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Assessment Instruments of STEM Project-Based Learning on Statistical Materials

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Abstrak

Sebagian besar siswa belum memiliki keterampilan menggunakan informasi, sehingga informasi tersebut kurang dapat diterapkan dalam kehidupan sehari-hari, bahkan dapat merugikan siswa. Hal ini menjadi tantangan bagi guru di era ini. Salah satu model pembelajaran yang dapat digunakan untuk menghadapi tantangan di era revolusi industri 4.0 adalah Project Based Learning. Oleh karena itu tujuan dari penelitian ini adalah untuk menganalisis kelayakan, kepraktisan, dan keefektifan instrumen penilaian pembelajaran berbasis proyek STEM. Model pengembangan penelitian yang digunakan dalam penelitian ini adalah model ADDIE. Subjek penelitian ini adalah dua kelas SMP yaitu kelas VIII A dan kelas VIII B yang akan dilakukan uji lapangan luas. Data yang dikumpulkan terdiri dari dua macam, Kualitatif dan Kuantitatif. Instrumen pengumpulan data yang akan dilakukan dibagi menjadi tiga kategori meliputi, 1) instrumen penilaian kelayakan produk, 2) instrumen kepraktisan produk 3) instrumen efektivitas produk. Hasil penelitian menyimpulkan bahwa instrumen penilaian pembelajaran berbasis Project Based Learning yang dikembangkan oleh peneliti termasuk kategori "sangat layak". Instrumen penilaian pembelajaran berbasis proyek STEM yang dikembangkan oleh peneliti termasuk dalam kategori "Sangat Praktis" dan skor angket tes kelompok besar untuk 27 siswa kelas VIIIB termasuk dalam kategori "Sangat Praktis". Instrumen penilaian Pembelajaran Berbasis Proyek STEM yang dikembangkan peneliti memperoleh hasil uji coba kelompok kecil termasuk dalam kategori "Sangat Efektif".

***Kata kunci*:** *Instrumen assesmen. STEM Project Based Learning, statistic*

Abstract

Most students do not have the skills to use information, so the information is less applicable in everyday life, and can even hurt students. This is a challenge for teachers in this era. One of the learning models that can be used to face challenges in the era of the industrial revolution 4.0 is Project-Based Learning. Therefore the purpose of this study was to analyse the feasibility, practicality, and effectiveness of the STEM project-based learning assessment instrument. The research development model used in this research is ADDIE model. The subjects of this research are two class of junior high school namely class VIII A and class VIII B which will be doing a broad field test. The data collected consists of two kinds, Qualitative and Quantitative. The data collection instrument to be carried out is divided into three category including, 1) product feasibility assessment instrument, 2) product practicality instrument 3) product effectiveness instrument. The result concluded that the STEM Project Based Learning-based learning assessment instrument developed by the researcher was declared "very feasible" category. The STEM project based learning assessment instrument developed by the researcher included in the "Very Practical" category and the large group test questionnaire score for 27 students of class VIIIB were included in the "Very Practical" category. The STEM Project-Based Learning assessment instrument developed by the researchers obtained the results of small group trials including in the "Very Effective" category.

Keywords: Instrumen assesmen. STEM Project Based Learning, Statistical

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1. INTRODUCTION

Learning in the era of the industrial revolution 4.0, students have unlimited access to information (Astuti et al., 2021; Avando Bastari et al., 2021; Robandi et al., 2019). However, most students do not have the skills to use information, so the information is less applicable in everyday life, and can even hurt students. This is a challenge for teachers in this era (Khalid, 2011; Mutakinati et al., 2018; Putri et al., 2020). Teachers must prepare learning by implementing new strategies to prepare students to face these challenges (Bayaga et al., 2021; Rashid et al., 2021; Wahyuni et al., 2021). Learning that prioritizes knowledge and overrides the content of attitudes and skills has a bad impact on students. The dominance of knowledge

in learning must be changed so that later students can compete in the era of the industrial revolution 4.0

One of the learning models that can be used to face challenges in the era of the industrial revolution 4.0 is Project-Based Learning (Jalinus et al., 2019; Made Sudana et al., 2019; Stylinski et al., 2020). Project-Based Learning is a learning model that focuses on concepts that prioritize discipline, involve students in problem-solving, allows students to work independently to build their learning, and produce student work products (Hira & Anderson, 2021; Noguera et al., 2018; Wakid et al., 2020). Project-Based Learning is a learning model that encourages students to work independently in their learning and produce real products. This project task can be interpreted as a complex task, based on challenging questions or problems, which involves students in designing, solving problems, making decisions, or conducting investigations (Basilotta Gómez-Pablos et al., 2017; Susilo et al., 2018). This project assignment provides an opportunity for students to work independently for a long time, creating products and presenting the created products. Through project assignments, students can solve problems in real life so that they can develop and improve students cognitive abilities and skills (Kavlu, 2016; Susilo et al., 2018). The advantages of Project-Based Learning are (1) the development of technical, personal, and contextual competencies; (2) student engagement with real problems from a professional context; and (3) collaborative learning is facilitated through the integration of teaching and research. These advantages are important for students' mathematics learning and align with efforts to develop 21st-century skills, including problem-solving, communication, collaboration, and critical thinking (Hanif et al., 2019; Kembara et al., 2019).

Project-Based Learning can be applied to various other learning models, for example, STEM Learning (Capraro et al., 2013; Nurtanto et al., 2020). STEM is a curriculum that focuses heavily on science, technology, engineering, and mathematics (Fitzallen, 2015; Li, Y., & Schoenfeld, 2019). STEM-oriented learning will form students' character who can recognize a concept or knowledge (science) and apply it with the skills (technology) (Jamaludin & Hung, 2017; Wai et al., 2010). STEM encourages students to master or design a method (engineering) by analyzing and calculating mathematical data (mathematics) to solve a problem (Rizaldi et al., 2020; Ting et al., 2022). STEM implementation can have a positive impact on learning, especially in improving student learning outcomes in science and technology (Hanif et al., 2019; Widiyanti et al., 2020). While STEM Project-Based Learning is a learning model that is used to meet educational needs in the face of technological advances. STEM Project-Based Learning consists of five phases, namely: 1) The preparation phase, which is to guide students to understand the theme, scope, and problem. 2) The implementation stage is the stage that provides opportunities for students to produce projects according to their designs. 3) The presentation stage is the stage that requires students to present their projects. 4) The evaluation stage is a stage that requires teachers to provide evaluations or suggestions for projects carried out by students. 5) The correction stage is a stage that encourages students to make corrections according to the evaluation obtained (Capraro et al., 2013; Gandi et al., 2019; Hussin et al., 2019).

The application of STEM Project-Based Learning in schools is still rarely done, especially for junior high school students. So far, students are only given daily assignments that contain short description questions so that it does not explore students' abilities in analyzing problems (Afriana et al., 2016; Owens & Hite, 2020; Wilson, 2021). Based on observations at Al Inayah Junior High School, Purwosari, teachers have not implemented Project Based Learning STEM learning due to the teacher lack of understanding in preparing assessment instruments. The learning that has been carried out so far has only used the lecture and discussion method, especially on statistical material. This statistical material is related to 1) analyzing data based on data distribution, mean value, median, and mode of the

data distribution to conclude, make decisions, and make predictions. 2) presenting and solving problems related to data distribution, mean value, median, mode, and data distribution to conclude, make decisions, and make predictions. This has an impact on student learning outcomes in statistical material. Based on the analysis of student learning outcomes on statistical material, it was found that as many as 62% of students got scores below the KKM. So to overcome these problems, it is necessary to develop Assessment Instruments of STEM Project-Based Learningon statistical material to make it easier for teachers to apply STEM project-based learning in mathematics classes.

Research related to the development of assessment instruments has been carried out by several researchers, including (Budiman & Jailani, 2014; Jirana et al., 2017; Nur & Rasjid, 2019). The difference between this research and previous research is that this study discusses the study of the development of assessment instruments that can be implemented in project-based STEM learning. This assessment instrument is focused on junior high school statistics. The assessment instruments in question are statistical questions for SMP based on STEM project-based learning, and scoring rubrics based on STEM project-based learning. STEM-based project-based learning statistical material questions for SMP will be displayed in the e-module. Based on these problems, the purpose of this study is to analyse the feasibility, practicality, and effectiveness of assessment instruments the STEM-project-based learning.

2. METHODS

This research is development research that aims to determine the feasibility, practicality, and effectiveness of assessment instrument the STEM-based project-based learning. The research development model used in this research is ADDIE (Boonprasom & Sintanakul, 2020; Suryaningtyas et al., 2020). The ADDIE model is used to guide the development of effective training program tools and infrastructure. This model uses 5 stages, namely: (1) analysis, (2) design, (3) development & implementation, (4) evaluation. The subjects of this study were students of class VIII A Al Inayah Middle School, Purwosari, which will be a limited field test and Class VIII B which will be a wide field test. The data collected consists of two kinds, namely: a) Qualitative, namely data in the form of input or suggestions from a team of experts and students at the time of product testing and data development process. B) Quantitative, namely data from the questionnaire results of the expert team and students during product trials, both small group trials and large group trials. The data collection instrument to be carried out is divided into three categories.

The instrument used to measure the feasibility assessment will be carried out by media experts, material experts and learning experts using the assessment questionnaire method (Handoyono & Mahmud, 2020). Then, the results of the percentage of product validation can be grouped in the score interpretation criteria according to the Likert scale so that conclusions will be obtained about the feasibility of the product, the score interpretation criteria based on the Likert scale are show in Table 1.

Table 1. Criteria Eligibility Interpretation

Percentage Completeness	Criteria
$80\% < x \leq 100\%$	Very worthy
$60\% < x \leq 80\%$	worthy
$40\% < x \leq 60\%$	Enough worthy
$0\% < x \leq 40\%$	Not worthy

The practicality of the product will be analyzed by describing the validation results which refer to the indicators or criteria that have been prepared. The practicality of the product is categorized based on two aspects, namely the theoretical aspect and the practical

aspect. The practicality of the product based on the theoretical aspect is seen from the results of the assessment or qualitative statement given by the validator. The practicality of the product based on the practical aspect can be seen from the results of the user response questionnaire after using the product that has been developed. Table 2 are the score interpretation criteria based on the Likert scale.

Table 2. Criteria Practical Interpretation

Percentage Completeness	Criteria
80% < RST ≤ 100%	Very Practical
60% < RST ≤ 80%	Practical
40% < RST ≤ 60%	Enough Practical
20% < RST ≤ 40%	Enough Practical
0% < RST ≤ 20%	Not Practical

The effectiveness of the assessment instrument based on STEM Project-Based learning is measured by two indicators, namely: student ability and student response. To determine the ability of students used tests. To find out the student's responses, the Student Response Questionnaire was used. Table 2 show the score interpretation criteria based on the Likert scale.

Table 3. Criteria Effectiveness Interpretation

Percentage Completeness	Criteria
80% < RST ≤ 100%	Very effective
60% < RST ≤ 80%	Effective
40% < RST ≤ 60%	Enough effective
0% < RST ≤ 20%	Not effective

3. RESULTS AND DISCUSSION

Results

Development of assessment instruments that can be implemented in STEM project-based learning. This assessment instrument is focused on junior high school statistics. The assessment instruments in question are statistical questions for SMP based on STEM project-based learning, and scoring rubrics based on STEM project-based learning. STEM-based project-based learning statistical material questions for SMP will be displayed in the e-module. The display of the STEM-based project-based learning assessment instrument that was developed is show in Figure 1. Then scoring rubric based on STEM project-based learning is show in Figure 2.

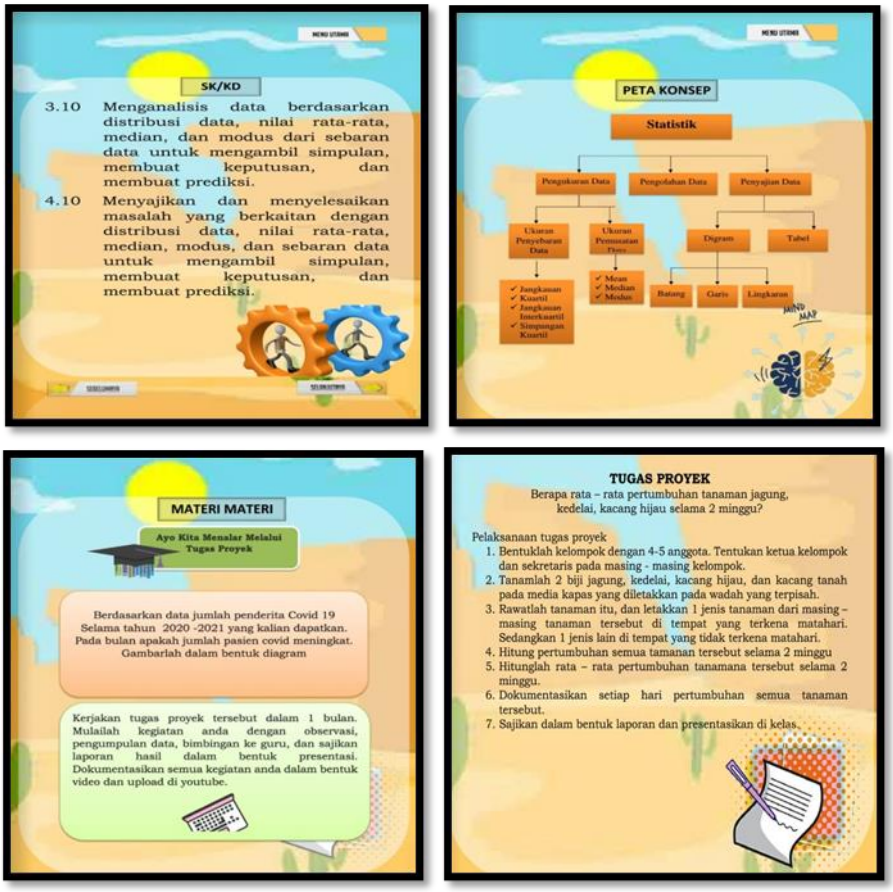
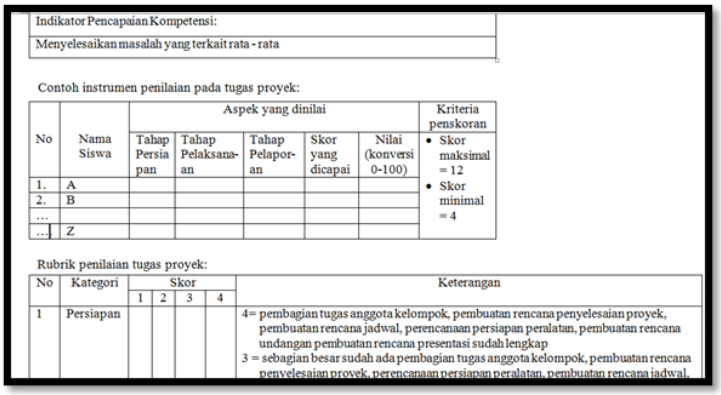


Figure 1. Task with SMP statistical material based on STEM project-based learning



Indikator Pencapaian Kompetensi:

Menyelesaikan masalah yang terkait rata - rata

Contoh instrumen penilaian pada tugas proyek:

No	Nama Siswa	Aspek yang dinilai					Kriteria penskoran
		Tahap Persiapan	Tahap Pelaksanaan	Tahap Pelaporan	Skor yang dicapai	Nilai (konversi 0-100)	• Skor maksimal = 12 • Skor minimal = 4
1.	A						
2.	B						
…							
…	Z						

Rubrik penilaian tugas proyek:

No	Kategori	Skor				Keterangan
		1	2	3	4	
1	Persiapan					4= pembagian tugas anggota kelompok, pembuatan rencana penyelesaian proyek, pembuatan rencana jadwal, perencanaan persiapan peralatan, pembuatan rencana undangan pembuatan rencana presentasi sudah lengkap 3 = sebagian besar sudah ada pembagian tugas anggota kelompok, pembuatan rencana penyelesaian proyek, perencanaan persiapan peralatan, pembuatan rencana jadwal,

Figure 2. Scoring rubric based on STEM project-based learning

The next stage is the trial stage, which is a small group trial carried out to determine the student's response to practicality and effectiveness. Table 4 presents the results of the questionnaire recapitulation and test results of participant education.

Based on Table 4, it can be seen that the results of student responses are given 12 statement items covering aspects of appearance, content, and learning with a score range of 1-4 have a very good response value, this can be seen from the average percentage given students that is equal to 86%. This number is between 80% - 100% included in the "Very Practical" category. Recapitulation results test student test try group small is show in Table 5.

Table 4. Recapitulation Questionnaire Rating Student Test Try Group Small

No.	Respondent	Aspect Evaluation			Amount Score
		Appearance	Contents	Learning	
1	SJ	17	15	8	40
2	DF	19	19	6	44
3	GD	18	19	6	43
4	VF	19	19	6	44
5	DRT	18	20	8	46
6	M N	14	18	6	38
7	TYH	14	16	6	36
8	DRT	19	14	8	41
9	OP	19	16	7	42
	Amount	**157**	**156**	**61**	**374**
	Percentage	**87%**	**86%**	**84%**	**86%**

Table 5. Recapitulation Results Test Student Test Try Group Small

No.	Name	Score Test	Information
1	SJ	75	Complete
2	DF	80	Complete
3	GD	85	Complete
4	VF	60	Not Complete
5	DRT	60	Not Complete
6	M N	80	Complete
7	TYH	80	Complete
8	DRT	85	Complete
9	OP	80	Complete
	Percentage Complete Study		**77%**

Base on Table 5 results test student which conducted on test try group small shows that of the 9 students in the class, 7 of them complete in doing the test questions given. Completed study category in work question test that is with the score on KKM that is 75. So the student percentage who have completed learning is 77% and falls into the category "Very Effective".

Results Stage Testing (Test Try Group Big)

In large group trial testing on students to knowing practicality and effectiveness product served in Table 6.

Table 6. Recapitulation Questionnaire Rating Student Test Try Group Big

No.	Respondent	Aspect Evaluation			Amount Score
		Appearance	Contents	Learning	
1	SDF	14	14	8	36
2	A A	19	19	8	46
3	DFR	18	19	6	43
4	WER	14	14	8	36
5	AW	19	19	6	44
6	DF	18	19	6	43
7	GR	19	20	7	46
8	GD	19	18	8	45

No.	Respondent	Aspect Evaluation			Amount Score
		Appearance	Contents	Learning	
9	HJ	20	19	7	46
10	KL	12	13	6	29
11	HJ	18	16	7	41
12	GY	18	18	7	43
13	FN	18	19	7	44
14	FS	19	18	8	45
15	KZ	18	19	7	44
16	GY	18	19	6	44
17	MAS	14	14	8	36
18	JK	14	15	8	37
19	MS	19	19	6	44
20	MA	18	18	6	43
21	GY	16	17	7	40
22	DD	14	14	8	36
23	FD	12	11	6	29
24	BJ	18	19	7	44
25	KL	14	14	8	36
26	MJ	20	19	8	47
27	PO	19	18	8	45
	Amount	**459**	**461**	**192**	**1.112**
	Percentage	**85%**	**85%**	**88%**	**85%**

Base on Table 6, results questionnaire participant educate on test try field showing that Assessment Instruments of STEM Project-Based Learningare given 12 item statement with batten score 1-4 which covers aspect appearance, contents and learning, obtained an average percentage score of 85% with the category "Very" Practical". This shows that the STEM project-based learning developed by the researcher is very practical to use in the learning process. Next to recapitulation data effectiveness of STEM project-based learning on students showed in the Table 7.

Table 7. Recapitulation Results Test Student Test Try Group Big

No.	Name	Score Test	Information
1	SDF	90	Complete
2	A A	65	Not Complete
3	DFR	85	Complete
4	WER	90	Complete
5	AW	90	Complete
6	DF	85	Complete
7	GR	95	Complete
8	GD	80	Complete
9	HJ	90	Complete
10	KL	75	Complete
11	HJ	80	Complete
12	GY	80	Complete
13	FN	80	Complete
14	FS	80	Complete
15	KZ	80	Complete
16	GY	85	Complete

No.	Name	Score Test	Information
17	MAS	90	Complete
18	JK	85	Complete
19	MS	65	Not Complete
20	MA	90	Complete
21	GY	100	Complete
22	DD	80	Complete
23	FD	85	Complete
24	BJ	85	Complete
25	KL	80	Complete
26	MJ	90	Complete
27	PO	90	Complete
Percentage Complete Study			**92%**

Based on the Table 7, two students did not complete the test and 25 others pass the test. To measure the effectiveness of the product by using the formula score average. The category of complete learning in working on test questions is with a score above the KKM which is 75. Until the result student percentage 92% of those who finished studying with the category “Very Effective".

Discussion

This development research produces a product in the form of an assessment instrument based on STEM Project-Based Learning on Statistical Materials. Research Assessment instruments based on STEM Project-Based Learning on Statistical Materials have the aim of knowing appropriateness, practicality, and effectiveness Assessment instrument based on STEM Project-Based Learning. Research and development of learning models or tools need to pay attention to the quality criteria to test the feasibility, practicality and product effectiveness (Hawari & Noor, 2020; Wildan, 2017). The criteria of each quality test can be determined by the researcher adjusted to the characteristics of the research. The STEM Project-Based Learning Assessment Instrument is stated worthy, practical and effective through 3 Step that is Step test validation of expert materials, media, and learning as well as stages test try small group and stage test big group.

The validity test stage is carried out by giving a validity sheet to the validation expert. The validation of the STEM-based project-based learning assessment instrument was carried out by media expert lecturers by being given 17 Items that include rules, procedures, and Assessment Instruments of STEM Project-Based Learningget a percentage of 82% which is included in the "Very feasible" category. While validation material is carried out by expert lecturers material by being given 14 questions which include rules, procedures, and presentation of material with a score range of 1-4 get a score of 45 or 80% which is included in the "decent" category. From the results of material expert validation data and Assessment Instruments based on STEM Project-Based Learning including the category "fit for use with revisions according to suggestions". Next, the teacher's response mathematics subjects who as learning experts get a percentage of 97% with the category of Assessment Instruments of STEM Project-Based Learning"Very Eligible.

The practicality assessment is carried out by providing a questionnaire to the student. The analysis of the practicality of the product was obtained from student response questionnaires and observation sheets (Juhji & Nuangchalerm, 2020; Mahiroh & Wintarti, 2020). The product trial phase was carried out twice, namely small group trials at 9 students in class VIII A showing acquisition percentage as big as 86% which included in the category "Very Practical” and acquisition the percentage of large group test questionnaire scores on 27

class VIIIB students was 85%, meaning that students gave a positive response and belong in the “Very Practical” category. The level of effectiveness is measured by the results of a test given to the student after learning to use the STEM-based assessment instrument Project-based learning. learning completeness is measured by the percentage of student which follows learning capable reach level mastery Theory minimum currently or a minimum of 80%. Group trial small, namely 9 students from class VIII A with 77% of test results completed learning which means the product is entered in the category "Very Effective". Next, that is test try group big conducted on 27 students of class VIII B with acquisition 92% student finished a study which it means including in category "Very effective".

It is in line with previous study that developed an instrument for assessing undergraduate students’ teamwork skills in designing and creating team product in the context of science, technology, engineering, and mathematics (STEM) learning (Shofiyah et al., 2022). The results show that the teamwork skill instrument is valid and reliable to measure the students’ collaborative skills in the STEM Project. In addition, the results of the three assessments showed that STEM project-based learning is effectively able to train students' teamwork skills. It is supported by other study that aimed to explore the effect of project-based learning (PBL) integrated in the STEM (Science, Technology, Engineering and Mathematics) activities, and analyze the creativity displayed by junior high school students in these activities (Lou et al., 2017). The key teaching points of the five stages of STEM project-based learning, preparation, implementation, presentation, evaluation and correction, can improve students’ creativity.

The implication of this research is to produce a product in the form of an assessment instrument based on STEM Project-Based Learning on Statistical Materials which is expected to be used by teachers in the learning process more effectively. This research is not perfect because it is still limited in analyzing the feasibility, practicality, and effectiveness of assessment instruments of the STEM-project-based learning. The limitation of this research lies in limited to the subject of field trials involving only one school, namely SMP Purwosari. So the results of this study cannot be generalized to different school situations. It is hoped that further research will be able to expand the research subject and deepen the use of the assessment instrument of STEM-based project-based learning.

4. CONCLUSION

Based on the research that has been done on the development of STEM-based problem-based learning assessment instruments, it can be concluded that the STEM Project-Based Learning-based assessment instrument developed by the researcher was declared "very feasible" by material, media and learning experts obtaining a percentage of 82% which was included in the "Very feasible" category. The STEM Project-Based Learning developed by the researcher obtained the results at the small group trial stage for 9 students of class VIII A showing a percentage gain of 86% which is included in the "Very Practical" category and the percentage gain in the large group test questionnaire score for 27 class students. VIIIB of 85% means that students give a positive response and fall into the "Very Practical" category. The STEM Project-Based Learning assessment instrument developed by the researcher obtained results in a small group trial, namely 9 students from class VIII A obtained 77% complete learning results, which means the product is in the "Very Effective" category. Furthermore, the large group trial was conducted on 27 students of class VIII B with the acquisition of 92% of students have completed their studies, which means that they are included in the "Very Effective" category.

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