



Development of 21st Century Learning Skills Assessment Instruments in STEM-Based Science Learning (Science, Technology, Engineering, and Mathematics)

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Abstract

This study aimed to develop a valid, practical, and effective 21st century learning skills assessment instrument for STEM-based science learning. This representation assessment instrument was developed with a 4 D development model with four stages, namely: definition, design, development, and distribution. The 21st century learning skills that are the focus of assessment in this instrument include critical thinking skills, creativity, communication, and collaboration. The subjects of this study consisted of 2 expert validators, 1 science teacher, and 26 students of grade VII SMP at SMPN 2 Sugio, Lamongan. Data collection methods used in this research is validation, questionnaire, observation, and documentation. Data analysis used in this study is the method of obtaining an average for each indicator, aspect, to the total mean, which is then referred to in the interval determining the level of validity & practicality of the product (scale 1-3), as well as statistical testing of paired sample T-test with descriptive statistical analysis. The results of this study are that the 21st century learning skills assessment instrument in STEM-based science learning is valid with a validity score of 2.87, is very practical to use (with a practicality score of 3), and has a positive effect on student learning skills.

Keywords: assessment; 21st century learning skills; science learning; STEM

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INTRODUCTION

In line with the nation's ideals in educating the nation's life, education is a field that often becomes development studies. This is shown from the birth of the 2013 curriculum. The government through the Ministry of Education and Culture continues to make reforms and innovations in the field of education to respond to challenges and shifting development paradigms from the 20th century to the 21st century (Kunandar, 2014). This paradigm shift is shown through the development of welfare which was originally based on resources to be based on civilization development, human resources as development burdens become human resources as development capital, and the role of the population as users becomes actors (Kemdikbud, 2013). By looking at these demands, it can be said that the development of science has an important position in that period. This is what then causes curriculum changes to be really needed to prepare a golden generation that is able to face challenges in the future.

The existence of curriculum changes will certainly lead to changes in the assessment system in learning. Assessment activities are the final activities of learning that have an important role in determining the success of students and showing the quality of the learning activities themselves. The assessment approach that is emphasized in the 2013 Curriculum is authentic assessment. Authentic assessment is a form of assessment on all aspects of learning,

both from the process to the product. In an authentic assessment, the depth of knowledge and expertise of students must be emphasized, not the quantity (Kunandar, 2014).

Judging from the nature of science and the characteristics of authentic assessment, it is appropriate if authentic assessment is used in science learning. Science learning does not only focus on a collection of facts, concepts, or theories but also on the process of discovering knowledge itself. In authentic assessment, skills assessment plays an important role in describing the learning outcomes of students. If knowledge competency describes "knowing", then skill competence reflects "can" (Kunandar, 2014). This is in line with the urgency of the 21st century learning paradigm, where education is able to ensure students have learning and innovation skills (Wijaya et al, 2016).

Skills are one of the competency domains that must be measured by students in addition to the realms of knowledge and attitudes. The realm of skills can be said to be a form of achieving the realm of learners' knowledge. In skill competency, there are six levels of skill scope, namely unconscious motion (reflex), basic movements, perceptual skills, physical skills, skills from a simple level, and communication skills either expressively or interpretively (Sudjana, 2010). The six forms of thought processes must of course be contained in each indicator on the skills assessment instrument. Assessment techniques that can be used in measuring skills competencies include practical tests (performance), project assessments, and portfolio assessments (Setiadi, 2016).

The 21st century learning paradigm requires students to have the ability to find out from various sources, formulate problems, think analytically, work together, and collaborate in solving problems (Ministry of Education Research and Development in Wijaya et al, 2016). The learning skills formulated by Trilling & Fadel are supported by the opinion of the US-based Partnership for 21st Century Skills which categorizes several learning skills needed in the 21st century known as "The 4Cs" (P21, in Zubaidah, 2016), including 1) communication, which consists of skills in conveying ideas both verbally or non-verbally, 2) collaboration, which is related to interactions between students, interactions between students and teachers, or interactions between students and people outside of school in activities learning, 3) critical thinking, which is related to the skills of thinking systematically and being able to solve problems, and 4) creativity, which is related to the ability of students to initiate new and original things. The four learning skills can be applied in science learning, especially in problem-solving based learning activities that involve motoric activities of students.

Talking about student learning outcomes in science learning, the Indonesian Student Competency Assessment (AKSI) notes that 73.61% of Indonesian students' scientific literacy is in the low category, 25.38% is in the middle category, and the rest is in the high category (Puspendik Kemendikbud, 2019). This description is supported by a survey conducted by PISA (Program for International Student Assessment) in 2015. PISA states that the average score of Indonesian scientific literacy is at 403 from the average score of scientific literacy in all OECD countries of 495. Indonesia occupies the position 62 out of 70 countries (OECD, 2015). The low science learning outcomes indicate that there is a need for renewal in a science learning approach that is more attractive and able to answer demands for human resource output to be better prepared for the 21st century.

Science, Technology, Engineering, and Mathematics (STEM) is a learning approach that appears as the urgency of 21st century skills that aim for students to successfully complete the problem-solving process using various disciplines (Corlu, Capraro & Capraro, 2014; Gulen, 2016; Yildirim, 2018b). Based on several studies that use STEM as a learning approach, it is found that STEM is able to increase scientific literacy (Ismail, Permanasari, & Setiawan, 2016; Khaeroningtyas, Permanasari, & Hamidah, 2016). STEM learning can be done in various forms of learning activities. One example in research conducted at SMPN 2 Pugung Lampung, especially in grade 8, the application of STEM was carried out through student worksheets which results showed an increase in effective scientific literacy and

students showed positive responses related to the use of these LKS (Sulistiyowati, Abdurrahman, & Jalmo, 2018). STEM-based worksheets can stimulate students to work in groups, interact with colleagues to manipulate various objects, ask questions, focus on observation, collect data and attempt to explain natural phenomena (Satterthwait, 2010). In line with 21st century learning skills, STEM also involves 4C's (creativity, critical thinking, collaboration, communication) in its curriculum (Beers in Anggraini, et al 2017). These facts related to STEM certainly further emphasize that STEM-based science learning needs to be done as a form of innovation in increasing students' scientific literacy.

Changes in the assessment system due to curriculum changes have caused several problems in schools. Based on the results of interviews with science teachers at SMPN 2 Sugio, most of the forms of assessment used in science learning so far have been test assessments (more towards the dimension of knowledge). Skills assessments are occasionally conducted (for example, such as practicum assessments), it's just that the implementation is still not optimal because the assessment process is carried out simultaneously with learning activities. This deficiency shows that the teacher actually still has difficulty making authentic assessments. In addition, learning activities at these schools are still teacher-centered, where students are still objects, not learning actors. These results in students tend to be less active in learning activities. Even though students are expected to have skills in using the knowledge they have. The skills consist of communication and information skills, thinking skills and problem solving, and interpersonal skills and self-directional (Partnership for 21st Century Skills, 2011a). If it is related to the skills assessment that has been carried out at the school, it can be seen that the assessment of 21st century learning skills has never been carried out because the learning strategies used do not stimulate the skills of students in solving problems, innovating in producing a learning product, or carrying out oriented activities. on cooperative learning.

Based on the problems that have been described previously, it is deemed necessary developed a skills assessment instrument to determine the extent to which 21st century learning skills (critical thinking, creativity, communication, and collaboration) that students have in science learning, especially those based on STEM. Assessment of 21st century skills such as assessment of critical thinking skills and creativity, has previously been carried out in the USA by applying the DTM (Design Thinking Model) model which consists of 5 stages, such as empathize, define, ideate, prototype, and test, where the results can help participants students develop many different ideas (i.e., fluency and creative flexibility) and encourage them to think of possible solutions, not just barriers (Sively, Stith, & Rubenstein, 2018). Communication skills as part of 21st century learning skills have previously been used as an object of assessment, one example is the students of SMKN 1 Seririt. The assessment of communication skills carried out in this study used 2 instruments, namely the material stimulus and the scale of interpersonal communication skills and supported by observation guidelines, which showed positive results on improving their communication skills (Dharmayanti, 2013). Assessment of creativity and collaboration skills has also been simultaneously carried out on students of the Pontianak State Polytechnic Informatics Engineering Study Program, through project-based learning using observation techniques which show an increase in the number of students who have high or very high levels of creativity and collaboration in each cycle (Sabirin, 2016). These three studies show that the urgency of achieving 21st century learning competencies is inevitable. Therefore, it is necessary to develop a skills assessment instrument to determine the extent of 21st century learning skills that students have, especially in science learning with a STEM-based approach. The difference from the skills assessment instrument that will be developed in this study compared to previous research is that all aspects of 21st century skills such as critical thinking, creativity, communication, and collaboration are measured as a whole and together through two skills assessment techniques, namely performance appraisal and project appraisal. Another novelty in this research is that learning activities are adapted to the STEM

approach, where project assignments or practicum contain integrated skills from several disciplines such as science, technology, engineering, and mathematics. Thus, to make this happen, the 21st century learning skills assessment instrument on STEM-based science learning must be developed and tested for its feasibility by reviewing its validity, practicality, and effectiveness. The overall results of these tests will be explained later in this article.

METHOD

This research is a type of research development or R & D (Research and Development) using the 4D development model which consists of stages, namely the stages of define, design, develop, and disseminate.

The defining stage begins with being carried out through several stages such as determining the problem behind product development, examining the characteristics of students who are in accordance with the product development design (which in this case is grade VII junior high school students), identifying the main concepts (learning materials) that are relevant with products developed through core competencies, basic competencies, and competencies achievement indicator, formulating the learning objectives of each learning activity to be carried out, identifying the 21st century student learning skills that become reference indicators that want to be measured in the product being developed, namely creativity, communication, collaboration, and critical thinking. In addition, the selection of science learning activities that are adjusted to the STEM principles and mapping the relationship between 21st century learning skills and STEM-based science learning is also carried out.

Table 1. Mapping Basic Competencies, Learning Material, Learning Activities, and Assessment Form 21st Century Learning Skills

Basic Competency	Learning Material	Learning Activity	21st Century Learning Skills Assessment Techniques
Doing experiments to investigate the effect of heat to	Temperature and Change.	Practicum "Long Expansion".	Performance assessment, consisting of: a. Activity assessment b. Student worksheet assessment
temperatures and states of matter and the of heat transfer.	Heat and Its Transfer.	Project 1. Make a simple thermos 2. Make a cooler pot 3. Make an eco-cooler	Project assessment

At the design stage, there are several things that are done such as: (1) compiling a grid based on a more operational list of learning skills that is adjusted to the learning material and the characteristics of students, (2) determining the checklist and rating scale used in each skill assessment instrument developed, (3) compiling an analytic rubric for each measurement indicator that has been previously set on each assessment instrument, and 4) making the overall skills assessment instrument.

The development stage can also be said to be the stage of data collection or testing of products that have been designed. At this stage, research activities are carried out by validating skills assessment instruments by expert validators with scientific backgrounds in accordance with the research theme, gathering information through the science teacher's response to the product being developed, and testing the effectiveness of the product through limited testing in learning activities by science teachers at a class.

After going through the effectiveness test in limited classes, the next step is dissemination (dissemination). At this stage, the skills assessment instrument that has been developed is handed over to science teachers to be tested in other classes, it's just that in an

undetermined time considering the conditions of social restrictions in the era of the COVID-19 pandemic. SMPN 2 Sugio limits face-to-face learning activities.

The subjects of this study consisted of 2 expert validators, 1 science teacher, and 26 students of grade VII SMP. The determination of the sample of students was done by using cluster random sampling technique. The research was conducted at SMP Negeri 2 Sugio in the academic year 2020/2021. Data collection methods used in this research is validation, questionnaire, observation, and documentation. Meanwhile, the data collection instruments used include validation test instruments, practicality test instruments, and 21st century skills assessment instruments in STEM-based science learning. The 21st century skills assessment instrument in STEM-based science learning which is developed consists of 1) performance assessment instruments, which are divided into student activity assessment instruments and student worksheet assessment instruments, 2) project assessment instruments, and 3) student worksheet. The data analysis method used in this study is 1) the average acquisition method for each indicator, aspect, and total mean, which is then referred to in the interval for determining the validity and practicality of the product (scale 1-3), and 2) statistical testing paired sample T-test with one group pretest posttest design through limited trials of product effectiveness.

RESULTS AND DISCUSSION

Characteristics of Product

The 21st century learning skills assessment instrument for STEM-based science learning is designed in two forms of assessment, namely performance assessment and project assessment. The performance assessment instrument which functions to assess the performance skills of students during the practicum is divided into 2 types, namely the instrument for assessing the activities of students and the instrument for assessing the results of the practicum report as outlined in the student worksheet. The components in the two instruments include:

Assessment Grid

In the learner activity assessment instrument, the grading grid consists of numbers, aspects of the 21st century learning skills assessment, assessment indicators, STEM categories, and assessment item numbers. In the LKPD assessment instrument, the grading grid consists of numbers, assessment aspects in LKPD, 21st century learning skills categories, assessment indicators, STEM categories, assessment weights, and assessment item numbers. Meanwhile, in the project appraisal instrument, the grading grid consists of numbers, assessment aspects, 21st century learning skills categories, assessment indicators, STEM categories, and assessment item numbers.

Table 2. Indicators of 21st Century Learning Skills on Performance Assessment Instrument

21st Century Learning Skills Category	Indicator
Creativity (Science, Mathematics, Engineering)	Fluency: a. Perform all experimental procedures smoothly and according to the scientific method. b. Perform measuring instrument calibration and read measurement results accurately. Flexibility: c. Overcoming problems in experiments based on experimental facts in a systematic and structured manner. Elaboration: d. Write down all measurements using the correct significant numbers and units.

21st Century Learning Skills Category	Indicator
	Originality: e. Write down all observations and measurements by prioritizing a scientific attitude (objective / what is and is open). f. Write down the results of data analysis by prioritizing a scientific attitude (objective / what it is and open).
Communication (Science, Technology)	Verbal: a. Discussing the results of experiments with several of his group colleagues and being able to find appropriate conclusions by using some relevant and reliable references such as books and the internet. b. Provide feedback when given instructions or questions from the teacher. Non Verbal: c. Listen to the teacher's instructions and explanations seriously.
Collaboration	a. Cooperation b. Self-involvement c. Responsibilities
Critical Thinking (Science, Mathematics, Technology)	Inference: a. Write down a provisional guess about the experiment by answering the questions on the introductory task in the form of logical propositions. Interpretation: b. Write down the results of data analysis by answering discussion questions in the form of propositions for the relationship between observed variables in the experiment. Evaluation of Arguments: c. Answering questions according to the topic and supported by a strong theoretical basis. Deduction: d. Making experimental conclusions based on observations and supported by relevant and reliable references such as books and the internet, so as to be able to answer the initial assumptions and purposes of conducting the experiment.

Table 3. Indicators of 21st Century Learning Skills in Project Assessment Instrument

21st Century Learning Skills Category	Indicator
Creativity (Science, Technology, Engineering, Mathematics)	Fluency: a. Perform all project procedures smoothly and according to the scientific method. b. Using measuring tools in project activities according to their proper function. c. The product of the project can work according to its function and the mechanism can be explained in accordance with the relevant theory. Flexibility: d. Solve problems in the project based on the facts found during the experiment in a systematic and structured manner. Elaboration: e. Testing out the product of the project, especially on its functionality and its relation to the science concept. f. Write down all observations and measurements using significant numbers and units (if any and in numbers) correctly and completely.

21st Century Learning Skills Category	Indicator
	g. Reports are written according to a predetermined format and use appropriate language and punctuation. h. The tools and materials used are in accordance with the project plan and support the functioning of the project products. Originality: i. Write down all observations and measurements by prioritizing a scientific attitude (objective / what is and is open). j. The product of the project is neat and attractive, but does not reduce the functionality of the product.
Communication (Science, Technology)	Verbal: a. Conducting discussions with colleagues in the group regarding what projects will be carried out and their working mechanisms by using books / the internet as a reference source. b. Starting and ending the presentation with greetings and using good and correct language. c. Demonstrate project products supported by the delivery of material / theoretical basis relevant to the experiment. d. Responds to audience and teacher questions in a concise (not extensive) and clear (easy to understand) manner.
Collaboration	a. Cooperation b. Self-involvement c. Responsibilities
Critical Thinking (Science, Mathematics, Technology)	Recognition of Assumption: a. Explain the things behind the implementation of the project and identify the problems discussed in the project. Inference: b. Explain the theoretical basis that is relevant and supports the project undertaken (sourced from trusted sources such as books and the internet), and formulate hypotheses (provisional assumptions) related to experiments / projects carried out in the form of logical propositions. Interpretation: c. Delivering the results of data analysis in the form of tables / graphs / propositions of relationships between variables completely and clearly so that it is easy to generalize / conclude. d. Demonstrate project products supported by the delivery of material / theoretical basis relevant to the experiment. Evaluation of Arguments: e. Answering audience and teacher questions according to the topic and supported by a strong theoretical basis.

Assessment Sheet

The components on the assessment sheet for both the performance appraisal and project appraisal instruments are generally the same, namely the identity, the assessment guide, the assessment table, a description of how the score is processed, and the assessor's signature.

Assessment Rubric

The performance appraisal rubric on the performance appraisal and project appraisal instruments is basically the same, consisting of the number, aspects and assessment indicators, and the assessment criteria for each score. The rubric used is an analytic rubric.

Student Worksheet

In the performance assessment activities, student worksheet functions as a means to assist students in carrying out practicum activities and reporting the results of these practicum

activities. The student worksheet used in this practicum activity consists of a cover page containing the identities of students, preliminary assignments, practical instructions, tables of observation and measurement results, discussion questions (data analysis), and conclusions. In project appraisal activities, student worksheet functions as a means to assist students in working on project assignments and reporting the results of these project activities. The students worksheet used in this practicum activity consists of a cover page containing the identities of students, a summary of the material, project assignment instructions, instructions for making tools, and guidelines for writing project reports such as background, problem formulation, hypothesis, results and discussion as well as conclusions.

The Expert Validation of 21st Century Learning Skills Assessment Instruments in STEM-Based Science Learning

To find out the extent to which the test is able to measure what is intended to be measured, validation is necessary (Ihsan, 2015). In this study, product validity was tested through expert validation. Expert validation was carried out by two expert validators who assessed the 21st century learning skills instrument in STEM-based science learning with several aspects of assessment such as format, content, and the language used in the instrument. Tests were conducted by two expert validators who assessed the 21st century learning skills instrument in STEM-based science learning with several aspects of assessment such as format, content, and the language used in the instrument. In the aspect of format, it is further broken down into several assessment indicators such as assessment guidelines, spatial arrangement, and score processing guidelines. In the content aspect, the things that are assessed include the suitability of the assessment with basic competencies, the suitability of the assessment with the form of STEM learning activities, the suitability of the assessment with 21st century learning skills, and defining indicators of 21st century learning skills itself. Furthermore, in the language aspect, the assessment indicators include grammatical correctness and sentence usage. In addition to practicum and project assessment instruments, student worksheet is also subject to validation testing. Not much different from the assessment instrument, the aspects assessed in the student worksheet also consist of aspects of format, content, and language. It's just that there are other aspects that are assessed in addition to these three aspects, namely the illustration aspect. Illustration is one of the supports so that instructions or explanations in the student worksheet become easier to understand and interesting for students. The number of assessment indicators on the expert validation test is 10-11 items with a score range between 1-3 on each indicator.

Based on the results of the assessment carried out by the two expert validators, the validation results were 2.88 (valid) for the performance assessment instrument, 2.92 (valid) for the project assessment instrument, and 2.80 (valid) for the LKPD. If averaged, the validity value of the entire assessment instrument reaches a score of 2.87 in the valid category.

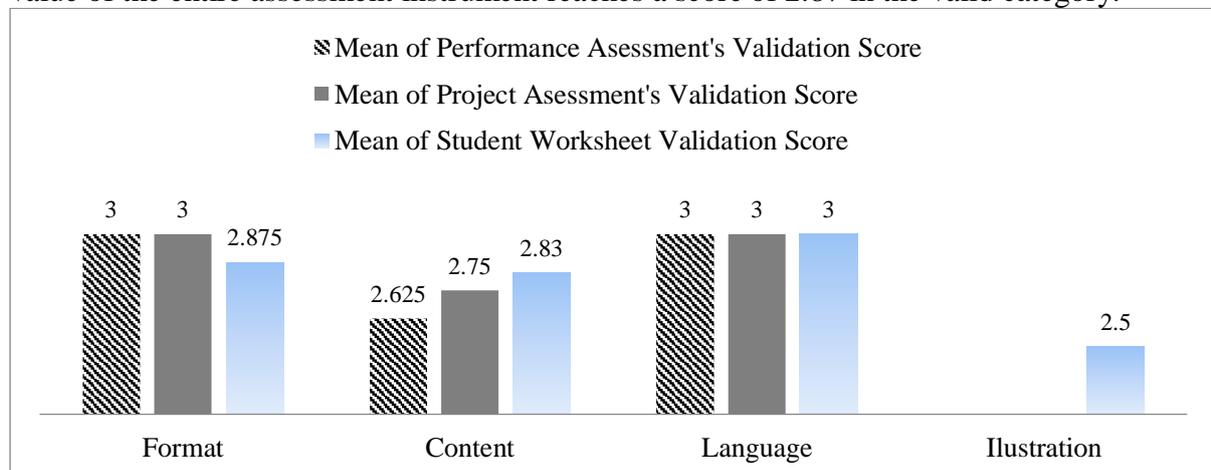


Figure 1. The results of the expert validation of the 21st century learning skills assessment instrument on STEM-based science learning for each aspect.

From Figure 1, it can be seen that both the performance assessment instruments or projects for the format and language aspects, the validation score obtained is 3 (very valid), while for aspects of 2,625 and 2,75 (valid). This is because there are assessment indicators that are not in accordance with STEM learning, namely in the aspect of creativity. Based on the results of the review conducted by the validator, STEM should be described in terms of fluency, flexibility, and originality by giving students the opportunity to determine their own practicum or project assignments to be carried out. This has been tried to be implemented in the field, but it is still ineffective. Students tend to feel clueless and just don't do the task. Lack of scientific literacy can also be the cause of these obstacles. Therefore, for practicum and project activities, descriptions of practicum activities and project assignment guidelines are still given to students, but students are given the opportunity to choose one of the project assignments and can improvise their products according to their own creativity.

The Practicality of 21st Century Learning Skills Assessment Instruments in STEM-Based Science Learning

Test of practicality was conducted by science teachers who assessed the skills assessment instrument based on its use in learning activities. The aspects assessed in the practicality test of the 21st century learning skills assessment instrument in STEM-based science learning include ease of use of instruments in assessment activities, time efficiency, clarity of assessment instructions, clarity of descriptions related to assessment criteria on rubric, use of language, guidelines for giving and score processing, the suitability between indicators and dimensions of 21st century learning skills and STEM-based learning, as well as the usefulness of instruments in supporting the task of teachers in conducting assessments and helping students in overcoming problems in learning activities. The number of assessment indicators on the practicality test was 16 items with a score range between 1-3 on each indicator.

Based on the results of the assessment that has been carried out by practitioners, the practicality test results of the 21st century learning skills assessment instrument in STEM-based science learning are 3 (very practical). Based on the results of reviews conducted by practitioners, there are not too many things that need to be improved from the instruments developed, because the assessment instruments can be used properly in learning activities. It's just that there may be some technical input, one of which is an assessment that requires more than one observer to observe student activities in more detail, so that the assessment time becomes more effective and efficient.

The Effectiveness of 21st Century Learning Skills Assessment Instruments in STEM-Based Science Learning

The effectiveness test is a feasibility test that is in development research and is used to determine the achievement of learning objectives so that the products developed are suitable for the learning process (Alfiriani & Hutabri, 2017). In this study, the effectiveness test was carried out to determine the effect of the use of 21st century learning skills assessment instruments in STEM-based science learning on the skill scores of students. This test was carried out in a limited manner in class VII-C with a total of 26 students. This skill instrument testing mechanism is carried out using a one group pre-test post-test design where data will be obtained when students' skill scores before using the 21st century learning skills instrument with the STEM approach and data on the skill scores of students after using the learning skills instrument 21st century with a STEM approach.

Table 4. Effectiveness Test Results

		Paired Differences		t	df	Sig. (2-tailed)
		95% Confidence Interval of the Difference				
		Lower	Upper			
Pair 1	Pretest - Posttest	-13.88404	-8.34673	-8.268	25	0.000

Based on the results of statistical testing with paired sample t-test, the results show that the Sig. (2-tailed) or a probability of 0.00. This means that there is a difference between the skills of students after being given treatment in the form of 21st century learning skills assessment instruments in STEM-based science learning with students' skills before being given treatment in the form of 21st century learning skills assessment instruments in STEM-based science learning. This statistical test of course has gone through normality and homogeneity testing to ensure that all data have a normal distribution and are in a homogeneous group. In addition, the average value of students' skills in science learning both before and after being assessed using the 21st century learning skills instrument was also analyzed. Based on the results of descriptive statistical analysis, the average value of students' science skills after being given treatment in the form of a 21st century learning skills assessment instrument in STEM-based science learning (80.77) was higher than the average value of students' skills before being given treatment in the form of an assessment instrument 21st century learning skills on STEM-based science learning developed (69,65). This means that the product developed has a positive effect on student learning skills.

The positive influence of students' learning skills after an assessment using the 21st century learning skills instrument developed can be caused by several factors. First, the assessment rubric. The assessment rubric used in this skills assessment instrument is prepared in a fairly detailed, clear, operational, and measurable manner so that in addition to making it easier for observers to provide assessments, it also provides opportunities for students to give their best performance. This is supported by research conducted previously by Nurhaifa, Hamdu, and Suryana (2020) who succeeded in developing a valid and reliable performance appraisal rubric in 4C skills-based STEM learning for learning in elementary schools. The rubric can assist teachers in assessing objectively based on criteria and indicators. The difference that is quite visible with the 21st century learning skills instrument in the STEM-based science learning that was developed is in the description of the indicators of the 4C itself and the skills assessment techniques used. The research consisted only of developing performance appraisal instruments, while the 21st century learning skills assessment instrument in STEM-based science learning that was developed discusses performance and project assessment instruments. However, the format of the rubric such as indicators and assessment aspects as well as category descriptions for each score is not much different.

The next factor that has a positive influence on students' learning skills after an assessment using the 21st century learning skills instrument that was developed is the project appraisal technique used in accordance with the STEM learning approach. Based on the results of observations on STEM-based learning that has been carried out especially in project activities, students are motivated to express ideas and ideas on project assignments and gain more learning experiences through several integrated disciplines. This result is also reinforced by research by Tseng et al., (2013) which states that project-based learning combined with the STEM approach can increase student interest in learning, learning becomes more meaningful so that it can improve students' mastery of concepts (learning outcomes). Rais (2010) states that through the Project Based Learning model, students' learning achievement increases because they find their learning ability through a sense of independence that is built together through learning in real contexts.

According to Permendikbud No. 66 of 2013 concerning Educational Assessment Standards, the assessment of student learning outcomes must be able to guarantee: 1) the assessment is planned according to the competence of students to be achieved, 2) the assessment is carried out in a professional, open, educational, effective, efficient, and in accordance with the socio-cultural context, and 3) the results of the assessment are reported objectively, accountably and informatively. All of these indicators have been implemented in the skills assessment instrument developed. First, the 21st century learning skills assessment instrument in STEM-based science learning is designed according to one of the basic competencies in class VII of SMP odd semester. This can be seen from the learning activities

carried out such as the practicum "Long expansion in solid substances" and the "Making Simple Thermos" project that the depth has been adjusted according to the competence of students in grade VII SMP. Second, the assessment activities are carried out openly and educatively where all aspects of the assessment are conveyed to students so that students can prepare themselves better and of course motivate teachers also to prepare more interesting STEM-based science learning activities. Third, all the results of the assessment of the skills instrument developed are assessed according to a rubric which details the limitations of scoring so that the results of the assessment can be accounted for.

CONCLUSION

Conclusions of the study can be formulated as follows: 1) the 21st century learning skills assessment instrument on STEM-based science learning that was developed measures 4 basic skills, namely critical thinking skills, communication, collaboration, and creativity of students through practicum and project activities using performance instruments (LKPD activity assessment and assessment) and project appraisal instruments, and 2) instruments for assessing 21st century learning skills in science learning STEM-based developed is declared valid, practical, and effective so that it is suitable for use in learning assessment activities.

RECOMMENDATION

The suggestions related to the use of 21st century learning skills assessment instruments in STEM-based science learning are: 1) this assessment instrument can be used by the teacher as a form of authentic assessment in science learning, especially with the STEM approach, 2) the use of this assessment instrument can encourage teachers to be more objective, accountable, and informative in conveying the achievement of students' skills, 3) the use of this assessment instrument can encourage teachers to design more interesting and creative STEM-based learning activities so as to improve students' 21st century learning skills. In addition, it is also necessary to know the deficiencies that exist in this study, namely the assessment by means of performance appraisal instruments or projects which are mostly carried out by means of observation, causing the time needed to carry out the assessment quite long considering the large number of students in the class. The solution that can be taken to overcome this problem is to increase the number of observers so that the assessment time is more efficient. In addition, for performance appraisal through practicum activities, not all aspects of 21st century learning skills can be measured and not all aspects of STEM can be adopted. Therefore, it is necessary to develop other skills assessment techniques that are able to measure all 4C's at once in an instrument as well as the development of assignment themes that are more contextual and able to integrate several fields of science according to the STEM principles.

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