

Developing Students' Worksheet-Based Science, Technology, Engineering, and Mathematics Assisted by Augmented Reality to Improve Creative Thinking

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Abstrak. This study aims to develop Augmented Reality-assisted Science, Technology, Engineering, and Mathematics (STEM) Student Worksheets to determine the characteristics and feasibility of augmented reality STEM student worksheets and determine the improvement of students' creative thinking skills. This research method uses the Research and Development (R&D) method. The design of this study uses the Thiagarajan (4D) model. The subject of the small group trial was Semester V A, and the large-scale trial was V B. The design used is the One Group Pretest-Posttest Design. STEM Augmented Reality student worksheets are prepared by collaborating on science, technology, engineering, and mathematics content. The results of the feasibility test in terms of the feasibility of content, presentation, and language in the criteria are very suitable for use in learning activities. The readability test results showed that the STEM Augmented Reality student worksheets were easy for students to understand. The application of Student Worksheet has facilitated the improvement of students' creative thinking which consists of fluent thinking, flexible thinking, original thinking, and elaborative with moderate categories.

Keywords: Student Worksheet, STEM, augmented reality.

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INTRODUCTION

In the 21st century, science and technology are developing rapidly. Students are required to master various skills to compete globally (Turiman et al, 2012). Education plays a vital role in preparing students for their future. (National Education standards, 2011) states that in education, 21st-century skills such as thinking and problem-solving skills can be developed. Education teaches students the right way of thinking and provides accurate information to bring students the correct thinking skills (Bacanli et al., 2009).

The 2013 curriculum prepares students to have faith, productive, creative, practical and innovative abilities. However, the 2013 curriculum being implemented will not be able to overcome the problem of the quality and quantity of Indonesian human resources who are globally empowered if they do not systematically prepare them to develop the knowledge, skills and attitudes required by the 21st-century world of work. Overcoming this, education with a Science, Technology, Engineering and Mathematical (STEM) approach can be the key to creating the next

generation of a nation that can compete in the global arena. STEM is a meta-discipline at the school level consisting of science, technology, engineering, and mathematics teachers who work together in the learning process to form a single unit that cannot be divided (OP Sukmagat, et al., 2020).

Tseng (2013) stated that STEM education provides opportunities for teachers to show students how concepts, principles, and techniques from science, technology, engineering, and mathematics are integrated into the development of products, processes, and systems used in their daily lives. Therefore, a comprehensive learning tool is needed, one of which is the Student Worksheet (Permendikbud, 2013). To improve contextual learning outcomes, teachers must create worksheets that include activating students and increasing creative thinking skills. These various thinking skills are a process and student behaviour integrated to learn and understand the content of learning materials (Beers, 2011). Worksheets contain assignments that must be done by students in which they contain material, summaries and instructions for implementing learning tasks that must be done by students

referring to the essential competencies to be achieved (Zahro, 2017). In line with research (Oktaviani, 2019), student worksheet based on Science, Technology, Engineering and Mathematics (STEM) can improve students' creative thinking skills.

Based on the results of observations with Madrasah Aliyah teachers in Majalengka, there are no media that develop STEM-based student worksheet assisted by Augmented reality in learning. Teachers do not understand the STEM-based learning approach and how to apply it to students. Currently, teachers use worksheets conceptually so that learning is challenging and less meaningful. In addition, during the pandemic, there are limitations in both time and effectiveness. Students need teaching materials that are easy to understand and allow them to learn independently according to their abilities. Student worksheet based on Science, Technology, Engineering and Mathematics (STEM) assisted by Augmented Reality will present nervous system material that is equipped with steps for implementing independent learning along with evaluation using packaged in one computer and android application. The presentation of STEM-based worksheets is expected to increase students' interest in learning and creative thinking skills, making the concepts and materials taught easy to understand.

METHODS

This research is a type of Research and Development (R&D) research. The design of this study uses the Thiagarajan (4D) model. The 4D development model consists of 4 stages: define, design, develop, and disseminate (Thiagarajan, S., Semmel, D. S., Semmel, 1974).

Define

At this stage, the researchers collected data and information related to Student Worksheets to support the learning process at school. Researchers also conducted interviews with teachers and students regarding the learning process, including teaching materials, media, and learning methods. The final activity in the research stage is identifying and formulating problems.

Design

Design researchers carry out activities: 1) compiling student worksheets based on Science Technology Engineering Mathematical (STEM); 2) creating and designing storyboards for the android version of augmented reality media as supporting media for student worksheets.

Develop

Develop is the stage of developing a product to be developed, namely student worksheets based on Augmented Reality-assisted Science Technology Engineering (STEM), whose implementation consists of 1) validation of learning media experts, linguists, material experts, and learning practitioners; (2) product revision from the validation results of 4 validators; (3) a small-scale trial of 10 students to know the effectiveness of using augmented reality-assisted STEM-based student worksheets; and 4) a large-scale trial of 25 students of class Biology V B Universitas Majalengka, for the 2021/2022 academic year.

Data analysis technique

Product Validation

Media experts, linguists, material experts, and education practitioners validated the product development results. The percentage of validity scores were analyzed using the following formula:

$$P = \frac{\sum X}{\sum X_1} \times 100\%$$

description:

P = percentage value validity

$\sum X$ = the number of answers of all respondents in one aspect

$\sum X_1$ = ideal number of answers in one aspect

100% = permanent

Student Response Analysis

Scores of student responses to STEM-based worksheets assisted by augmented reality were analyzed using the following formula (Wicaksono et al., 2014):

Creative Thinking Data Analysis

Data on the results of students' creative thinking using STEM-based worksheets assisted by augmented reality were analyzed for normality of the data using the Shapiro-Wilk test, and the effect of student worksheets based on Science Technology Engineering Mathematical (STEM) assisted by augmented reality on creative thinking was measured using the pre-experimental design method. This research method is a method in which the dependent variable is influenced by the independent variable and other factors that influence it. This is due to the absence of control variables, and the sampling is not random (Sugiyono, 2015). The design used is the One

Group Pretest-Posttest Design. The data analysis technique used paired sample t-test (paired sample t-test) assisted by IBM SPSS Statistics 22 software.

RESULTS AND DISCUSSION

The product developed in this research is a Student Worksheet based on Science Technology Engineering Mathematical (STEM) assisted Augmented Reality on the Coordination System Concept, Sub-Concept of the Human Nervous System to improve students' creative thinking. The components of the student worksheet product were developed to consist of a cover page, an introduction, a table of contents, competency standards and essential competencies, basic theory and student worksheets, bibliography. The use of STEM in the learning process positively affects activities and improves learning outcomes (Murnawianto et al., 2017). The role of Augmented Reality in

student worksheet is as a media aid in realizing images of the organs of the human nervous system to make them look real. Worksheets were developed based on creative thinking indicators, which in this study were limited to 4: fluent thinking, flexible thinking, original thinking, and elaborative.

The results of product development in the form of STEM-based worksheets assisted by Augmented Reality; before testing, product validation was carried out by four validators consisting of a team of material experts, learning media, language, and learning teachers/practitioners. Product validation is done by giving a questionnaire to the validators. Based on the product validation results, student worksheet is considered feasible to be used in the learning process. The following is the data from the validation test results:

Table 1. Presentation of Product Validation Results

No.	Validator	Score		Score (%)	Category
		average	Max Value		
1	Theory	84	95	88.42	very Valid
2	Learning Media	72	90	80	Valid
3	language	85	110	77.27	Valid
4	Teacher/Practitioner	95	115	82.60	very Valid
Number of Average Percentage of Validations				82.07	very Valid

Based on table shows the percentages that are quite ideal, namely: the results of the validation of the material expert team of 88.2%, which is categorized as very valid, and the expert media team of 80%, which is categorized as valid, the linguistic team of 77.27% which is categorized as valid, and the teacher/education practitioners by 82.60 % with a very valid category. The results of the questionnaire analysis from the validator team contained suggestions, and product revisions, including adding a glossary on the last page of the

worksheet, a separate maker of pictures of nervous system organs was made so that it can be scanned by the Augmented Reality application, in addition to the student, worksheets must be equipped with practice questions related to students' creative thinking. Using student worksheet teaching materials that have been declared valid can motivate students to be more active because students are directly involved in the learning process. It can also develop students' creative thinking skills (E. Rahayu, H. Susanto, 2012).

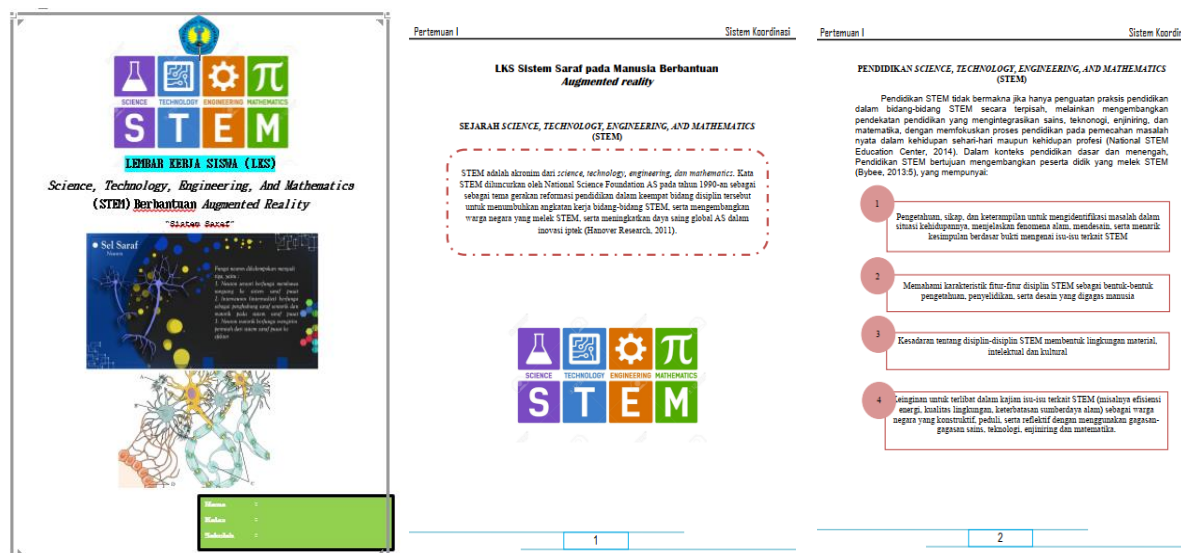


Figure 1. Cover and Introduction Pages

The next stage is conducting a small-scale trial; the sampling technique is using a purposive sampling technique. According to (Sugiyono, 2015), purposive sampling is a research sampling technique based on specific considerations that are not intentional. In this small-scale trial, a sample of 10 students was taken to know the effectiveness of the product

that had been developed in terms of its feasibility before conducting a large-scale trial. Student responses by distributing a 10-point Likert-scale questionnaire to STEM-based student worksheet products assisted by Augmented Reality in a limited-scale trial are presented in the following table:

Table 2. Small-Scale Student Responses

No	Statement	$\sum R$				amount NRS	% NRS	Criteria
		SS	S	TS	STS			
1	A1	7	3	0	0	37	92.5	Very strong
2	A2	5	5	0	0	35	87.5	Very strong
3	A3	4	5	1	0	33	82.5	Very strong
4	A4	3	7	0	0	33	82.5	Very strong
5	A5	2	8	0	0	32	80	Very strong
6	A6	3	5	2	0	31	77.5	Strong
7	A7	2	7	1	0	31	77.5	Strong
8	A8	3	7	0	0	34	82.5	Very strong
9	A9	4	5	1	0	33	82.5	Very strong
10	A10	6	4	0	0	36	90	Very strong
Average							83.50	Very strong

Table 2 shows student responses to STEM-based worksheets with Augmented Reality in small-scale trials obtained an average of 83.50%, categorized as very strong. Therefore, it can be concluded that the use of the developed student worksheet received a positive response and was feasible to be applied to the learning process of biology, the sub-concept of the nervous system in humans. The next stage of carrying out a large-scale trial is the results of the distribution of student response questionnaires.

Student responses in large-scale trials of

STEM-based worksheets assisted by Augmented Reality showed a very positive response, evidenced by an increase from an average of 83.50% to 89% with a solid category. Although according to the opinion (Wicaksono et al., 2014), student responses exceed 50% of the questions, it can be concluded that the developed media get a positive response.

The Effectiveness of Using Augmented Reality-Assisted STEM-Based Worksheet on Creative Thinking

Creative thinking is a process of developing unusual ideas and generating new thoughts that have a broader scope. Although creative thinking can also create quality thinking, the creative process cannot be carried out without the knowledge gained by developing good thinking

(Febrianti et al., 2016). The students' creative thinking results were obtained from the pretest and posttest on a large-scale student worksheet trial. The data from the pretest-posttest results were analyzed and presented in the following figure.

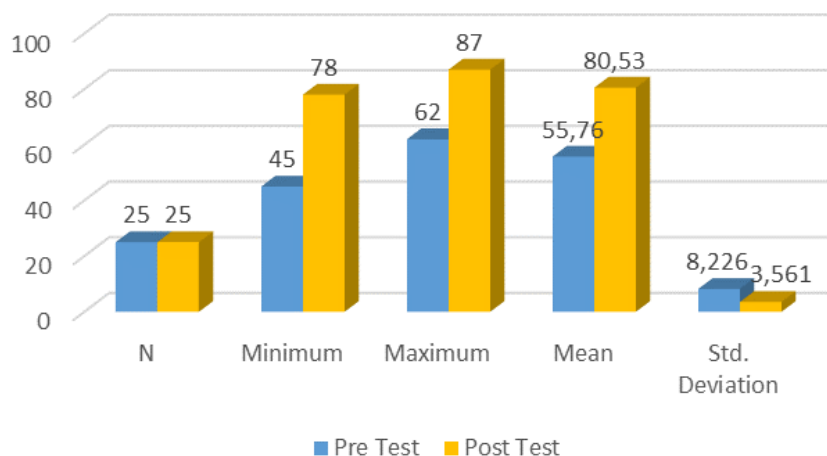


Figure 2. Students' Creative Thinking Scores

Figure 2 describes the descriptive statistical analysis results of two interrelated samples, namely pretest and posttest. The pretest got an average score of 55.76; for the posttest, it was 80.53 from 25 students. Pretest 55.76 < posttest 80.53. Therefore, it can be concluded that there is a difference in students' average creative thinking between the pretest and the posttest. The results of the N Gain test on average pretest-posttest values are presented in the following table.

Table 3. Analysis of N Gain

Average Pretest	Average Posttest	N Gain	Criteria
55.76	80.53	.56	Currently

The results of the n-gain test on the average pretest-posttest score of 0.56 in class X MIPA Madrasah Aliyah Siti Khodijah Sindangwangi Majalengka District with moderate criteria.

Based on the results of the n-gain analysis, it can be concluded that applying STEM-based worksheets assisted by Augmented Reality can facilitate students in increasing creative thinking.

The preparation of STEM-based worksheets assisted by Augmented Reality is integrated with creative thinking indicators consisting of fluent thinking, flexible thinking, original thinking, and elaborative to develop students' creative thinking. Based on the results of research (Oktaviani Putri Sukmagati, Dwi Yulianti, 2014), the development of STEM-based worksheets is considered adequate because it can facilitate the improvement of creative thinking for each indicator. Furthermore, in line with the research (N Fitriani, G Gunawan, 2017), the combination of STEM aspects can guide students' creative thinking. The improvement of students' creative thinking for each indicator can be seen in Figure 3.

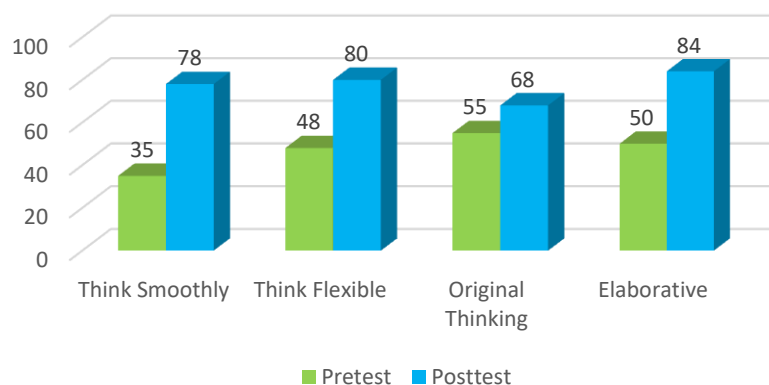


Figure 3. Improving Creative Thinking

An n-gain analysis test showed each indicator's percentage increase in creative thinking. The results showed increased fluent thinking, flexible thinking, original thinking, elaborative thinking and fluency, flexibility, elaboration, and originality. Furthermore, every indicator of creative thinking experienced a significant increase except for the indicator of original thinking, which was not too significant and had low criteria.

The assessment of fluent thinking is seen from the ability of students to make an idea from the existing problems. Fluent thinking is also influenced by how much students know about the learning material to be studied. Application of STEM-based worksheets assisted by Augmented Reality as a result of development can facilitate the improvement of fluent thinking. Based on the average pretest and posttest scores on the fluent thinking indicator, the n-gain score of 0.66 has moderate criteria.

Flexible thinking is a student's thinking skills in creating different ideas and ideas in viewing an object problem (Munandar, 1999). Therefore, assessing students' flexible thinking can be based on the ability to analyze and solve a problem based on their creative ideas and categorize problem objects found in life (Setiawan, N. R., & Suratno, 2014). In this study, the increase in flexible thinking indicators was evidenced by an increase in the average pretest-posttest score of

0.61 with moderate criteria.

Someone who has developed his original thinking will be able to express his ideas and ideas based on the results of his thoughts that have uniqueness and different opinion from other people (Ayu & Tri, 2019). Applying STEM-based worksheets assisted by Augmented Reality can improve original thinking, which is evidenced by the results of the n gain analysis getting an average score of 0.29 with low criteria. However, the increase in students' original thinking is considered the smallest due to the reasoning ability of students who have not developed optimally so that students in expressing their ideas and ideas are still fixated on books and other references. In addition, the composition of the original thinking indicator instrument is only a small number.

Elaborative skills include enriching and enhancing ideas or products; increasing or detailing an object, idea, or atmosphere to make it more interesting (Sumarmo, 2010). Students' elaboration after applying STEM-based student worksheet with Augmented Reality-assisted increases based on the n gain score of 0.68, which is categorized as having moderate criteria. Hypothesis testing in this study uses a paired sample t-test which aims to see if there is a difference in average between two related samples.

Table 4. Summary of Hypothesis Analysis Conclusion

Analysis	Test Type	Results	Criteria	Conclusion
Normality	Shapiro-Wilk	Sig. Pre test = 0,331 Sig. Post test = 0,295	Accept Ho	Normal substituted data
hypothesis	Paired Sample t-test	tcount = -24,471 df = 25 sig (2-tailed) = 0,002	Reject Ho	There are significant differences

The result data obtained a sig (2-tailed) value of $0.002 < 0.05$; the criteria were to reject H_0 or accept H_1 . Based on the analysis results, it can be concluded that students' creative thinking significantly differs between the pretest and posttest. Applying STEM-based worksheets assisted by Augmented Reality can improve students' creative thinking on the sub-concepts of the human nervous system (Zahara et al, 2021& Rasyid et al, 2021).

CONCLUSION

The development of STEM-based worksheets assisted by Augmented Reality was declared feasible to be used in the learning process. The product validation results by four validators give an average very valid assessment. Student responses to student worksheet during small-scale and large-scale trials gave a positive response with percentages of 83.50% and 89%, respectively. The application of the student worksheet has facilitated the improvement of students' creative thinking, which consists of fluent thinking, flexible thinking, original thinking, and elaborative with moderate categories. Hypothesis testing proves a significant difference between the pretest and the posttest.

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