interpreting the results with the initial problem [3,4]. The process in math literacy is useful for students to understand how mathematics functions in the real world and how to use mathematics to solve real-world problems. Therefore, students have to be equipped with mathematical literacy skills.

PISA is one of the International surveys that assess students' mathematical literacy skills. PISA (Programme for International Student Assessment) assesses the students' mathematics achievement that focuses on students' ability to solve real-world problems [5]. The latest of PISA's survey in 2018 showed that only 28% of Indonesian students could solve problems in a simple context, and only 1% of students are able to solve problems in complex situations that require good thinking and skills [3]. These findings show that Indonesian students are still hard to solve real-world problems.

Mathematical modelling is one of the tools that can train students' ability to solve a real-world problem. It is converting or representing real-world problems into mathematical forms to find solutions [6,7]. Mathematical modelling is a process of using mathematics to describe, analyze, make assumptions, or provide knowledge concerning real-world phenomena [8]. Students can use mathematical modelling to transform a structured mindset in solving real-world problems with the stages that are able to guide students in understanding problems [9]. Thus, mathematical modelling is suitable to help students transform real-world problems into mathematical problems. This is in line with the results of Indrawati & Wardono, they say that mathematical modelling significantly influences students' ability to solve real-world problems [10].

Based on the current requirements in education development and learning processes in the 21st century that required utilizing technology, in this study, the mathematical modelling problems will be encased in interactive learning media. Learning media is able to be a tool that can help students understand the problems and make students more interested in learning. The application of learning media can provide effectiveness in learning processes, improve understanding, increase student interest, and accuracy in presenting data and information [11].

Based on previous research conducted by Priangga & Wardono, who developed learning media based problem solving, the use of media in the learning process can improve students' problem solving ability [12]. Besides, the research conducted by Afgani, Darmawijoyo, & Purwoko, that develops learning media could make students interested in learning and increase students' motivation and improve students' learning outcomes [13]. However, the research has not focused on helping students solve problems with mathematical modeling. Therefore, this article will discuss the stages of designing interactive learning media with mathematical modelling in accordance with the principles of developing mathematical modelling problems put forward by Catherine Paolucci.

## 2. METHOD

This article discusses the initial stages in designing interactive learning media developed with design research methods using a development study. The following stages of design research are as follows:
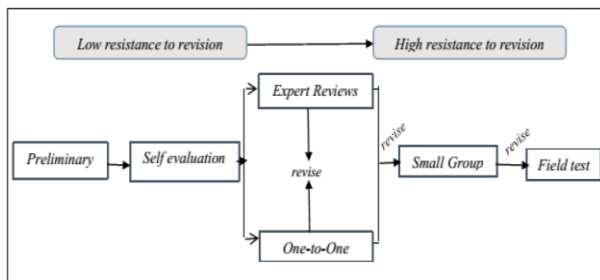


**Figure 1.** Design Stages [14,15]

Based on these steps, this article will discuss the Preliminary Design stage. This stage consists of the analysis and design activities. Analysis activities consist of junior high school students' ability to solve real-world problems analysis, curriculum analysis, and material analysis. Design activity is the activity in designing interactive learning media using mathematical modelling. In designing media, this article is applying the principles of designing mathematical modelling problems, according to Catherine Paolucci. There are the following principles and criteria of each principle in designing mathematical modelling problems, according to Catherine Paolucci [16] are as follows:

**Table 1.** Principles and Criteria in Designing Mathematical Modelling Problems

| No. | Principles | Criteria |
|---|---|---|
| 1. | *There is some genuine link(s) with the real world of the students* | It is related to the real world and aims to motivate students and describe mathematical relationships in students' life |
| 2. | *There is an opportunity to identify and specify mathematically tractable questions from a general problem* | (a). Require students to represent the context mathematically through images, graphs, tables, sentences, etc. That possibly help them to solve the problems |
| | *statement* | (b). There is a sub-question of the common problem given. |
| 3. | *Formulation of a solution process is feasible, involving the use of mathematics accessible to students, making necessary assumptions, and the assembly of necessary data.* | (a). Involves the use of mathematics accessible to students<br>(b). Appropriate assumptions to solve the problem<br>(c). Require students to collect the necessary data |
| 4. | *A solution of the mathematics for the basic problem is possible, together with interpretation* | Have one/more solutions and allow students to conclude problems |
| 5. | *An evaluation procedure enables checking for mathematical accuracy and the solution's appropriateness to the contextual setting.* | (a). There is a procedure for examining the obtained solutions<br>(b). Solutions to problems have relationships with real-world students. |
| 6. | *The problem may be structured into sequential questions that retain the integrity of the real situation (These may be given as scaffolding hints at the direction of the teacher or be used to provide organized assistance by suggesting a line of investigation)* | Problems are organized into sequential questions |

To fulfill every criterion of the principle, interactive learning media is developed by following the mathematical modelling process put forward by Blum & Niss. The following processes of mathematical modelling are as follows:
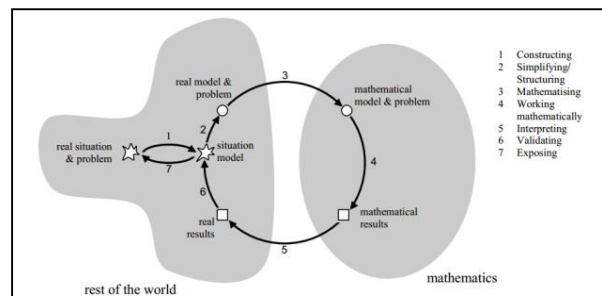


**Figure 2.** Mathematical Modelling Process [17]

Based on this process, the indicators of each process of mathematical modeling are as follows :

**Table 2.** Mathematical Modelling Process and Indicators

| Step | Indicators |
|---|---|
| *Constructing* (Understanding the problem) | Identify the given issue |
| *Simplifying/Structuring* (Simplification/building structure) | (a). Make assumptions of a problem<br>(b). Determine the necessary variables in resolving the problem |
| *Mathematising* | Designing mathematical models |

| | from problems |
| --- | --- |
| *Working Mathematically* | Solving problems from established mathematical models |
| *Interpreting* | Generalize mathematics results that obtained into a real-world context |
| *Validating* | Re-examining the results obtained |
| *Exposing* | Describes the final finding of the settlement obtained |

## 3. DISCUSSION AND RESULTS

This article discusses the preliminary stage of design, which is in this stage consists of the design and the analysis of interactive media. The description of these stages is as follows:

### 3.1. Analysis

In this stage, students' ability to solve real-world problems and curriculum were analyzed. Pisa results in 2018 show that Indonesia's average score is still far from the international average. Only 28% of Indonesian students are able to solve problems in a simple context while the average percentage of OECD scores is 78%, and only 1% of students are able to solve problems in complex situations that require good thinking and skills, while the average OECD score percentage is 11% [3]. Based on PISA results, it can be concluded that Indonesian students' ability to solve real-world problems is still relatively low.

In analyzing the curriculum (the material), we chose linear equations as the content of designed interactive learning media. The basic competencies in this material are as follows; describes the linear equations and inequalities of one variable and its resolution; solve the issues related to equations and inequality linear of one variable [18]. Based on these basic competencies, this material has integration with the real world. Therefore, the content of the linear equation needs to connect to real-world problems. In curriculum analysis, the curriculum used is the curriculum 2013, which is in this curriculum the ability that students must have been the ability to remember, understand, apply, analyze, evaluate, and create according to Permendikbud No. 104 in 2014. These skills are needed for students to solve real-world problems [19].

Based on the explanation above, it is necessary to train students' skills in solving problems. Mathematical Modelling framework was used to design interactive learning media. However, to make students interested and motivated in learning and help students understand the problems' situation, then modeling problems are presented in the form of interactive media. The advantage of using interactive media is that it can make the learning process more interesting and interactive so that students are motivated and willingness to learn [20].

This is in line with the results of research conducted by Afgani, Darmawijoyo, & Purwoko, which is learning media can make students interested in learning and increase students' motivation in learning and improve student-learning outcomes [13].

### 3.2. Design

The design step is applying the principles of designing mathematical modeling problems, according to Paolucci & Wessels [16] , and it will be related to the mathematical modelling process, according to Blum [17]. The designing process will be explained as follows:

### 3.2.1. The First Principle

The design process starts from the first principle, there is a connection with the real world of students. The criterion principle is the contexts related to the real world and aims to motivate students and illustrate mathematics's relevance in students' lives. To fulfill the first principle, we chose calorie burning as a context of the mathematical modelling problem. The problems that have developed are as follows:

> Burning calories or calories out per day depends on the Basal Metabolic Rate (BMR) and calories burned while exercising. If daily average calories need are 2500 for men and 2000 for women. Just decide how long you have to exercise to burn the calories you consume per day?

**Figure 3.** Mathematical Modelling Problem

Through this problem, students will learn about the form of real-world applications from a linear equation. To meet the criteria from the context in motivating students and describing the relevance of mathematics in life, the media developed in interactive media using illustrations of the problems. Here is the appearance of the mathematical problems in the developed media:
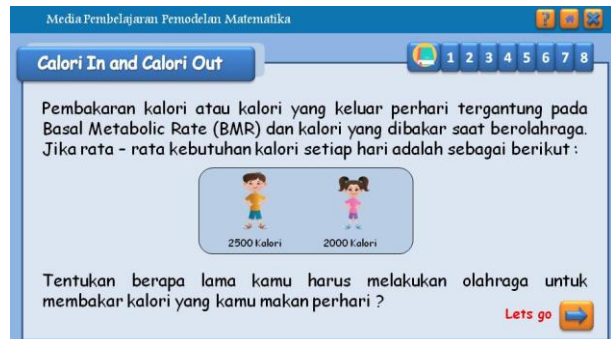


**Figure 4.** Display of Mathematical Modelling Problem

### 3.2.2. The Second Principle

The second principle provides an opportunity to identify and determine the mathematical questions of common problems. There are two criteria in this principle, namely 1). Require students to represent the context mathematically through images, graphics, etc. that can help them solve problems; 2). There is a sub-question of the common problem given. In interactive media, there are questions to identify what information is known and what is asked on the problem to meet these criteria. When associated with mathematical modelling processes, this principle contains the first mathematical modelling processes, which is constructing. Here is the appearance of the developed media:
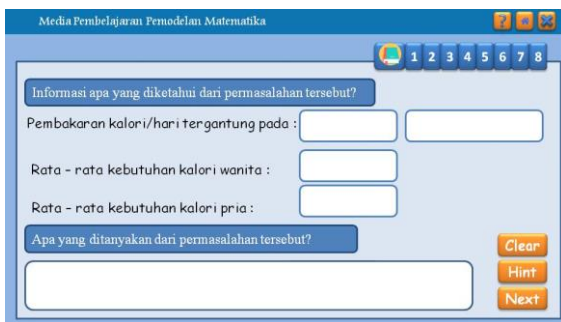
**Figure 5.** Display of Constructing Step

### 3.2.3. The Third Principle

The third principle is formulating solutions by using mathematics that can be accessed by students, making the necessary assumptions, and collecting the necessary data. In this principle, there are three criteria; Involves the use of mathematics that is accessible to students, appropriate assumptions to solve the problem, and last require students to collect the necessary data. This principle is related to the second and third steps of mathematical modelling, namely structuring and mathematizing. In the structuring step, the students should make assumptions about the provided information. In this step, fill the second criterion of the third principle design, which is the appropriate assumption to solve the problem. Here is the appearance of the developed design media:

**Figure 6.** Display of Structuring Step

In the mathematizing step, students make mathematical modeling of the given problem, and this step is also connected to the criteria for mathematical use and data collection. Which is in making the mathematical model involves the use of mathematics and data information from the problem. Here is the appearance of the developed design media:

**Figure 7.** Display of Mathematising Step

### 3.2.4. The Fourth Principle

The fourth principle is a sensible mathematical solution, along with interpretation. This principle's criterion is to have one/more solutions and allow students to conclude the problems. The designed interactive learning media accommodates open-ended solutions to fulfill the fourth principle. If it is related to mathematical modelling processes, this principle is connected to working mathematically and interpreting steps. Working mathematically or using mathematics is a step to determine the resolution of the problem using mathematical calculations. Here is the appearance of the developed design media:
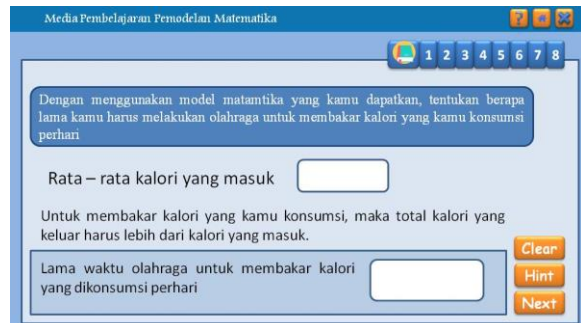
**Figure 8.** Display of Working Mathematically Step

In the interpreting or reporting steps, students report the results they get by concluding the problems resolved. Here is the appearance of the developed design media :
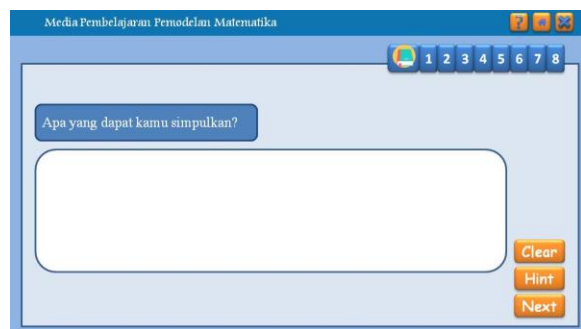
**Figure 9.** Display of Interpreting Step

### 3.2.5. The Fifth Principle

The fifth principle is an evaluation procedure enables examination of the mathematical accuracy and suitability of solutions concerning contextual. In this principle, there are two criteria, namely 1). the procedure to investigate the solution obtained; 2). The solution to the problem relates to the real world of students. The criteria in this principle relate to validating steps in mathematical modelling. To meet these criteria, the developed media should have a step to validate the results obtained. Here is the appearance from the fifth principle:
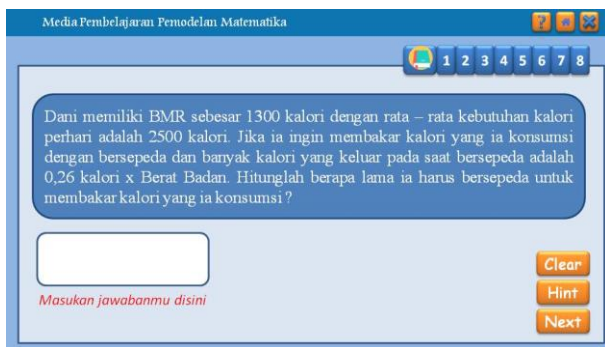


**Figure 10.** Display of Validating Step

### 3.2.6. Didactical Design Principle

The last principle is the didactical design principle, in this principle the problems are organized into sequential questions that maintain the real situation's integrity. The criteria in this principle are problems organized into sequential questions. To fulfill this principle, the developed media follows mathematical modelling steps where students are required to follow every stage in solving problems and make students easy in solving problems.

## 4. CONCLUSION

Based on the principles of developing a mathematical modelling problem, it could be concluded that the designed media fulfills the five principles proposed by Paolucci & Wessels, there is related to the real world, an opportunity to identify and specify mathematically tractable questions from a general problem statement, formulation of solution process is feasible, involving the use of mathematics accessible to students, a solution and interpretation of mathematics for the basic problem is possible, an evaluation procedure enables checking for mathematical accuracy and solution's appropriateness to the contextual setting. Moreover, such designed media is ready to develop into a prototype.

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