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Development of Student Activities in Algebra based on Problem Solving in Middle School

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ABSTRACT

This research was motivated because the Student Activity Sheets (LAS) circulating in the market or those used during classroom learning did not contain problem-solving-based LAS. The purpose of this study was to develop a Student Activity Sheet (LAS) on algebra-based problem solving in secondary schools and to determine the feasibility and practicality of the developed LAS as well as to see the potential effects of the developed LAS on students' problem solving abilities. The LAS design was validated by experts and tested by students. The validity instrument uses a validation sheet and the practicality instrument uses a student response questionnaire. The results showed that the problem-solving-based LAS produced had met the valid and practical product quality criteria. This LAS development research is in line with development research steps. This step includes two aspects, namely the development aspect of the LAS and the feasibility of the LAS being developed. The results of this study are that the problem-solving-based LAS produced is valid and practical and learning using the developed LAS has a potential effect on students' mathematical problem solving abilities.

Keywords: *Student Activities Sheet, Problem Solving, Problem Solving Ability, Algebra*

1. INTRODUCTION

Mathematics is one of the most important subjects in education. Learning mathematics itself consists of the dimensions of knowledge, concepts, principles and procedures that are taught to students in stages. This is because mathematics is a knowledge that is tied to knowledge or other subjects. Based on NCTM (2000) there are five standard content of mathematics, namely geometry, algebra, numbers and operations, as well as data and probability analysis. Algebra is a mathematical science, where its application is widely used in everyday life and plays a role in the process of solving problems [1]. By studying algebra can bridge students in solving problems using their own strategies [2]. If students are not able to solve algebraic problems, it is likely that students will have difficulty solving other mathematical problems [3].

Algebra material is one of the intermediate and advanced level subjects. The difficulties faced by these students include the introduction of various elements of algebraic forms, difficulties in understanding algebraic concepts, difficulties in calculating algebraic operations, and difficulties in associating them with everyday life. Learning difficulties are influenced by the teacher's teaching methods and students' perceptions of teaching materials. This is in accordance with Suwarto's research which explains that students who do not have the necessary materials slow down the learning process [4]. The prerequisite for understanding teaching materials applies to teachers, especially with regard to the order of teaching materials and the order of lessons in class. Difficulty in solving algebraic problems causes students to make mistakes in solving algebraic problems. Subanji stated that students' errors included the construction of algebraic addition operations for similar variables, addition of different algebraic forms, quadratic operations, and algebraic square root operations errors [5]. Therefore, to correct common mistakes, teachers need to identify the causes of errors. Errors made by students in answering questions can be used by teachers as a tool to determine student understanding in the learning process, so educators must be careful not to affect further math problems later.

Teachers can apply a learning approach in the classroom to solve a problem in algebra. One of them is through problem solving. Mathematics learning currently focuses on learning that can develop higher order thinking skills such as reflective thinking and

problem solving [6]. Abdurrahman revealed that by providing problem-solving-based activities, it is hoped that students will more easily understand and solve problems [7].

But in reality, student learning activities are still relatively low. This can be seen from research conducted by Agustin, et al where teachers still dominate in the teaching and learning process and the interactions that occur between teachers and students have not been maximized, causing a lack of student participation in learning activities [8]. Students are not given the opportunity to build their own knowledge and teachers tend to force their way of thinking the same as the way students think [9,10]. In addition, the LAS used today still has drawbacks. Most LAS only emphasize formulas and contain material summaries, sample questions, practice questions without showing explanations or how to find formulas and not paying attention to the criteria for validity, effectiveness [11,12]. In line with that, the LAS used usually does not contain the context of everyday life and the questions given are not related to real problems so that they do not encourage students to solve the problems given [13]. Based on observations made by Santari & Endang that the activity sheet used only contains a summary of the material and is immediately followed by practice there are no steps that guide students in solving problems [14]. From this explanation, it can be concluded that the current LAS does not meet the criteria that can make it easier for students to solve problems.

Therefore, it is necessary to develop a quality LAS for the needs of students. LAS should also contain questions that contain problem-solving strategies because with problem solving students can be actively involved in exploring, observing, and experimenting which later is expected to make it easier for students to understand concepts [15]. The problem solving step according to Polya consists of 4 steps, namely 1) Understanding the problem, 2) Making a plan, 3) Implementing the plan, 4) Looking back [16]. In learning mathematics, problem solving is the main thing to improve students' thinking skills which are useful in exploring the skills and knowledge that already exist in students' personalities as well as previously acquired skills that can be applied in solving non-routine problems during the learning process [17,18]. With problem solving will require students to improve critical thinking skills, apply procedures and deepen understanding of concepts [19]. Furthermore, it is necessary to change the learning process that makes students more actively involved [10].

2. RESEARCH METHOD

The research method used in this study is development research which aims to produce teaching materials in the form of Student Activity Sheets (LAS) in algebra based on valid and practical problem solving and have a potential effect on students' mathematical problem solving abilities for learning mathematics. This research was conducted in the odd semester of the school year 2020/2021. The LAS development procedure used in this study consisted of two stages, namely the preliminary study (preparation stage, analysis stage and design stage) and formative study (evaluation and revision stage) which consisted of self-evaluation, expert, reviews, one to one, small group and field tests [20]. The instrument used in this study was a student response questionnaire which was developed using a Likert scale with scores of 1, 2, 3 and 4.

After participants solved a problem with contradictory information in the form of a test for about 30 minutes, then they were classified into two categories, "YES" or "NO" answer. Then selected subjects who met three critical thinking indicators and for each of the two subjects with consistent answers (both from test results and during interviews).

3. RESULT AND DISCUSSION

3.1. Result

3.1.1. Preliminary Stage

The research preparation carried out is the activity of developing teaching materials in the form of student activity sheet. In addition, the researchers determined the school chosen as the research site to carry out one-to-one and small group trials and to carry out field tests. Next, the researcher met the head where the researcher would conduct the research which was then directed to the homeroom teacher of the research subject to discuss so as to obtain the information needed when carrying out research such as information about the research subject and the time of the research. Then the researchers began to take care of administration such as research permits. After discussing with the homeroom teacher, the researcher got 3 students as one-to-one test subjects and 6 students as small group test subjects. Next, the researcher contacted the students who were the test subjects to inquire about their availability.

At this stage of student analysis aims to obtain information about the number of students and the ability of each individual student. The student analysis phase aims to determine the problem-solving abilities of the students to be studied. At this stage, the researcher analyzes the students of the research subjects and then analyzes the abilities of the students seen from the profiles and grades of each student's report cards.

The researchers analyzed the class that was the subject of the study with the help of the mathematics teacher and homeroom teacher. From the results of interviews with teachers, researchers found that student

learning outcomes were low. This is because students are still difficult to master the material and represent a problem, thus causing low student learning outcomes. Then, the teacher recommends 9 students as research subjects who will be divided into 3 students in the One To One trial stage and 6 students in the Small Group trial stage. Research subjects are selected based on the availability of students and students have studied the prerequisite material from algebra.

Based on these interviews, researchers can conclude several characteristics of students who will become research subjects:

1) Students are still less active in learning activities
2) Student availability
3) Students have studied the prerequisite material from algebra

Next, the researcher analyzed the curriculum used in the school where the researcher conducted the research, where the curriculum was the 2013 curriculum. After analyzing the curriculum, the researcher analyzed the material developed in student activity sheet which focused on algebra, where this material was selected based on the results of discussions with supervisors and subject teachers. It is known that algebra is an important science of mathematics which is a prerequisite material for other materials. This material also has many benefits and implementations in everyday life.

The third stage is the Design stage. At the design stage, the initial product development is in the form of Problem Solving-based algebraic student activity sheet. The activities in algebra focus on the material of operations on algebraic forms, linear equations and inequalities of one variable, system linear equation two variables and quadratic equations. The design process begins with formulating indicators and learning objectives and determining appropriate activities. The draft of the contents of the student activity sheet to be developed is structured in Table 1.

Table 1. Model of critical thinking process

Stages	Description
Front Cover	1. Title : Student Activity Sheet 2. Material Name 3. Author Name 4. Curriculum: 2013 revision 5. Group Member Name 6. Day and Date 7. School Name 8. Time allocation.
Page 1 and 2	1. Basic Competence 2. Indicators of Achievement of Basic Competencies 3. Learning Objectives 4. Instructions for Use 5. Basic Concept.
Learning Activities	Problem Solving Activities.
Back Cover	A brief explanation of the Problem Solving-based Student Activity Sheet.

Figure 1 shows the initial design of the Student Activity Sheet on problem-solving-based algebra.

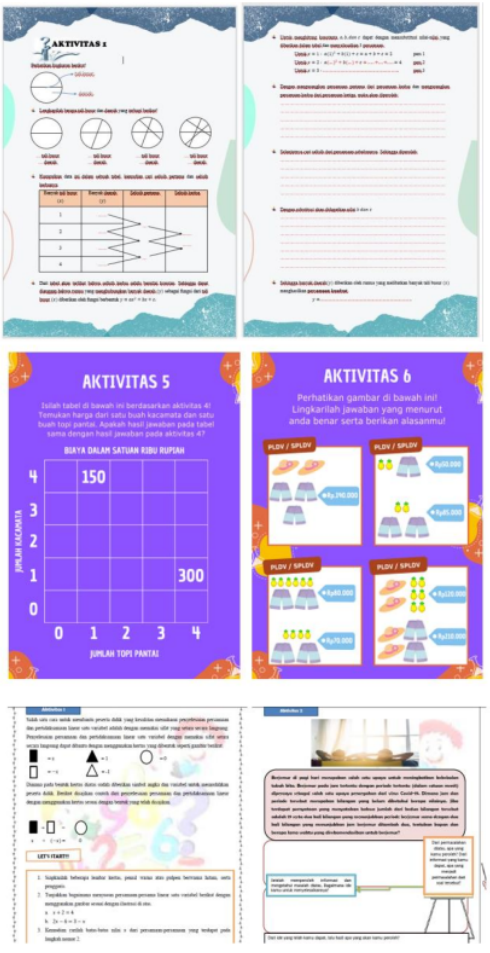


Figure 1. Student activity sheet

3.1.2. Formative Evaluation Stage

3.1.2.1. Self-Evaluation

At this stage, the researcher and the supervisor assessed the design and construct of the problem-solving-based student activity sheet developed. If there are errors both in terms of constructs, content and language, the researcher will make revisions. The results of the revision at this stage are called Prototype 1.

3.1.2.2. Expert Review

At this stage the researcher validates the student activity sheet to several expert lecturers called expert review. Validation is carried out on the student activity sheet that has been developed based on the validity in terms of content (content), construct, and language. Then the researcher validated the expert. At the validation stage with several validators consisting of expert lecturers and mathematics teachers. Validation is done by giving products in the form of student activity sheet and student activity sheet validation sheets to experts to get suggestions and comments to revise products in the form of student activity sheet that were developed to become even better student activity sheet. The student activity sheet validation process is carried out by asking questions and filling out the student activity sheet validation sheet. Furthermore, the validator provides suggestions and comments by writing them on the student activity sheet validation sheet which will be used as consideration for improving the student activity sheet.

Based on suggestions and comments from the validator, a revision was made to prototype 1 shown in Table 2 and Table 3.

Table 2. Comments and suggestions along with revision decisions

Comments/Suggestions	Revision Decisions
The content of the LAS should not be activities Problem Solving. So develop activities that invite students to be active in the form of activities instead of doing questions like worksheet in general	The contents of the LAS have been corrected according to suggestions.
Illustrations of existing problems should be more realistic and in accordance with the context of the problems presented	Illustration has been changed
Solution columns in the form of tables, graphs or others, please correct them to make them more appropriate	The solution column has been fixed.
Instructions for LAS work are more clarified	LAS work instructions have been clarified
Information from the problems presented is more clarified so as not to cause double interpretations	Problem information has been clarified

Based on the calculation of the validation sheet that has been filled in, the validity of the LAS that has been developed has criteria that are suitable for use with revisions according to suggestions with a percentage of 84,11%.

3.1.2.3 One-to-one

In addition to being given to an expert review, the prototype was also tested on 3 students to see the validity of the problem solving based LAS on algebra that had been developed.

This one-to-one trial was carried out by testing the LAS meeting 1 and LAS meeting 2 and asking students to do the LAS given. Students ask the researchers about the difficulties during LAS work and then collect the results of the LAS work. Then, the researcher interacted with the students to find out what difficulties were received by the students during the LAS work, so that they could provide input to improve the LAS. After interacting with students, the researcher gave a comment sheet to see the students' suggestions and comments on the LAS that had been given.

Based on the researcher's observations of the results of student answers on the LAS and the comment sheet that has been filled out, students can follow the steps in the activities contained in the LAS, it's just that there are some confusions that cause errors in some steps in the LAS activity. Students said that there were some difficulties in the given activity. This is because students do not understand the prerequisite material and the steps of the activity are less detailed, so the researchers improve the LAS to make it easier to understand. Table 4 shows overall results of observations regarding the difficulties experienced by students in doing LAS at the one to one stage along with revision decisions.

Table 3. Expert review revision result

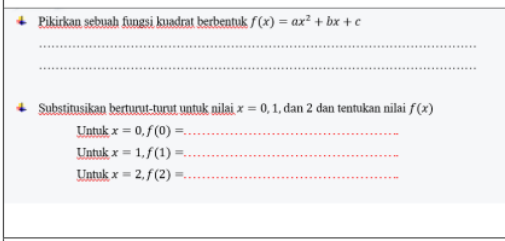
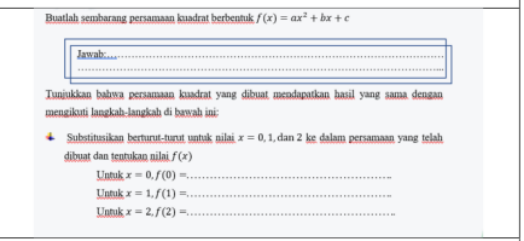
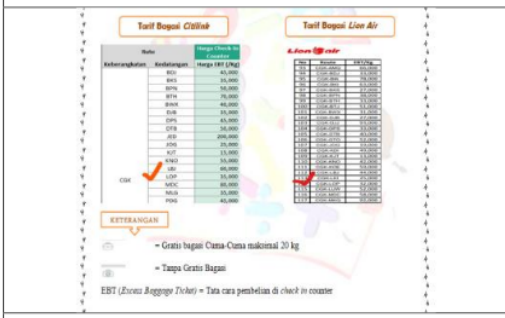
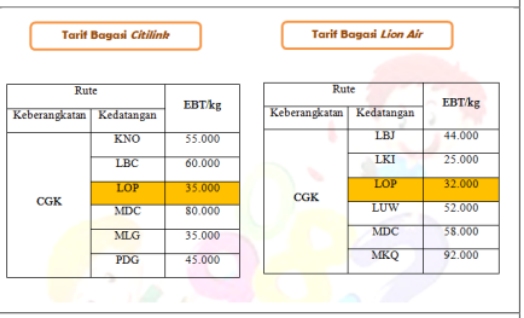
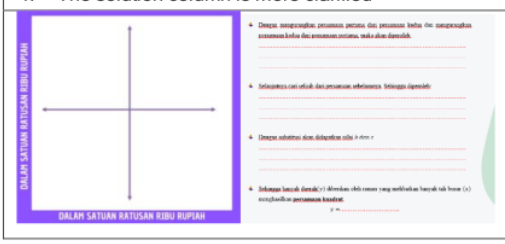
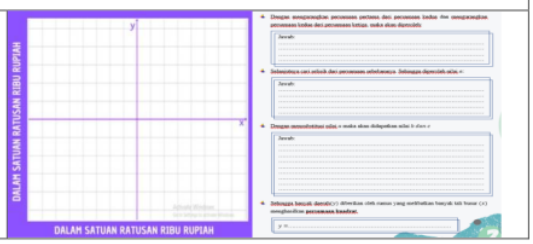
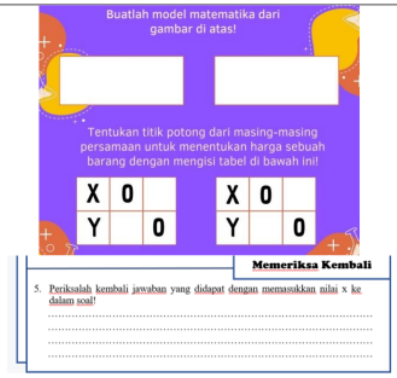
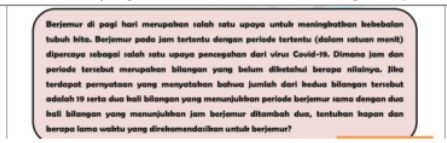
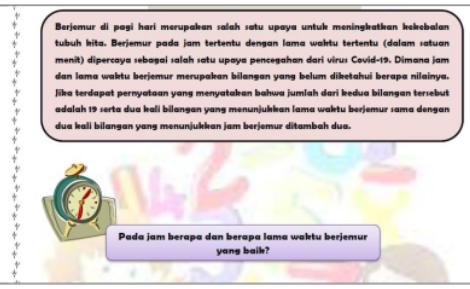
Before Revision	After Revision
1. Illustration has been changed	
	
2. Instructions for work are more clear	
	
3. Problem information clarified	
	
4. The solution column is more clarified	
	

Table 4. One To One observation result

No.	Comments/Suggestions	Revision Decisions
1.	Students have difficulty understanding the stages of completion.	Further clarify the stages of completion.
2.	Students have difficulty understanding the information on the given problem	Clarifying more information on the given pro

Based on students' comments and suggestions, the results of the answers and observations, the researchers revised the LAS that had been developed. Table 5 shows the results of the one to one stage revision.

Table 5. One-to-one revision result

Before Revision	After Revision
1. Further clarify the stages of completion	
	
2. Clarifying more information on the given problem	
	

3.1.2.4 Small Group

The result of the revision of the expert review and one-to-one is called Prototype 2 which is then tested on a small group which is divided into 2 groups. One group consists of 2-3 students who are not the subject of the study. This trial aims to see the practicality of the problem-solving-based algebra activity that has been developed.

In the small group trial, students were asked to do the LAS given by discussing with their group members. After the LAS was completed, the researcher invited the students to interact to discuss the difficulties and confusion in doing the LAS.

After interacting, students were asked to fill out a practicality questionnaire given by the researcher and write down comments and suggestions on the LAS as a consideration for making further revisions. The questionnaire given consisted of 10 questions which were divided into 7 positive statements and 3 negative statements and were filled out individually by students. The following are the results of the calculation of the data from the practicality questionnaire.

Based on the results of the questionnaire calculation above, the average percentage of validity is 91.38% which shows that LAS based on problem solving in algebra has very practical criteria.

Based on students' comments and suggestions, overall it can be seen that students have given a positive assessment of the developed LAS. It's just that there are several obstacles encountered, one of which is at the stage of re-examination. The command line used is still difficult to understand, so the researchers corrected the order to the problems contained in the LAS. After obtaining the results of the small group trial and revising the LAS based on the comments/suggestions of the

students, prototype 3 was obtained and it can be declared as a valid and practical product.

Table 6. The calculation of the practicality questionnaire

No.	Practicality Indicator	Percentage	Criteria
1.	LAS display is very attractive.	93.75%	Strongly Agree
2.	Learning mathematics in algebra using LAS makes me understand better	93,19%	Strongly Agree
3.	Problem solving based LAS interest me to use it in learning mathematics in algebra	89,28%	Strongly Agree
4.	Complete information in LAS can help me solve the problem	92,76%	Strongly Agree
5.	The language used in LAS is easy to understand	90,68%	Strongly Agree
6.	The activity instructions in the LAS are very clear, making it easier for me to carry out all activities	86,93%	Strongly Agree
7.	Questions in LAS are able to encourage me to be able to draw conclusions from each problem	87,35%	Strongly Agree
8.	The steps for solving problems in LAS in algebra I can't understand	77,91%	Agree
9.	LAS design is boring	83,33%	Strongly Agree
10.	I can't draw conclusions on every problem that exists in LAS in algebra	73,45%	Agree
Average Percentage		91,38%	Very Practical

3.1.3. Field Test

This stage is the last stage of formative evaluation on the development of LAS in algebra-based problem solving in secondary schools after going through the expert review stage, one to one, small group. Where this stage aims to determine the potential effect of the LAS that has been developed on students' problem solving abilities. The potential effect is seen from the given LAS work and interviews. At this stage of the field test, LAS prototype 3 was tested which was valid and practical to research subjects.

At the beginning of learning both at the first meeting and the second meeting, the researcher made an apperception of the prerequisite material for the algebra context. In addition, researchers also provide motivation in the form of benefits obtained after studying the material. After doing apperception and giving motivation, the researcher asked the students to form groups, each group consisting of 3-4 people. Then, the researcher distributed the first meeting LAS to each group. The researcher guided the students to fill in the group identity which was followed by paying attention to the learning objectives and instructions for use. Then, the researcher gave the opportunity to the whole group to do the LAS by discussing it with their respective group members. After the LAS work was completed, the researcher asked one of the group representatives to present the results of the discussion. After the group representatives finished presenting the results of their discussions, the researcher gave the opportunity to other groups to provide responses. At the end of the lesson, the researcher evaluates the results of student

discussions and equates students' perceptions by reinforcing the concepts that have been obtained.

During the learning process, researchers encountered obstacles including some students who were still less active in learning activities. In addition, students are also still not used to using LAS in learning. Students are also not used to solving problems based on problem solving. The solution of these obstacles, the researchers make suggestions in this study.

3.2. Discussion

3.2.1. Development of Valid and Practical Problem Solving-Based Student Activity Sheet

This study aims to produce LAS on algebra-based problem solving that is valid and practical and has a potential effect on students' problem solving abilities. This research refers to development research with 2 stages, namely the preliminary stage (preparation, analysis and design) and the formative evaluation stage (self evaluation, expert review, one-to-one, small group and field test) [20].

In the preliminary stage, researchers made preparations to develop teaching materials in the form of LAS. In addition, the researcher also determines the research location where the researcher will conduct a one-to-one, small group, and field test. After all the preparations have been made, the researcher carries out the next stage of the preliminary stage, namely the analysis stage. At the analysis stage, there are three things that are analyzed, namely student analysis, material analysis and curriculum analysis.

The next stage of the preliminary is the design stage. At the design stage, the researcher designs a product in the form of algebraic activities that are poured into a problem-solving-based LAS. The activities focus on the material of operations on algebraic forms, linear equations and inequalities of one variable, system linear equation two variables and quadratic equations.

After all the preliminary stages were carried out, the researcher proceeded to stage 2 of development research, namely the formative evaluation stage. This formative evaluation stage starts from the self-evaluation stage, where at this stage the researcher and the supervisor assess the design and construct of the problem-solving-based LAS developed. If there are errors both in terms of constructs, content and language, the researcher will make revisions. The results of the revision at this stage are called Prototype 1. After getting the product in the form of prototype 1, then it is validated by the expert at the expert review stage. In addition to being validated by experts, Prototype 1 was also tested one-to-one which was tested on 3 students from different classes with students as research subjects.

The trial at the one-to-one stage aims to find out what difficulties are experienced by students when working on the problems presented in the LAS. The comments and suggestions given from expert reviews and one to one regarding the shortcomings and difficulties when working on LAS are used as revision material to improve LAS prototype 1 in terms of content, construct, and language so that it can produce a valid LAS prototype 2.

After seeing the validity of the developed LAS, the practicality of the LAS will also be seen. The practicality of LAS is also seen at the expert review stage, that the developed LAS can already be applied to the learning process in the classroom. In addition, practicality can be seen from the results of small group trials. In the small group stage, LAS was tested on 2 small groups, each consisting of 3 students. Based on students' comments and suggestions, overall it can be seen that students have given a positive assessment of the developed LAS. It's just that there are several obstacles encountered, one of which is at the stage of re-examination. The command line used is still difficult to understand, so the researchers corrected the order to the problems contained in the LAS. After obtaining the results of the small group trial and revising the LAS based on the comments and suggestions of the students, prototype 3 was obtained and it could be declared as a valid and practical product.

3.2.2. Potential Effects of Problem Solving-Based Student Activity Sheet

After seeing the validity and practicality of the revised LAS, the LAS prototype 3 which has been developed by researchers is valid and practical. Then, the valid and practical LAS was tested at the field test stage to see the potential effects of problem-solving-based LAS. At the first meeting, students worked on problem-solving-based LAS in groups. At the second meeting, the same learning process was carried out as in the first meeting, where students worked on problem-solving-based LAS in groups. Based on the analysis of the results of student work carried out during two meetings that during the learning process students seemed very enthusiastic about working on problems in the LAS. This LAS can also make students better understand how to find solutions to problems because in the LAS contains problem solving steps that lead students to solve problems and find solutions to the problems given.

4. CONCLUSION

Based on the research that has been done that the developed LAS is valid and practical and has a potential effect on students' problem solving abilities. Validity is seen from the results of validation by 2 expert reviews,

namely in terms of content, construct, and language with an average arithmetic percentage of 84.11% and practical with an average arithmetic percentage of 91.38%. Practicality is also seen from the results of interviews with students regarding the completion steps of problem solving-based LAS. LAS-based problem solving also has a potential effect on students' problem solving abilities. Judging from the analysis of the results of student answers that students have been able to understand the completion steps listed on each of the questions in the LAS.

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