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Research Article

Effectiveness of student math-worksheets with a picture-based approach of the STEM

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Abstract

The integration of approaches between science, technology, engineering, and mathematics (STEM) in education is one of the solutions to achieve learning objectives. By applying the STEM approach to Student Math-worksheets (SMw) supported by picture models, it is expected to be an alternative source of learning that is more effective in guiding learning with supported pictures that help participants develop imagination and connect the lesson with the circumstances. This study aims to determine the effectiveness of the use of Student Math-worksheets with a picture-based STEM approach. The research method used is the percent N-Gain and t-test. As for the tests used in the form of pretest and posttest from the experimental class and the control class, then analyzed the effectiveness test using percent N-Gain and the results will be analyzed by t-test and then continued with the Effect Size test to find out the effective/successful scale of the use of Student Math-worksheets. The result is that the Student Worksheets used is quite effective, and there are significant differences in the effectiveness and analysis of high-scale effect size tests.

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Introduction

STEM is an extension of science, technology, engineering, and mathematics (Fisher, 2015). STEM is an essential issue in the world of education today (Abdurrahman et al. 2019; Dare et al. 2018). STEM learning is project-based and problem-based knowledge as a means to present meaningful and interdisciplinary learning experiences that can cover two or more of the four main disciplines contained in STEM (Breiner et al. 2012). STEM is a learning approach between two or more fields of science provided in STEM, between the fields of science contained in STEM also with one or more other school subjects (Hernandez et al. 2014). STEM education is an approach to teach STEM content from two or more STEM domains, which are bound by STEM practices in authentic contexts to link the subject in enhancing student learning (Kelley & Knowles, 2016). A study showed that students who focus on STEM better prepared for future career opportunities (Park et al. 2017), the goal in the STEM field is to strengthen teacher practice in improving student achievement (Erdogan et al. 2016; Rany et al. 2020; Yasin et al., 2020). Students' perceptions about the value of STEM education vary, depending on the learning environment, especially the affective aspects, intellectual challenges, epistemological foundations, and academic freedom, many students feel that STEM education prepares them for college (Mullet et al. 2018).

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The quality of modern life depends on innovation and development in the STEM discipline (Huda et al. 2019; Park et al. 2017). Educational policies in many countries have emphasized the importance of STEM (Apple, 2017), STEM education can be described as a large-scale education reform aimed at targeting teaching and learning (Isabelle & Valle, 2015). Knowledge and application of STEM can be assessed based on the skills demonstrated. The skills shown are beneficial for understanding how the curriculum can prepare students to become workers (Petrun Sayers et al. 2020). STEM education has many potential benefits for individuals and the nation as a whole (Barakabitze et al., 2019). In general, the STEM initiative has two main interconnection objectives, at the national level, the STEM initiative seeks to increase groups that meet the workers' requirements that the nation should need to remain economically competitive in the global market. At the individual level, the STEM initiative aims to produce citizens who can do financially secure jobs in the ever-increasing world of technology (Syazali et al. 2019).

STEM education can increase the independence of students because it is vital to introduce young people to the STEM topic to motivate and encourage them to pursue STEM subjects in each class (Kanematsu & Barry, 2016). Four STEM branches; science, technology, engineering, and mathematics are the leading academic sciences of all students; especially science and mathematics (Bell et al. 2017). In mathematics, using the STEM concept will make students more often apply the material in everyday life so they will get used to solve mathematical problems in daily life by thinking scientifically, using technology to obtain various information. Data processing with ability techniques, Mathematical learning patterns with the STEM approach emphasize the principles of practice, wherein each student's learning is always facilitated to practice so that they get an unforgettable learning experience (Milaturrahmah et al. 2017).

STEM needs to be studied in college studies in educational development (Sagala et al. 2019), to find out STEM's participation in efforts to influence change, it must be critically contemplated and broaden scientific approaches to studying STEM (Means et al., 2018; Suherman et al., 2018), expanding cooperation in STEM is recommended to deepen understanding of recruitment, retention, progress and attendance issues (Metcalf et al. 2018). The progress of information and communication technology is significant for STEM education because it can increase the independence of students by learning on their initiative. Therefore it will provide opportunities in realizing STEM goals and effectiveness (Kanematsu & Barry, 2016). An in-depth understanding of STEM education for students helps inform future curriculum design, program evaluation, and education policy (Mullet et al. 2018), as in the basic framework of the 2013 curriculum structure at the junior high school/madrasa level aimed at creating a generation of Indonesians who have life skills as individuals who are faithful, productive, creative, innovative and competent and able to contribute to the life of society, nation, state and world civilization. This provides a platform for the development and implementation of STEM education.

A study shows that alternatives in learning can use picture media based on Islamic values (Aini et al. 2019). The use of picture media can deepen the explanation in abstract mathematics lessons. The selection in the use of appropriate learning models can stimulate the growth of students' enjoyment of an experience, foster and increase motivation in working on assignments, making it easier for students to understand the lesson to enable participants' students to achieve better learning outcomes. One model that can be used is picture based. The picture-based learning model can support students to learn well and be more active in following the learning process in the classroom (Surya & Putri, 2017). The picture learning model is a learning method that is applied in learning using pictures that are paired or sorted to become a logical sequence of images (Petrun Sayers et al. 2020).

To improve the skills of prospective teachers requires an exclusive strategy so that students who will teach in the future also have excellent skills (Pahrudin et al. 2019; Suherman et al. 2020; Syazali et al. 2019). Strategies that focus on improving teaching practices provide the highest potential for improving learning outcomes (Barakabitze et al. 2019; Weintrop et al. 2016). Increasing STEM persistence needs to focus on strategies related to academic adjustment (Dika & D'Amico, 2016; Gansemer-Topf et al. 2017). STEM school culture looks stable and uniform across schools and model types. However, the kind of model seems to affect the amount of time students spend in school (Tofel-Grehl & Callahan, 2014). In addition to the type of model, the completeness of the learning tools available also dramatically influences. Many learning tools, one of which is the student worksheet (Latifah, 2016). Student worksheets are printed materials in the form of sheets of paper that contain articles, summaries, and instructions on the implementation of tasks done by students referring to the essential competencies that must be achieved (Nurfadilah Mahmud & Amin, 2019). Integration with the STEM approach applied in student worksheet with the

picture model is expected to produce a good student worksheet that can be used as one of the teaching materials used by teachers in delivering teaching material.

Related to the results of observations, obtained information regarding the relationship of the availability of components of learning tools used in the school include: students are still challenging to understand the material, no student worksheet (SW) functions as a learning companion for students. Student worksheet learning media is a critical teaching material in the learning process. The existence of student worksheets as teaching material is beneficial for students in understanding the material, so it is necessary to do innovation to have readiness in developing mathematics teaching material in the form of the student worksheet. So researchers provide a solution that is by developing student worksheets with a picture-based STEM approach.

A study showed that SW was feasible and effective to use, at the practical level SW was in the perfect category, at the level of effectiveness student worksheet obtained sig <0.05 proving a significant difference between the experimental and control classes included in both types (Husna & Mulyani, 2018; Wagiran et al. 2019).

Problem of Study

STEM is collaborative problem-solving which requires any student to apply an integrated knowledge. STEM is claimed to affect students' achievement but yet is not declared "why" and "how" its effect in higher thinking skills (Shanta & Wells, 2020). Some previous research report that the developed students' worksheets effective in increasing literacy based on STEM (Sulistiyowati et al. 2018), can improving of in critical and creative thinking (Yulianti et al. 2020), and effective to increasing problem solving (Taub et al. 2018). Based on the previous study, it can be underlined that there is an existing gap, namely to find the effect of student math-worksheets with a picture-based approach on STEM. This study aims to determine the effectiveness of the use of Student Math-worksheets with a picture-based STEM approach.

Method

Research Model

This study produced student worksheet with a picture-based STEM approach. With the development phase using the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation). The data analysis technique used is descriptive quantitative to process the data from the validator's assessment, students and teacher responses, and effectiveness tests. Whereas in processing data in the form of comments, suggestions, and improvements from the validator as well as a description of the feasibility of the research use descriptive qualitative research.

Participants

STEM-based approach to picture on rectangular and triangle VII grade material of SMw implemented. To the implementing this product, regards to the 60 students in junior high school. The research uses two group subject, including experimental class using STEM approach to Student Math-worksheets (SMw) supported by picture models and the control class using the method in class as curriculum.

Data Collection Tools

Instruments utilized in this learning activity enclosed the information, lesson plans, student worksheets, as well as test items. The effectiveness of math-worksheets with a picture was developed and given in the teaching process.

Data Analysis

The method used in this study uses the analysis of percent N-Gain and T-test followed by the analysis of effect size test, the percent N-Gain analysis aims to determine the effectiveness of the use of student worksheet and the t-test is used to find out whether there are significant differences in efficiency. In contrast, the analysis of the effect test size aims to see the scale of effectiveness of the use of the student worksheet. The following table will display the percent N-Gain criteria and effect size criteria

Table 1.

N-Gain Effectiveness Category (Hake, 1999)

Percentage (%)	Category (C)
$C < 40$	Ineffective
$40 \leq C < 55$	Less effective
$55 \leq C < 75$	Quite effective

$C \geq 75$	Effective

Table 2.

Criteria for Interpretation of Cohen's d Values (Peng & Chen, 2014)

Cohen's standard	*Effect Size*	*Percentile standing*	*Percent of nonoverlap*
	2.0	97.7	81.1%
	1.9	97.1	79.4%
	1.8	96.4	77.4%
	1.7	95.5	75.4%
	1.6	94.5	73.1%
	1.5	93.3	70.7%
High	1.4	91.9	68.1%
	1.3	90	65.3%
	1.2	88	62.2%
	1.1	86	58.9%
	1.0	84	55.4%
	0.9	82	51.6%
	0.8	79	47.4%
	0.7	76	43.0%
Medium	0.6	73	38.2%
	0.5	69	33.0%
	0.4	66	27.4%
Low	0.3	62	21.3%
	0.2	58	14.7%
	0.1	54	7.7%
	0.0	50	0%

Procedure

This study produced student worksheet with a picture-based STEM approach. With the development phase using the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation). The data analysis technique used is descriptive quantitative to process the data from the validator's assessment, students and teacher responses, and effectiveness tests. Whereas in processing data in the form of comments, suggestions, and improvements from the validator as well as a description of the feasibility of the research use descriptive qualitative research. It can be seen examples of student math-worksheet at appendix 1.

Results

Furthermore, in the attractiveness response test results obtained by small group trials with a percentage value of 73.75% in new criteria. Field trial results got an amount with a percentage of 75.88% in exciting approaches, and the results of the trial response of subject teachers with a rate of 75.45% in interesting criteria, this trial was conducted by researchers by giving questions about pretest and posttest to students in the experimental class and the control class, the table below is the result of calculating the n-gain percent criteria for the student worksheet product.

Table 3.

Experiment and Control Group Pretest and Posttest Values

Group	Mean	Median	Variance	Minimum	Maximum
Experiment	62.80	66.67	417.10	28.57	94.44
Control	30.95	31.03	50.17	15.38	44.44

The table above shows the average value of the experimental class is 62.80% included in the category of quite effective/quite useful, and the average cost of the control class is 30.95% included in the ineffective/ineffective category, based on the n-gain effectiveness category criteria according to table 1.

The basic concept of the t-test or independent sample t-test of the n-gain results to test a significant difference as

- Is part of the parametric statistical analysis used to check whether there are differences in the average scores (scores) of two unpaired data groups
- The type of data used in this test is interval or ratio scale data.
- Data are typically distributed and homogeneous (not an absolute requirement) (Lisdiani et al. 2019).

The basis for a normality test decision is if the value of sig. > 0.05, then the data is normally distributed and if the value of sig. <0.05, then the data are not normally distributed. The normality test must adjust to the number of samples (N), the use of the Shapiro Wilk normality test if the number of the two classes is less than 50, conversely, if the number of samples is more than 50, then the normality test will refer to the sig value. Kolmogorov-Smirnov Test. (Sahid Raharjo. 2017).

Tabel 4.

Tests of Normality

	Class	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	Df	Sig.	Statistic	Df	Sig.
NGain_Persen	Experiment	.126	31	.200*	.936	31	.063
	Control	.131	29	.200*	.961	29	.346

The table below shows the data are normally distributed because of the value of sig. > 0.05 which is 0.20. Thus the independent t-test can be continued because it meets the requirements.

Table 5.

Independent Samples Test

Levene's Test for Equality of Variances		t-test for Equality of Means								
		F	Sig.	T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
NGain_ Percent	Equal variances assumed	43.469	.000	7.957	58	.000	31.84262	4.00187	23.83201	39.85323
	Equal variances not assumed			8.172	37.545	.000	31.84262	3.89674	23.95095	39.73429

Next, to find out whether there are differences in the effectiveness of the experimental class and control class research results are significant or not, how to interpret the independent sample test table. Based on table 5, the value of sig. The Levene's Test for Equality of Variance is 0,000 <0.05, it can be concluded that the n-gain percent data variance for the experimental class and the control class is not homogeneous. Thus the independent t-test for the n-gain score is guided by the sig value. contained in the Equal variances not assumed table, based on the independent sample test table, the sig value is known. (2-tailed) is 0,000. based on decision making if the value of sig. (2 tailed) <0.05 then there is a significant difference between the experimental class and the control class and vice versa if the value of sig. (2-tailed)> there is no significant difference. Thus it can be concluded that there is a significant difference in effectiveness between the experimental class and the control class.

Table 6.

Group Statistics

	Class	N	Mean	Std. Deviation	Std. Error Mean
NGain_Percent	Experiment	31	62.7972	20.42287	3.66806
	Control	29	30.9546	7.08295	1.31527

Then the influence of applying the Student Worksheet with the picture-based STEM approach will be seen. The table above is a demographic group from the t-test to calculate the effect size using Cohen's formula. The results of the group statistics in the experiment class had highest than control class. It is clear that mean on the experiment class was 62.7972 while the control class was 30.9546.

Discussion and Conclusion

The use of the effect size test is to measure how effective the improvement of a study is. So if the n gain test has been done and indicated an increase/effective, then to measure how significant the increase is, use the effect size test (Cohen et al. 2009). From the calculation of the effect size above, the results obtained are 2.09, according to the criteria table of effect size score 2.09> 2.0, the conclusion is the effectiveness of the use of the Student Worksheet with a picture-based STEM approach obtains a high effectiveness scale.

Student Math-worksheet is material after knowing the results of the above calculation has passed valid criteria in terms of format, language, technical, and content (Nurfadilah Mahmud et al. 2019) because STEM education can increase student independence by learning on their initiative. Therefore it will provide opportunities in realizing STEM goals and effectiveness (Kanematsu & Barry, 2016). A study supporting problem-based learning is a useful alternative for developing student learning skills in mathematics (Aini et al. 2019). such as the results of the validity of the Student Worksheets with very decent and exciting criteria, and the use of the Student Worksheets makes students independent and more skilled in learning and able to think more critically in solving mathematical problems.

Statistical meta-analysis techniques estimate the average impact of increasing STEM learning on student achievement in mathematics. As for strengthening the STEM teacher workforce skills that lead to an increase in student learning in mathematics (Stohlmann et al. 2011). STEM education as an integration of science, technology, engineering, and mathematics with instruction involving students in projects, real-life problems, and collaboration, explicitly aims for students to learn how to approach everyday life with analytical thinking skills and enthusiasm for study (Ashdown & Bernard, 2012), statement of an analysis which states that applications that utilize information and communication technology can support learning in 21st-century science (Rahayu et al. 2019). as in this study involving students in the practice of working on projects in the student worksheet by linking material to the STEM field.

This study also applies picture-based learning, which can make students more active in education, make students productive, creative, innovative, and able to interact in learning, and can create learning activities that provide excitement for students through sorting logical operations (Purwani et al. 2018). The application that using this picture-based Student Math-worksheet makes it easy for students to associate images with real situations makes them more creative and innovative and creates a pleasant and more active learning atmosphere so that the learning process in class runs well.

Based on the results of research conducted by researchers, student math-worksheet with the STEM-based approach to Picture on rectangular and triangle VII grade material of SMP, is quite effective in use. The t-test results showed that there were significant differences, and the effect size test showed that the effectiveness of the use of student worksheet in the study was large scale. The researcher suggests that in future studies for using student worksheet that is accompanied by a learning process so that it affects the learning outcomes of students and research results will be more effective.

Recommendations

Based on the above conclusions, the authors suggest that the use student math-worksheets with a picture-based approach to STEM in the teaching and learning. This research can be followed by further research combining to different model.

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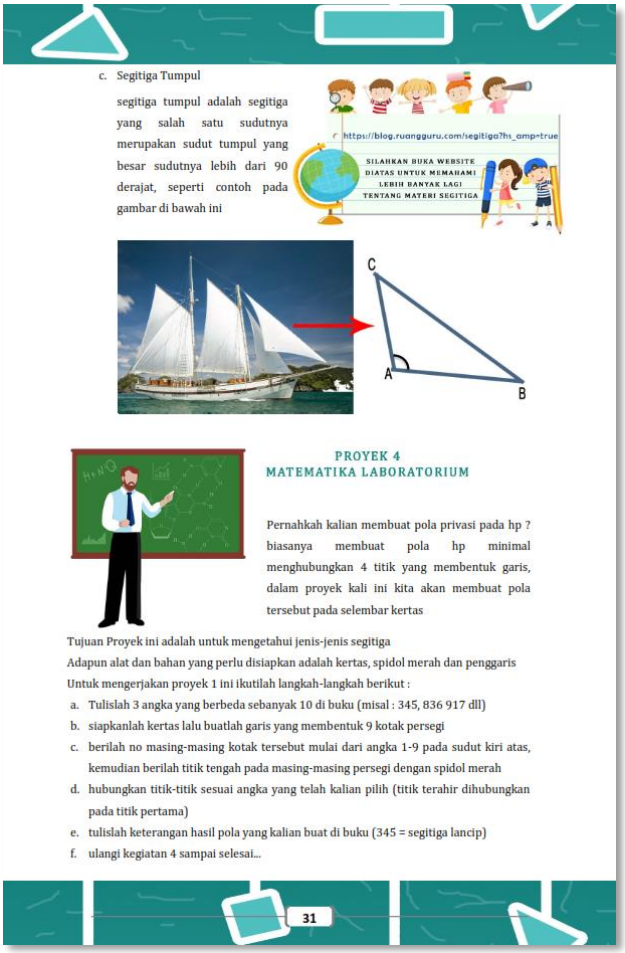
Appendix 1.
Examples of Student Math-worksheet



c. Segitiga Tumpul

segitiga tumpul adalah segitiga yang salah satu sudutnya merupakan sudut tumpul yang besar sudutnya lebih dari 90 derajat, seperti contoh pada gambar di bawah ini

PROYEK 4
MATEMATIKA LABORATORIUM

Pernahkah kalian membuat pola privasi pada hp ? biasanya membuat pola hp minimal menghubungkan 4 titik yang membentuk garis, dalam proyek kali ini kita akan membuat pola tersebut pada selembar kertas

Tujuan Proyek ini adalah untuk mengetahui jenis-jenis segitiga
Adapun alat dan bahan yang perlu disiapkan adalah kertas, spidol merah dan penggaris
Untuk mengerjakan proyek 1 ini ikutilah langkah-langkah berikut :

a. Tulislah 3 angka yang berbeda sebanyak 10 di buku (misal : 345, 836 917 dll)
b. siapkanlah kertas lalu buatlah garis yang membentuk 9 kotak persegi
c. berilah no masing-masing kotak tersebut mulai dari angka 1-9 pada sudut kiri atas, kemudian berilah titik tengah pada masing-masing persegi dengan spidol merah
d. hubungkan titik-titik sesuai angka yang telah kalian pilih (titik terahir dihubungkan pada titik pertama)
e. tulislah keterangan hasil pola yang kalian buat di buku (345 = segitiga lancip)
f. ulangi kegiatan 4 sampai selesai...

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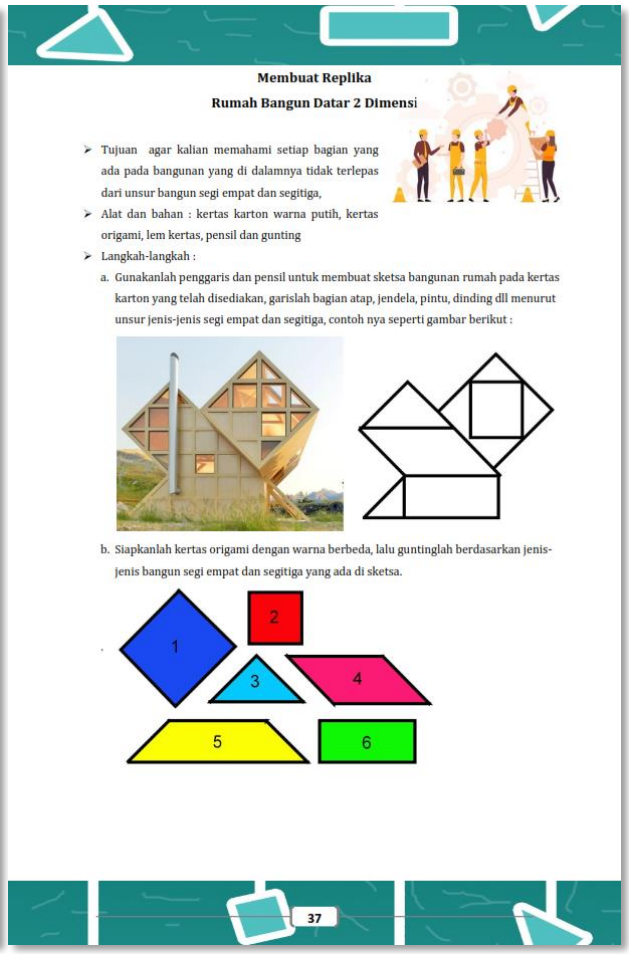

Membuat Replika
Rumah Bangun Datar 2 Dimensi

- Tujuan agar kalian memahami setiap bagian yang ada pada bangunan yang di dalamnya tidak terlepas dari unsur bangun segi empat dan segitiga,
- Alat dan bahan : kertas karton warna putih, kertas origami, lem kertas, pensil dan gunting
- Langkah-langkah :

a. Gunakanlah penggaris dan pensil untuk membuat sketsa bangunan rumah pada kertas karton yang telah disediakan, garislah bagian atap, jendela, pintu, dinding dll menurut unsur jenis-jenis segi empat dan segitiga, contoh nya seperti gambar berikut :

b. Siapkanlah kertas origami dengan warna berbeda, lalu guntinglah berdasarkan jenis-jenis bangun segi empat dan segitiga yang ada di sketsa.

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