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Using ASSURE learning design to develop students' mathematical communication ability

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ABSTRACT: This article describes the improvement of students' mathematical communication ability using ASSURE (analyse, state, select, utilise, require and evaluate) learning design. This study used the experimental method with the pre-test post-test control group design. The population in this study was the students of class VII SMP Negeri in Garut Regency, which includes lower-, middle- and upper-level schools. Each sample was taken randomly, in three categories. Two classes used ASSURE learning design with a problem-based learning (A-PBL) and discovery learning (A-DL) model for each class, and the last class used conventional learning design with a problem-based learning and discovery learning (K-PBL/DL) model. The results showed that the improvement of students' mathematical communication ability by using the ASSURE learning design is better than students using conventional learning design. Furthermore, the use of A-PBL and A-DL are equally suited to improving students' mathematical communication ability in middle and upper-level school, while in lower level schools, it is more suitable to use A-DL.

INTRODUCTION

Mathematical communication is a central force for students in formulating mathematical concepts and strategies, success capital for students on approach and completion in scientific exploration and investigation, and a means for students in communicating with their friends to obtain information, share thoughts and inventions, brainstorm, appraise and sharpen ideas to convince others [1].

Stacey explains that communication skills are one of the factors that contribute to determine the success of students in solving problems [2]. Furthermore, Hulukati also reinforces this statement by stating that mathematical communication ability is a prerequisite for solving problems [3]. Therefore, mathematical communication ability becomes an essential skill and must be mastered well by students.

Numerous studies indicate that students' mathematical communication ability in Indonesia is still poor [4-7]. The research results of Rohaeti [4] and Purniati [5] concluded that the mathematical communication ability of junior high school students is still weak. Furthermore, Kadir documented that the average score of mathematical communication ability obtained by the students only reached 3.9, while the maximum score was ideally 10, and concluded that students' mathematical communication skills (MCS) were still weak [6].

In line with these results, preliminary studies conducted by Pujiastuti found that the mathematical communication ability of junior high school students is still poor, based on the average score of their mathematical communication skills obtained [7]. Therefore, mathematical communication becomes an important ability to be developed further by junior high school students in Indonesia.

In general, the learning design used in Indonesia is the learning model of instructional system development procedure (ISDP). Zuhairini et al explained that ISDP is a form of teaching based on a system, an organised unity consisting of several components interconnected with each other to achieve a goal [8]. The elements of ISDP include objectives, subject matter, teaching tool/media, methods, and evaluation/assessment [9]. These five components interact with each other to achieve the goals that have been formulated. Considering these elements, the researchers assume that there could be some flaws in them.

Firstly, these items do not pay attention to the characteristics of students. However, it is important to do so, because the characteristics of students vary between one another mainly in the learning style of students and the use of learning media. Next, whereas the concept of mathematics in general, is abstract, to teach the concepts of mathematics to students who still think in concrete learning, learning media should be considered and get attention. Therefore, learning mathematics requires a learning design that is not only focused on the purpose of teaching alone, but also pays attention to the characteristics of students in learning, and involves aspects of learning media in mathematics subjects. The learning design that is more oriented toward the characteristics of students and one that requires the use of instructional media is the ASSURE learning design.

LITERATURE REVIEW

The ASSURE learning design is an abbreviation of the necessary steps contained in the learning model. Smaldino et al explain that ASSURE consists of six steps [10]. The first, is analysing student characteristics (analyse learner characteristics). The second is formulating the standards and learning objectives to be achieved (state standards and objectives). The third is selecting methods, media and teaching materials (select methods, media and materials). The fourth is using media and materials (utilise media and materials). The fifth is involving student participation in learning (require learner participation). The last is evaluation and revision (evaluate and revise). All of these components focus on emphasizing teaching to students to interact with their environment and not passively receiving information [10].

Several learning models can support the learning design of ASSURE to improve mathematical communication ability; namely, problem-based learning (PBL) and the guided discovery model [11]. After selecting the learning model, ASSURE recommends choosing the type of instructional media to be used. Mathematics learning media are able to facilitate students in learning mathematics, and one of them improves students' mathematical communication skills [6].

Lesson material delivered through substantive learning media should contain adequate competency standards [12]. Therefore, students' mathematical communication skills can be improved using the ASSURE learning design with the appropriate method and learning media.

METHOD

The study involved three sample groups with a total of 303 students. The first group was an experimental class 1 consisting of 101 students with criteria for 34 students each at lower and middle-level schools, and 33 students at the top level. This class used ASSURE learning design with a problem-based learning (A-PBL) model.

Further, the second group was an experimental class 2 consisting of 103 students with criteria for 35 students at the lower level school, and 34 students at each of the middle and top levels. This class used the ASSURE learning design with the discovery learning (A-DL) model. Finally, the third group was a control class consisting of 99 students with criteria for 33 students at the lower level, 32 students at the middle level, and 34 students at the top level. This latter class used conventional design with PBL and DL learning models.

In this research, three research assistants and mathematics teachers assisted the researcher. All mathematics teachers have the same education level, i.e. Master of Education, and research assistants as observers were from the pre-service mathematics teachers. The research assistants were assigned to provide learning in the experimental class. The mathematics teacher taught in the control class, while the observer observed and noted various points according to the observation sheet provided. Before the research started, the researcher first presented an overview and training on the ASSURE learning design, as well as the applied learning model.

The procedure used in this research was divided into two stages; namely, the preliminary stage and research implementation. The initial phase was divided into five stages. First, the determination of population and investigation samples, as well as field surveys. Second, making and developing research instruments. Third was creating instructional media. Fourth was disseminating the use of ASSURE designs and equating perceptions about the implementation of learning by using problem-based learning and discovery learning models to teachers, mathematics teachers and the observers involved in conducting the research. Fifth was testing the research instrument.

The implementation stage had five phases. First was the dissemination of student learning style questionnaires. Second was conducting a pre-test on the ability in mathematics communication. Third was the implementation of treatment in the learning process. Fourth was a post-test on the ability in mathematics communication. The last was to analyse the research data.

The teaching materials used in this study were the subject matter of the set, lines and angles. The researchers arranged educational materials equipped with teacher guidelines, the steps of which were adapted to the model of problem-based and discovery learning. In addition, students also used student worksheets that served to train students' mathematical communication ability both in the classroom, as well as during homework.

Before analysis, all data were grouped under ASSURE and non-ASSURE designs, the learning models used (A-PBL, A-DL, K-PBL and DL), and school level (upper, middle and lower). A quantitative data analysis procedure was done through two stages that were to test the normality of data distribution, either the whole data or partially according to data analysis and determination of a possible testing tool, by using two-way ANOVA test.

RESULTS

Descriptive statistics concerning students' mathematics communication ability before and after, and their improvement are presented in Table 1.

Table 1: The description of students' mathematical communication ability results.

School level	Group	Number of students (n)	Pre-test		Post-test		Improvement	
			Mean	SD	Mean	SD	Mean	SD
Lower	A-PBL	34	4.47	2.98	9.47	4.01	0.33	0.18
	A-DL	35	4.54	2.55	10.31	3.32	0.38	0.18
	K-PBL/DL	33	4.33	1.98	8.00	3.03	0.24	0.15
	Total	102	4.45	2.52	9.28	3.58	0.32	0.18
Middle	A-PBL	34	4.65	1.50	11.85	1.91	0.47	0.11
	A-DL	34	4.50	1.38	11.38	2.05	0.45	0.10
	K-PBL/DL	32	4.81	1.93	9.84	2.38	0.34	0.10
	Total	100	4.65	1.60	11.05	2.26	0.42	0.12
Upper	A-PBL	33	7.64	3.12	16.36	1.71	0.71	0.10
	A-DL	34	7.65	2.63	16.38	2.41	0.71	0.18
	K-PBL/DL	34	7.53	2.12	13.18	1.70	0.45	0.10
	Total	101	7.60	2.62	15.30	2.47	0.62	0.18
Total	A-PBL	101	5.56	2.98	12.52	3.95	0.50	0.20
	A-DL	103	5.55	2.68	12.67	3.74	0.51	0.21
	K-PBL/DL	99	5.59	2.45	10.37	3.24	0.34	0.15
	Total	303	5.57	2.71	11.87	3.79	0.45	0.20

In general, Table 1 shows that students' mathematical communication ability at the beginning of the pre-test result between A-PBL, A-DL and K-PBL/DL groups demonstrated similar mean scores. However, after being given different treatments, the score of achievement (post-test) showed different mean scores. Similarly, with the improvement of students' mathematical communication skills, the average rating of improvement ranged from 0.24 to 0.71. However, statistical testing was required, regarding the significance of the differences that arise (see Table 2).

Table 2: Advanced test recapitulation of ANOVA difference based on school level and learning design.

School level	Paired learning model	Mean deviation	Sig.	Interpretation
Lower	(A-PBL)-(A-DL)	0.042	0.585	Hypothesis accepted
	(A-PBL)-(K-PBL.DL)	0.094	0.830	Hypothesis accepted
	(A-DL)-(K-PBL.DL)	0.136	0.006	Hypothesis rejected
Middle	(A-PBL)-(A-DL)	0.022	0.684	Hypothesis accepted
	(A-PBL)-(K-PBL.DL)	0.134	0.000	Hypothesis rejected
	(A-DL)-(K-PBL.DL)	0.112	0.000	Hypothesis rejected
Upper	(A-PBL)-(A-DL)	0.004	0.999	Hypothesis accepted
	(A-PBL)-(K-PBL.DL)	0.253	0.000	Hypothesis rejected
	(A-DL)-(K-PBL.DL)	0.257	0.000	Hypothesis rejected

Table 2 indicates that in lower level schools, the average comparison of mathematical communication skills between students who received A-PBL and students who received A-DL did not show any significant difference. These results are supported by Tinungki [13] who states that MCS would be increase by implementing a learning model, which gives students the opportunity to discuss and to interact each other, and also the influence of teachers' beliefs and knowledge in handling practices during class discussion of mathematics [14][15].

Similarly, the average of MCS between students who received A-PBL and students who received K-PBL, DL were compared. One of the factors that increased MCS was the teachers' knowledge of teaching problem-solving, teachers' priority for student thinking and the learning models used in the learning process [16-18].

However, in the comparison of the mean MCS between students receiving A-DL and those receiving K-PBL, DL, there was a significant mean difference. Based on the average score of MCS, students who received A-DL were better than students who received K-PBL, DL. Furthermore, at the middle- and upper-level schools, the design pair-A-PBL and A-DL learning models showed no significant difference in mean MCS. Also, the average of MCS students who received A-PBL and A-DL were better than students who received K-PBL, DL.

The results of this test indicate that the use of the ASSURE learning design for both problem-based learning and discovery learning models is equally suited to improving MCS in middle- and upper-level school students. Furthermore, for lower-level schools, it is more appropriate to use the ASSURE learning design with the discovery learning model. Teacher performance in the problem-solving tasks was a manifestation of their ability to implement problem-solving strategies and students must learn mathematics as an independent exploration of student interests, tailored to the problem-solving view [19].

There were four indicators of mathematical communication ability. The first indicator uses the symbols/notations and mathematical operations appropriately. The second indicator gives the idea - what is known and asks for a problem and gives the reason. The third indicator presents contextual problems in the form of images, graphs, tables or algebra. The fourth indicator describes images, graphics, tables or mathematical sentences into contextual and appropriate descriptions. Based on all indicators, the highest improvement of mathematical communication ability lies with the third indicator, obtained by the group of students who received the ASSURE design of learning using the problem-based learning model. The improvement in the upper-level school students showed a significant increase of 0.80. While the percentage of the lowest ability improvement is the capacity to use the symbol/notation, mathematical operations appropriately, i.e. in the lower-level school students group with the utilisation of the conventional design that reached 0.16. The learning trajectory in the learning process has an important role in developing mathematical communication ability based on its indicators [20][21].

Below is an example of how to solve the problem of mathematical communication ability of the third indicator.

The second test, question number 1b In the class, there are two groups of children who love playing basketball and swimming. The comparison of the number of children who like basketball and like both is 5:4, while the ratio of the number of children who like swimming and both is 3:2. If the number of children who like to exercise using both is 16, present this problem in a Venn diagram.

One of student's answers is shown in Figure 1.

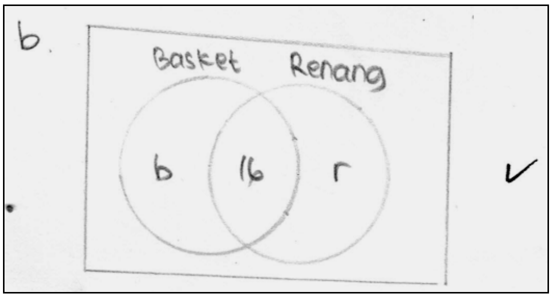

Figure 1: Student's answer about MCS in the third indicator.

Figure 1 shows that the student has been able to presents contextual problems in the form of images. These results indicate that students have a good ability in the third indicator. The achievement of indicators of mathematical communication ability about presenting contextual problems in the form of pictures, graphs, tables or algebra, is quite sufficient. At the middle- and upper-level schools, there was no difficulty in presenting the problem in the form of drawings, but in lower-level schools, the students were still unable to understand the issues given. As a result, in showing the problems provided in the form of drawings, they still experienced difficulties.

CONCLUSIONS

In general, the mathematical communication ability of students who received ASSURE learning design was better than the students who received the conventional learning design. As per school level, at every school level, the use of ASSURE learning design using problem-based and discovery learning models produced the same mathematical communication ability, and both provided better mathematical communication ability than groups of students who received only conventional learning design.

At lower-level schools, the use of ASSURE learning design with the discovery learning model is more effective for lower-level schools to improve mathematical communication skills. However, at middle and high school levels, the use of ASSURE learning design with problem-based learning and discovery learning models is effective for mathematical communication ability.

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