

# Student Worksheet on Mathematical Learning Based on Modeling to Develop Higher Order Thinking Skills of Senior High School Students

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**Abstract**—This study aims to produce valid, practical, and effective student worksheets on mathematical learning based on modeling to develop higher-order thinking skills (HOTS) of class XI high school students in semester 2. This development research uses a design research type of development study. The trial was carried out in three stages, namely: expert trials and one to one, small group, and field tests. The subject of this research is the worksheet of students. The instruments used consisted of expert review validation sheets, student assessments, and learning outcomes test instruments. The results showed that the developed Student worksheet had fulfilled the aspects of validity, practicality, and effectiveness. (1) The results of validity indicate that the Student worksheet developed in the valid category with the average index of experts and comments from students one to one. (2) The results of the small group show the Student worksheet developed in the practical category. (3) The results of the field test show that the Student worksheet is effective from the HOTS students

**Keywords:** *student worksheet, modeling, HOTS*

## I. INTRODUCTION

The standard expected for high school students is in accordance with the Education Standards Agency (BSPN) in terms of understanding and using concepts in solving problems, using reasoning, solving and understanding problems, completing and interpreting solutions, presenting mathematical ideas with symbols, tables, diagrams or other media, and having an attitude of appreciating the usefulness of mathematics in life. This is in line with the 2013 curriculum regarding understanding the knowledge related to real-world phenomena. Matters relating to mathematics learning are problem-solving (problem-solving), working on the Higher Order Thinking Skills (HOTS) type, and also discussing mathematical problems based on modeling.

The main domain of mathematics learning objectives according to curriculum demands, is to develop the potential of students in higher-order thinking skills (HOTS). The ability of HOTS students consists of thinking critically, creatively, and solving problems [1]. HOTS is a very important ability to be developed in mathematics learning because it deals with solving problems related to the real world or non-routine; students really need HOTS skills. [1] explained that the

learning objectives that develop HOTS are to equip students with skills in giving reasons and making decisions. In line with the results of [2] also explained that when students use HOTS abilities, students can decide what to do by creating new ideas, making estimates, and resolving non-routine problems.

Reported also from [3] explained that the tendency of students in Indonesia to work on memorizing questions and low ability to reason a problem and apply it. This was evidenced by the participation of the Indonesian State in international studies such as TIMMS and PISA. The TIMMS survey conducted by the International Association for Educational Evaluation and Achievement (IAE) states that the cognitive domain includes knowledge, implementation, and reasoning. [4] also mentioned that the 2015 TIMMS results that Indonesian students are still weak in high-level thinking skills. Most students have not been able to combine several facts and concepts to be able to apply and communicate the results of reasoning. In line with this, the PISA study is also conducted every three years by the Organization for Economic and Development Cooperation (OECD), which aims to investigate students' mathematical abilities. [5] also mentions that Indonesia's ranking is still in the lower levels in the field of mathematics.

The focus of the study is mathematical reasoning and the ability of students to implement it into everyday life, which is still minimal. It is also shown in the form of student weaknesses to link mathematical concepts with real-world problems formally. Therefore, an approach is needed to help students solve problems related to the real world. One approach that can be used in mathematics learning is modeling. [6] also explained that modeling is one way to achieve the competency goals of primary and secondary school graduates by developing mathematical skills and mathematical modeling at school.

[7] says the importance of students' abilities in learning is closely related to solving real-world problems through modeling mathematics-based learning. Learning using modeling is a process of solving real problems using mathematical concepts and rules by turning real-world problems into mathematical problems. The mathematics-based modeling process uses mathematical concepts contained in the curriculum as an approach to learning.

Learning mathematics based on modeling is one of the processes of the mathematics learning approach that is currently used by almost all developed countries in the world. [8] says that mathematical modeling is an important topic that has often been discussed and promoted by the world over the past few decades. Mathematical modeling, according to [9] is a process that uses mathematics to represent, analyze, make predictions, or provide insight into real-world phenomena (problems). According to [10], mathematical modeling is the process of changing problems in the real world into mathematical forms to find solutions or solutions to a problem. From some opinions above, it can be concluded that mathematical modeling is a process of solving problems in everyday life by representing or changing the real context problem into a mathematical model to find solutions to these problems.

According to [8], important mathematical modeling is taught for students in schools to support mathematics learning and develop students' mathematical competencies in the world. [11] said that mathematical modeling is a very important topic for international competition studies such as the Trends of International Mathematics and Science Study (TIMMS) and the Program for International Student Assessment (PISA) conducted on a global scale and measuring students' success in the field of mathematics. Therefore, modeling mathematics-based learning is very necessary in schools so students can develop mathematical competencies and be able to compete in world study activities such as TIMMS and PISA. Mathematical modeling is needed at school, so students are accustomed to dealing with real-life problems at the PISA level and able to compete at the international level.

The process of mathematical modeling systematically involves the cognitive actions of students in the learning process to find solutions to real problems[12]. According to [13] also explains that mathematical modeling is an important topic in mathematics because it is relevant and suitable for provoking student participation in social life. In more detail explained by [14] that the mathematical modeling process is a cycle that starts with a real problem (usually based on reality) that requires a model to describe, explain, or predict the solution of a process. From these opinions, it can be concluded that mathematical modeling has relevance to the real world. Many problems in real life that make mathematics as a tool in finding solutions and solutions to real problems.

The following is a chart of steps in solving real problems through mathematical modeling.



Fig. 1. Process of mathematical modeling [14]

From the chart, it is clear that several processes must be carried out in modeling, including; identify problems and variables, form models of variables, carry out operations using modes, interpret results, validate mathematical models, and interpret conclusions [14].

One instrument that can be used in modeling mathematics-based learning is Student worksheet. Learning by using a Student worksheet makes students focus on understanding lesson material [15]. The use of a good context can also facilitate students' abilities in mathematical modeling learning.

According to[16], Student worksheet learning mathematical modeling is one of the learning resources that can be developed by the teacher as a facilitator in the learning process in the classroom and can be arranged and designed according to the daily life situation being faced. The advantage of using Student worksheet is to make it easier for students to carry out independent learning and learn to understand the problems given. In modeling mathematics-based learning, valid Student worksheets can improve students' understanding in identifying problems, making assumptions and variables, and finding solutions to problems, [17].

Based on these descriptions, the results of previous studies show the importance of developing HOTs aspects in mathematics learning. The data shows that the approach to mathematics-based modeling needs to be improved. Also, mathematics learning is still very rare in the Student worksheet that is specifically designed to use learning models to develop HOTs students. This shows the importance of developing Student worksheets by using mathematics-based modeling learning to develop HOTs abilities of high school students. Therefore, this study was conducted to develop the HOTs ability of high school students using Student worksheets in modeling mathematics-based learning.

**II. METHOD**

This study is a design research type of development study using [18-19]. The product of this development research is Student worksheet modeling based mathematics learning to develop HOTS abilities of XI IPA high school students. The learning model used in this study is Model Ecliting Activities (MEA's) developed by [20]. MEA is a learning model that is relevant to mathematical modeling. Components contained in MEA's are aligned with the stages of mathematical modeling.

The focus of this research is Student worksheet, which is designed to use a financial context. Financial problems are very much discussed in the world of education. Therefore, researchers use the financial context in compound interest

material. By using the concept of compound interest in the material in high school combined with the problems that occur in the real world, namely the problem of inflation and investment. By using the concept of inflation and investment, the researcher created a question item which was later designed into a student worksheet used in mathematics learning — student worksheet, which is designed using the modeling phase in its completion. Student worksheet 1 is about the problem of vacation to Europe carried out by someone. Student worksheet 2 contains the problem of purchasing a Daihatsu Ayla car with investment savings plus top-up every month.

The modeling-based Student worksheet's developed contain descriptors as follows:

**TABLE I. INDICATORS AND DESCRIPTORS STUDENT WORKSHEET IS BASED ON MODELING**

Indicator	Descriptor	
	Student Worksheet 1	Student Worksheet 2
Identify and understand problems	Students can write information that is known about the value of savings, travel costs to Europe, the inflation rate of 5 years, JCI index of 5 years	Students can write information that is known about the value of savings, the price of Daihatsu Ayla cars, top-up costs every year, the inflation rate and the JCI index in the last five years
Make assumptions	Students can determine the information to limit problems such as the inflation rate of the last five years that has the same value in the future. Compound interest from the last five years index data is considered the same as the future.	Students can determine the information to limit problems such as the inflation rate of the last 5 years that has the same value in the future. Compound interest from the last 5 years index data is considered the same as the future.
Defines a variable	Students can declare information whose values change and are expressed by mathematical symbols such as average inflation, initial savings, compound interest, the initial price of tourism costs to Europe.	Students can declare information whose values change and are expressed by mathematical symbols such as average inflation, initial savings, compound interest, the initial price of the Daihatsu Ayla car
Do mathematical calculations	Students can determine the relationship between variables from initial savings to savings after an investment movement (CSPI) and also the initial cost of tourism to Europe with tourism costs after being affected by inflation.	Students can determine the relationship between variables from initial savings to savings after an investment movement (CSPI) and also the initial cost of tourism to Europe with tourism costs after being affected by inflation.
Analysis and judging	Students determine the average inflation, compound interest from data, Students examine the parts of the problem solution	Students determine the average inflation, compound interest from data, Students examine the parts of the problem solution
iterate (repeat/check again)	Students check the steps in solving the problem of travel to Europe again	Students check back the steps in solving the problem of buying a Daihatsu Ayla car
Interpret results	Students determine what year a person can travel to Europe	Students determine what year a person can buy a car, Daihatsu Ayla

The study was conducted at 11th grade Palembang SMA Negeri 11, majoring in science with compound interest subject matter. The object of the study was 39 students as a field test class taken by researchers.

The development procedure in this study refers to [18-19], which consists of the preliminary and formative evaluation stages. At the preliminary stage consists of analysis, design, and development. While in the formative evaluation stage consists of self-evaluation, prototyping (expert review, one to one, small group, and field test).

At the stage of analysis carried out by researchers in the form of analysis of curriculum, students, materials, and supporting books used by students. At the design, the stage includes the design of items before being changed to students' worksheets. Item 1 is about

the relationship between inflation and investment associated with the issue of vacation to Europe. After the items are completed, they are modified into sheets of student

worksheets that are feasible to use the modeling stage. Item 2 contains the relationship between inflation and investment plus top-ups every month on the issue of purchasing a Daihatsu Ayla car. The items were then modified to become student worksheet sheets using the modeling stages.

Data collection techniques in this study using a walkthrough, observation, and oral interviews. The walkthrough contains expert notes containing comments and suggestions made by researchers directly to experts. Observations were also carried out by researchers directly to students. And they are also interviewing each stage of formative evaluation, starting from one to one, small group and field tests.

III. RESULTS AND DISCUSSION

A. Research result

The stages that are carried out before the pilot researchers into the field are the stage of self-evaluation. The researcher conducts his own assessment by understanding and studying the questions using the stages of mathematical modeling, conducting Focus Group Discussions (FGD) in mathematical modeling classes with supervisors and colleagues from the undergraduate, master, doctoral, and alumnus levels. The group consists of about 20 people. This forum was conducted to obtain suggestions and comments so that the draft questions that were designed by the researcher obtained improvements if there was a lack of workmanship. The following are the results of the self-evaluation stage:

TABLE II. RESULTS FROM THE STAGES OF SELF-EVALUATION

Suggestions and comments	Revision division
There are a few changes to the LKPD's design including 1. Based on the layout of the image, 2. Erase words or sentences that are less clear (make people ambiguous). On this worksheet, changes to the design appear 1. Points in the word "recapitulation are converted into recapitulations," arrows that have no function deleted. 2. The picture of a thinking person is replaced by a question in the sentence before the image so that the image has meaning. The picture on the brochure has too little writing, so it is unreadable, it's good to draw all the brochures and writings in addition to the cost of the wizard to Europe.	The layout of the image has been fixed Ambiguous images have been deleted  Already changed  Already deleted The picture was not changed, because the researchers had the opinion that the brochure used was only intended to see the cost of "travel to Europe" only. And this is in accordance with the costs asked for the problems given.

The product produced in the form of Student Worksheet based on modeling mathematics learning as a prototype 1. Then the prototype was developed first and carried out trials aimed at looking at product quality in terms of aspects of content, constructs, and language. The prototype 1 Student

Worksheet validation was conducted by five experts, two colleagues, and one to one students as many as two people who sat in class X IPA and XI IPA from different high schools. Validation carried out using an instrument in the form of a validation sheet in terms of content, constructs, and language. In this case, the researcher made email correspondence to the experts, but only got one reply from all of them — one expert via e-mail, Stevanus Budi Waluya. And the rest of the other expert reviews are done face-to-face by making an appointment and meeting him directly. These experts consist of 4 people, including Nila Kesumawati, Destiniar, Yulia Resti, and Bambang Suprihatin. From these experts, the researchers approached and obtained comments and suggestions to revise the prototype 1 Student Worksheet produced. The results of the expert reviews were analyzed and recapitulated so as to obtain an average of 78.67% in the valid category. This means that the prototype 1 Student Worksheet is feasible to use to the next stage.

In addition to validating with experts, researchers also asked for comments and suggestions from colleagues. These colleagues include compulsory mathematics study teachers, Ms. Ellyza, as the teacher whose class was taken for research samples and Indonesian language teachers, Ms. Asmina, who taught at the 11th High School. Comments from colleagues also expressed well. Thus researchers also validate prototype 1 to one to one student totaling 2 people. The first student was Bima (BM), the 17th high school student of Palembang was a class X student majoring in science. The second student is Silfani (SF), a class XI student from the 11th High School in Palembang. The results of comments and student suggestions one to one is one of the inputs of researchers to see the readability and interest of students with prototype 1 products that are designed.

In addition to conducting trials to experts and students one to one, researchers took interview data and analyzed the results of student work one to one.

From the results of the analysis in the stage of expert review and one to one, the following excerpt from one of the revised prototype sheets to prototype 2:

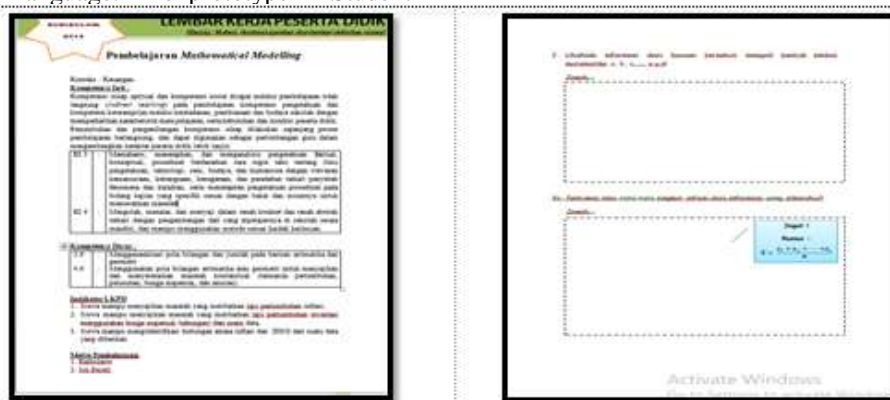


Fig. 2. Change in sheet Student Worksheet to prototype 2

To see the practicality of students from the results of a prototype that has been repaired, namely prototype 2. In the

process of testing the prototype 2, the researchers tested the small group students as many as six students. By using Model

Learning Activities (MEAs) learning, Student Worksheet trials were also conducted. From the results of the Student Worksheet trial in the small group student group, it was stated that the prototype 2 Student Worksheet was suitable for use by students. This is indicated by their learning process during the trial activities. The Student Worksheet, which was tested, was

two pieces, which have been improved through one to one process and expert review.

The results of the small group stages obtained from the stages of the small group were obtained from interviews and observations of researchers as follows:

TABLE III. SMALL-GROUP RESULTS

Students comment	Revised Decisions
<b>LKPD 1</b>	
1. Students still do not understand the command about the formulation section	The formulation question is revised
2. The section question command interprets the results not understood by students	The question of interpreting the results is revised
3. The problem part is doing too much math	Problems in doing math are deducted
<b>LKPD 2</b>	
1. Students still do not understand the command from the formulation section	The formulation question is revised
2. Students do not understand the command questions at the stage of interpreting the results	The question of interpreting the results is revised

The results of the prototype 2 were revised from the small group trial, so it became a prototype 3. This large group trial used the XI IPA 3 class, which numbered 39 children. By using the learning process of the external activities model (MEA's), the students are divided into nine groups of 4-5 people. The study group was given 2 Student Worksheet as a test field material. Similarly, in the small group trial, the researchers collected data using data collection techniques in the form of analysis of the results of student answers, interviews, field notes of researchers and observers (fellow researchers). Researchers use Student Worksheet's using financial contexts. The financial context of the revised Student Worksheet 1 contains holidays to Europe using the concept of someone to be able to travel with the investment savings that he has, but tourism prices continue to rise because of the impact of inflation each year. The problem was raised by researchers aimed at exploring students' understanding of the relationship between inflation and investment in line with that context. To provoke students to develop high-level thinking skills (HOTS), the researcher has designed modeling Student Worksheet. Student Worksheet uses the concept of compound interest in solving these problems. By using a learning model that is relevant to modeling, researchers use MEA's in the learning process. The MEA's learning model itself consists of 4 stages: newspaper article, warm-up question, mathematic information, and problem statement.

In the next meeting also, researchers used Student Worksheet 2 using a higher-level concept than Student Worksheet 1. The concept provided still touched on financial issues in terms of investment and inflation. But the investment presented is added with additional costs each month, or better known as the addition of top-ups for a certain period. The problems presented are in the form of purchasing a Daihatsu Ayla car with an investment plus top up per year and also the price of cars affected by inflation every year.

Using this context, researchers invite students to develop their HOTS abilities. Each stage of mathematical modeling

using the MEA stages is carried out by researchers in retrieving data on this field test stage.

### B. Discussion

Before conducting the research, the researcher observed the public high school 11 and met with Mr. Sukri, S.Pd as the curriculum representative at the school to obtain data on the teaching schedule and the number of classes that could be used.

Furthermore, this study aims to produce a modeling-based learning Student Worksheet that can be used by high school students of class XI IPA using a financial context. The material used by researchers is compound interest, the concept is found in geometry series material in the material syllabus of class XI IPA. The researcher held a discussion and asked the teacher of the subject of study, Ellyza, S.Pd, in the form of an interview. The results of the interview are:

Researcher: "Have the students of class XI Science learned the concept of geometry series at the point of compound interest in the previous material?"

Teacher: Students of class XI IPA have not studied the concept of compound interest before. So that systematically, students only recognize the concept in the next semester. "

With the information obtained, the researcher developed the concept of compound interest combined with problems related to everyday life. The problem raised by researchers is the level of inflation and investment (CSPI).

After the preliminary stage, the next step is formative evaluation. In this study, the formative evaluation phase included self-evaluation, prototyping (expert review, one-to-one, small group), and field tests [18-19]. In the stage of self-evaluation, researchers and supervisors and colleagues in the mathematical modeling class share the improvements that have been designed. In addition to the revised draft, researchers conducted an expert review and one to one trial to improve the

draft prototype 1 that had been designed. From the results of the trial stages, the results are obtained with good categories. However, prototype 1 must still be revised to see the readability and interest of students in the small group stage.

The practicality of the prototype 2 Student Worksheet that has been revised by the researcher is shown by a trial in the small group stage. At this stage, the researcher tried out on six heterogeneous students of XI IPA class high school students. Using MEA's learning that is relevant to modeling, the Student Worksheet provided is two pieces of Student Worksheet using a financial context with different problems. Students are required to be able to complete two pieces of Student Worksheet given using the stages of modeling based learning. In this small group, data collection was carried out in 3 meetings, which included work on Student Worksheet conducted by students, direct observation by researchers and colleagues (obtaining field notes), interviews about the results obtained during the learning process. From the results shown in this small group stage, students only experience difficulties in determining assumptions. So at this point, students are invited by researchers to explore relevant information in solving the problems given.

So that it can complete the Student Worksheet with the stages of mathematical modeling. However, the overall results obtained at this stage get a good category with the point students are interested in working on the Student Worksheet's has given using the financial context.

Prototype 2 is still revised according to comments and suggestions from the small group stage. In large classes such as field tests, many findings were obtained by researchers. Prototype 2 obtained is a valid and practical Student Worksheet in terms of content, contract, and language. Analysis of

observations found at meetings 1, 2, and 3 used 2 Student Worksheet. The Observer who observed group 1 said that at the first meeting, group 1 was able to identify and understand problems, make assumptions, and define variables. But there are still errors in the stages of doing mathematical calculations or finding the right formulation as a solution to the problem and interpreting the results. As for group 6, students are also able to identify and understand problems, make assumptions, and define variables. As for the stages of doing mathematical calculations or finding formulations, analyzing solutions, and interpreting results, there are still mistakes in writing down answers.

As for the second meeting, there were differences of opinion when discussing so that group 1 did not discuss properly and ran out of time. As a result group, 1 only writes answers to the stage of doing mathematical calculations. Whereas for group 6, the observer said that students were able to answer correctly every stage of mathematical modeling. So the researchers concluded that group 6 has the potential for mathematical modeling capabilities.

To see the potential effects of Student Worksheet on modeling mathematics-based learning, the results of student answers were analyzed based on indicators of mathematical modeling. The indicator has six steps in the process, including identification of problems, making assumptions, describing variables, doing mathematical calculations, analyzing and evaluating solutions, and interpreting results. The following are some excerpts of the results of student analysis according to the indicators.

1) (*Indicator 1: Identifying and understanding the problem*)

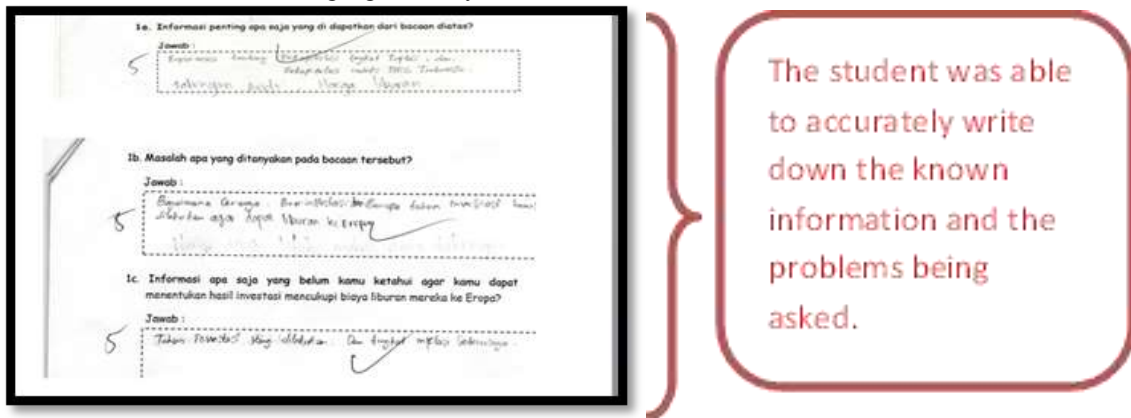
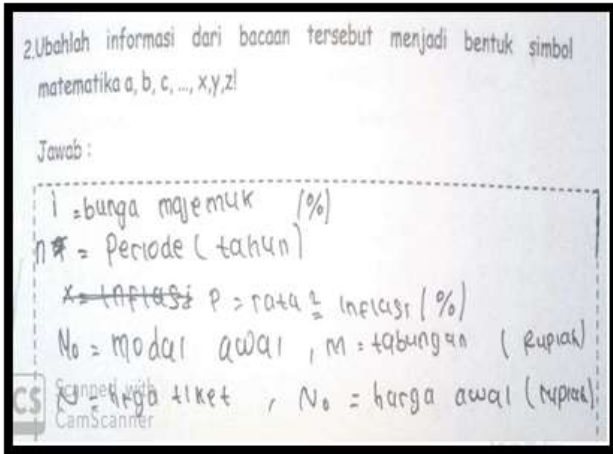


Fig. 3. results of the identification indicator answers understand the problem

Based on the analysis of students' answers to the indicators of identification and understanding of the problem, each group was able to follow the method of giving the correct answers to the questions at that stage. In the indicators, make assumptions some groups of students are still confused to determine the

allegations that can be taken in the red thread in solving the problems faced. The results of describing the variables are felt by researchers to students in the form of students able to write information in the form of mathematical symbols.

2) Indicator 3: defining the variable)



The student was able to state the information into the forms of mathematics symbols.

Fig. 4. results of the identification indicator answer description variable

Furthermore, the analysis of student answers to other indicators gets good grades. This means that there are groups that are able to write answers, even though they are not

systematic. But there are also those who have not answered every question given.

b. Dari hasil pada point (5a), lengkapilah tabel berikut ini

Jawab:

Tahun	n	p(%)	$(1+i)^n$	$(1+i)^n$	$N_0$	$N_n$	$M_0$	$M_n$	
2018	1	5,42%	1,0542	3,1043	1,0542	29500000	31098900	20000000	22886000
2019	2	5,42%	1,1113	1,2195	1,1113	29500000	32304460	20000000	24309560
2020	3	5,42%	1,1716	1,3463	1,1716	29500000	34561308	20000000	26933401
2021	4	5,42%	1,2351	1,4821	1,2351	29500000	36434694	20000000	29742555
2022	5	5,42%	1,3020	1,6272	1,3020	29500000	38409360	20000000	32044404
2023	6	5,42%	1,3726	1,7815	1,3726	29500000	40491141	20000000	36270406
2024	7	5,42%	1,4470	1,9470	1,4470	29500000	42685761	20000000	40053410
2025	8	5,42%	1,5254	2,1254	1,5254	29500000	44999336	20000000	47230993
2026	9	5,42%	1,6081	2,3172	1,6081	29500000	47438300	20000000	48044721
2027	10	5,42%	1,6952	2,5236	1,6952	29500000	50004351	20000000	53074200
2028	11	5,42%	1,7871	2,7461	1,7871	29500000	52709694	20000000	58452916

Students tried to conclude the solution to the problems but they still found incorrect solution.

Fig. 5. results of student interpretations

From the results of the students' answers in Figure 9, it can be seen that students have been able to determine the cost of tourism to Europe based on the completion of the previous mathematical model. In the second meeting on learning Student Worksheet 2, there were four groups that answered correctly, namely groups 2, 4, 6, and 7, while the other four groups did not solve the problem at the stage of interpreting the results.

Worksheet were familiar to students, questions, and information in the Student Worksheet using effective sentences, and the sequence of questions arranged systematically, making it easier for students to complete the Student Worksheet. Students also said that the content contained in the Student Worksheet was interesting because it was close to real-life, so students focused on working on the Student Worksheet.

Based on the results of the analysis of student answers, it can be seen that almost all groups are able to work on problems at each stage of mathematical modeling. This means that the Student Worksheet developed by researchers has a potential effect on mathematical modeling capabilities. From the answers above, it is proven that actually, students can work on HOTS problems.

IV. CONCLUSION

This study resulted in Student Worksheet learning mathematical modeling using the financial context of compound interest material for class XI students that is valid, practical, and has a potential effect on mathematical modeling abilities. Interesting contexts, effective sentences, familiar images, and systematic Student Worksheet arrangements make students happy to learn about mathematical modeling and can develop HOTS students' abilities as well.

From the results of the interview, it can also be concluded that the sentence contained in the Student Worksheet is said to be effective because students can understand the intent of each question well. In addition, based on interviews with students, it was concluded that the images contained in the Student

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