USING PORTFOLIO ASSESSMENT TO ENHANCE STUDENTS' SCIENCE PROCESS SKILLS IN STEM LEARNING ACTIVITIES

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Abstract
Using portfolio assessment to enhance students' science process skills was potentially impactful in the STEM learning activities. Its benefits to navigate students gaining comprehensive experiences is necessary. The objective of this study was to examine portfolio assessment in enhancing students' science process skills in STEM learning activities. A quantitative research approach was implemented, with a sample of 33 students between the ages of 14 and 16, drawn from Indonesian public senior high schools. The instrument used to collect the data was a test. It consisted of multiple-choice and open-ended questions. The data were analyzed by using descriptive statistics. The findings reveal key indicators of science process skills in STEM learning activities, identifying portfolios that influence students' engagement and understanding within the STEM learning activities. Importantly, this study highlights the critical role of encouraging students to ask questions, which can significantly enhance their science process skills.

Keywords: Portfolio, Science Process Skills, STEM learning

INTRODUCTION
In recent years, there has been a growing emphasis on using authentic assessment in teaching and learning processes (Chere-Masopha & Mothetsi-Mothiba, 2022). This trend has also been observed in the field of science education, where portfolios have emerged as a viable instrument for assessing and enhancing STEM learning (Oferdahl & Impy, 2012). The use of portfolios, which are a collection of students who work overtime, can provide insight into
students’ attitudes, knowledge and skills related to STEM subjects (Costa et al., 2020; Larkin & Lowrie, 2022; Wahono et al., 2020).

Assessments in STEM education are designed to assure student proficiency in course learning outcomes as part of a scaffolded approach (Shidiq & Faikhamta, 2020). In countries like Singapore, Finland, and Japan, STEM education assessments are intricately designed to gauge not only students' knowledge but also their application skills and critical thinking. Singapore, for instance, employs a holistic assessment model that emphasizes both theoretical understanding and practical problem-solving abilities. Finland, known for its innovative education system, incorporates collaborative projects and real-world applications in its assessments. Meanwhile, Japan focuses on rigorous testing combined with hands-on learning experiences, ensuring that students are well-prepared for technological advancements and industry demands (Bărnuțiu-Sârca & Ciascai; Wahono et al., 2020; Yata et al., 2020).

In addition, portfolio assessment is an effective way to supplement traditional assessment methods (Morris et al., 2021; Normayanti et al., 2020; Oferdahl & Impey, 2012). The visionary goals of using portfolios were measured by the school attitude assessment survey-revised and students’ attitudes towards science instruments. This measure is to indicate student’s engagement level towards STEM education. For instance, studies conducted by Brandmo et al. (2020) and Guzey et al. (2016) found a positive correlation between students’ attitudes in the peer discussion groups which improved an effective way of implementing the assessment rather than formalized written peer commentary. Students can take a particular action to engage in creating a meaningful inside from their feedback: core feedback, attractive oral feedback, beginning dialogue and cooperating with peers.

Since the portfolio was introduced in Indonesia in 2019 by the Ministry of Education and Culture in Indonesia, this idea has gained more attention in other parts to promote and encourage portfolio assessments in the Indonesian curriculum and implemented at the school context (Priatna et al., 2019). For the successful implementation of portfolio assessment, using STEM education is required (Guzey et al., 2016). The feature of STEM education could help students to make decisions and act at the global challenge and society (Guzey et al., 2016; Hığde & Aktamış, 2022). Using portfolios in STEM education could also be exercised by students (Morris et al., 2021; Normayanti et al., 2020). It is also could also improve students’ science process skills in the learning process activities (Hsiao & Su, 2021; Kim, 2020; Larkin & Lowrie, 2022; Oferdahl & Impey, 2012).

However, there are several challenges in implementing STEM learning and portfolio assessment in the school context. Studies from (Chere-Masopha & Mothetsi-Mothiba, 2022; Costa et al., 2020; Guzey et al., 2016; Harahap et al., 2019) have shown that students have confronted the obstacles in the project when learning integrated STEM lessons and using portfolios to collect their work; these challenges included: (1) the lack
of time to create a final project as well as challenges encountered during the process of learning, (2) the lack of students understanding of learning design and assessment to provide questions and tackle challenges that promote higher-level learning, (3) the lack of learning resources and material to improve classroom practice and multiple measure of learning, (4) the lack of learning STEM and using portfolio assessment in the school.

In our study, we argue that students should learn STEM education initiatives to improve proficiency in STEM fields to prepare for their careers related to the 21st century, requiring critical science skills such as inquiry and scientific visualization. Also, a study of Nurhayati, et al. (2022), resulted that learning using STEM-based modules had an effect on students' higher order thinking skills. In addition, STEM integrated learning produces problem-solving skills. Its effect sizes with high criteria were found to be critical thinking, learning outcomes, and affective (Lufri et al., 2023).

The purpose of our study is to examine the ability of portfolio assessment for capturing students' science process skills practices regarding the process of STEM learning activities (Astuti et al., 2021). The portfolio assessment is a valuable tool for assessing student activity and achievement and promoting engagement and motivation among students (Banks & Barlex, 2020).

The tool could be implemented in the school curriculum, since the Indonesian Government has mentioned using portfolio assessment in the National frameworks for teaching and learning science, emphasizing inquiry skills and scientific practices as essential components (Inayah et al., 2020). Therefore, portfolio assessment aligns well with these frameworks as it allows for the evaluation of student's progress towards achieving these skills and practices as a supplementary tool to enhance STEM learning, specifically to improve students' science process skills (Sagala et al., 2019).

By assessing students' work overtime, portfolios can provide a comprehensive and holistic view of their skills development in STEM subjects (Normayanti et al., 2020). Furthermore, portfolio assessment can promote student engagement and motivation as they have more ownership over their learning (Oferdahl & Impey, 2012; Shin et al., 2018; Wahono et al., 2020). It is therefore recommended that educators and policymakers consider implementing portfolio assessment in their STEM programs to enhance students' learning experiences, foster engagement, and promote academic achievement (Oferdahl & Impey, 2012).

METHODS
Research Design and Collection
This study applied the quantitative method which was carried out to understand a research problem (Hall & Hall, 2020). It is also focused on purposeful sampling and conducting in-depth case studies which is a research problem based on the trends in the fields and the need to explain why the findings occurred (Salmona et al., 2019).

This phase assessed the science process skills of students learning in STEM learning activities using...
portfolio assessment. The form of portfolio was administered to an experimental population of students to evaluate the learning process and its outcomes (Liu, 2022). In order to have valid and represented portfolio assessment, the items of it were required to be evaluated. Hence, it was sent out to adjust the The instruments consisted of multiple choice and open-ended questions, and participants provided their perspectives on the implementation by providing feedback, comments, and notes in response to the questions (Salmona et al., 2019).

**Research Participants**

The population of this study comprised 33 seventh-grade Indonesian secondary school students who have studied science subjects in their classroom. This section is intended to provide participants with science process skills. The examinations were administered to evaluate students' comprehension of the overall concepts, and portfolio evaluation was used to document their work. This study sought to comprehend the participants by examining what occurs in the present (Ekoto et al., 2022).

In addition, this study's instrument underwent multiple revisions based on feedback from the validator and subject matter experts. The purpose of revising instruments was to provide students' STEM learning with a proper measurement. The revision was also to figure out the abilities of portfolio assessment, as well as its vocabulary for describing the structure adequately.

The authors included achievement as a secondary selection criterion because this study acknowledges that students may place a greater emphasis on cognitive abilities. In order to increase the probability of obtaining sufficient data, 33 students have been selected as participants, as this helps clarify concepts and present practices in the public Indonesian senior high schools. Participants' ages range from 14 to 16 years old, and they have school-level science-learning experience (Hiğde & Aktamış, 2022; Liu, 2022).

**Statistical Analysis**

Students have to respond and complete the test in each stage of learning. The researchers evaluated students' knowledge of science lesson implementation in this section. In addition, the authors acquired data on the students' critical thinking and collaborative problem-solving abilities. These instruments were chosen for several reasons, including the fact that teachers and students were already familiar with questionnaire tests and assessing students' comprehension and knowledge of learning concepts (Liu, 2022). Consequently, these instruments have been used to evaluate secondary school students' perspectives on broad scientific concepts.

At the end of the semester, a portfolio assessment was used to analyze students' science process abilities about the overall concept of science learning at an implementation of STEM learning (Oferdahl & Impey, 2012). Researchers have employed quantitative methods of analysis. The numerical data and field notes from the test established the quantitative data.

The results of the quantitative approach was analyzed by using
software programs such as IBM SPSS and JASP software has been analyzed to describe students' thinking skills. The statistical descriptive analytics results have been calculated to evaluate the frequency and proportions and provide useful information for portfolio assessment (Hall & Hall, 2020).

In this section, the authors have also analyzed the descriptive statistics by expressing the mean from the learning implementation. The statistical analysis and measurement of scales consisted of questions with multiple scoring points that were used to assess students' science process skills. During the implementation of science lessons, providing the context of the study is the key to involve the conception in real-world problem situations, numerical data and field notes from tests established the quantitative data (Normayanti et al., 2020).

The results of quantitative software programs such as IBM SPSS and JASP software have been analyzed to describe students' thinking skills. The descriptive analytics results have been used to evaluate the frequency and proportions and also provide useful information to numerous individuals (Hall & Hall, 2020). In this section, the authors have also analyzed the descriptive statistics by expressing the mean from the learning implementation. The statistical analysis and measurement of scales consisted of questions with multiple scoring points that were used to assess students' science process skills during the implementation of science lessons by providing the context of the study by involving the conception in real-world problem situations (Alston, 2020).

RESULTS AND DISCUSSION

This part reported on the results of our study and the discussion from the STEM learning activities through applying portfolio assessment to expand students' science process skills. The overall goal of our study was to improve students' proficiency in STEM fields in preparing for 21st-century skills at this point in time. To accomplish this, students' science process skills during STEM learning activities were examined. Each of these skills has emerged in the context of global requirement skills.

Students’ Experiences using Portfolio Assessment during STEM Learning Activities

According to the Indonesian Ministry of Education and Culture (2017), it is required for students in Indonesian schools to participate in a minimum of five hours of science education every week. In this educational activity, students engage in the development of knowledge and skills in the fields of STEM through the utilization of portfolio assessment (Sukmayadi & Yahya, 2020).

This assessment method involves the systematic collection and evaluation of students' work across the six phases of the learning process. Based on the study conducted by (Bozkurt Altan & Tan, 2021), the researchers incorporated a five-stage construct process. These stages include
problem orientation, problem formulation, investigation leadership, difficulty solution, and reflection on investigation results, as depicted in Table 1.

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| 1  | The lesson starts with the problem and essential question | At this stage students are in groups:  
1. Given a discourse related to the problem material  
2. Understand the content of the discourse  
3. Answer questions based on the content of the discourse |
| 2  | Problem analysis and design of the project | At this stage students are given a project assignment from the tool and material brought by each group of students and determine:  
a. The purpose of the study  
b. Tool and material  
c. Drawing of the experiment and procedure  
d. Observation data |
| 3  | Discovery and development of the scheduled project | At this stage students are asked questions about the time they will spend working on the project portfolio. These questions are also useful to determine students’ ability to understand the material that has been taught by the teacher. |
| 4  | Implement the project | At this stage students carry out a project to make simple tool and test them. Then students fill in the contents of students’ worksheet in the form of observation data from the experiment. |
| 5  | Assess the final result | At this stage students are asked to answer two questions regarding the discussion of the experimental results based on observation data and make a final conclusion, then the teacher instructs each group to present the results of their project. |
| 6  | Evaluate and overview the result | At this stage students are given several questions and a questionnaire of student responses regarding learning using project portfolios. After that, students are asked to answer the questions and give their responses regarding the results of making simple tools. |

On the other hand, the implementation of STEM learning activities has the potential to enhance students' concentration on science and mathematics, as well as their understanding of the crucial role played by engineering and technology in preparing them for real-world scenarios (Chere-Masopha & Mothetsi-Mothiba, 2022).
Research showed that STEM education is an instructional method that has the potential to enhance students’ active learning and comprehension of scientific concepts and their application in real-world problem-solving environments (Bozkurt Altan & Tan, 2021; Oferdahl & Impey, 2012; Thi To Khuyen et al., 2020). The significance of this study depends on its ability to enhance students’ learning experiences through the exploration of their knowledge and the cultivation of 21st-century abilities (Thi To Khuyen et al., 2020; Wahono et al., 2020).

Furthermore, numerous studies have provided forth the argument that the utilization of portfolios presents a promising chance for gathering students’ work over an extended period. This approach offers valuable insights into their attitudes, knowledge, and skills about STEM disciplines, thereby serving as an effective tool for both assessment and improvement of STEM education (Kim, 2020; Koraneekij & Khaisang, 2019; Larkin & Lowrie, 2022; Liu, 2022; Oferdahl & Impey, 2012).

Assessment of Students’ Science Process Skill during STEM Learning Activities

Students’ science process skills indicated their level of understanding to apply theoretical knowledge to real world scenario. STEM learning activities that students carry out reflecting their subject mastery. The practice in the experiments can be done through the accumulation of experiences and cognitive aspect (Hsiao & Su, 2021; Thi To Khuyen et al., 2020). Hence, to figure out the quality of performance that students have done in doing STEM learning activities, it is necessary to utilize an instrument to indicate their level of students’ science process skills.

Portfolio assessment as an instrument is appropriate for measuring students’ science process skills. This instrument requires reasoning in every single step that can identify the purpose of the activity (Akiri et al., 2021). In STEM learning activities, students are always asked to conduct an action that is proper to show the expected result. Therefore, to achieve the learning outcomes, portfolio assessment was beneficial to identify students’ science process skills (Inayah et al., 2020). The following is the result of the science process skills of students who were conducting STEM learning activities measured by using a portfolio. As an instrument, portfolio assessment was predicted to lead students’ activities to enhance their understanding of STEM learning activities. This assessment’s influence on measureing students’ science process skills was potentially helpful in identifying which indicator that is the most affected in students’ STEM learning activities.

By knowing the most influential indicator, portfolio assessment can develop students’ thinking in STEM education. As can be seen from figure 1 below, conducting observations was the most affected indicator using portfolio during STEM learning activities with the value of average of 98.7. This indicates that as the teacher, students must be provided with the space for students to participate...
actively in STEM learning activities. Hence, they were able to express themselves and keep learning new experiences. Meanwhile, the lowest indicator of students’ process skills was the ability to ask questions with a value of an average of 56.7. This result was so important to interpret. Students did not ask any questions during STEM learning activities could be possibly meant in two ways, whether they did understand the learning process, or they were facing learning obstacles.

Students engaged in data collection during STEM learning activities are relevant to scientific experiments. Although, they were conditioned to do observations, they were essentially recording new information, gathering evidence, and validating the results. This portfolio as an instrument navigated students to have a good opportunity to understand what objective they wanted to achieve from STEM learning activities. It would be beneficial, therefore, since students can derive meaningful insights from it.

Meanwhile, the result that students might not ask any questions during STEM learning activities may seem negative. The function of a portfolio as a tool is to assess an individual's skills, knowledge, or performance in a particular field. Hence, the lack of questioning may indicate that students were not confident in their knowledge or were not interested in STEM learning activities.

This study delved into the application of portfolio assessment as a means of enhancing students' science process skills within the context of STEM learning activities. The overarching objective of this study was to enhance students' proficiency in STEM education, equipping them with the skills necessary for the challenges of the 21st century.

This entailed a comprehensive examination of students' science process skills, which are becoming
increasingly indispensable on a global scale. By drawing from insights into the systematic collection and evaluation of student work across different phases of the learning process, this study aligns with the imperative set by the Indonesian Ministry of Education and Culture for a minimum of five hours of science education weekly (Sukmayadi & Yahya, 2020).

In parallel, the incorporation of STEM learning activities has demonstrated the potential to intensify students' focus on science and mathematics, while also nurturing their understanding of the pivotal roles played by engineering and technology in addressing real-world scenarios (McCurdy, Nickels, & Bush, 2020; Yata, Ohtani, & Isobe, 2020). The significance of this study is to enrich students' STEM learning experiences by using portfolios of their knowledge and fostering 21st-century competencies (Okulu & Oguz-Unver, 2021; Yata et al., 2020).

Moreover, the findings resonate with the growing body of research that underscores the promise of using portfolios to accumulate students' work over extended periods, offering valuable insights into their attitudes, knowledge, and skills, and thereby serving as an effective instrument for both the assessment and enhancement of STEM education (Morris et al., 2021; Normayanti et al., 2020).

Students actively participating in data collection within the context of STEM learning activities play a pivotal role akin to that in a scientific experiment (Bybee, 2019). While they are initially guided to conduct observations, their primary role is to articulate new information, compile compelling evidence, and validate the results (Chan & Holbert, 2020).

In this context, the portfolio assessment, serving as a valuable instrument, plays a guiding role for students, offering a meaningful opportunity for them to comprehend the precise objectives they aim to achieve within STEM learning activities (Koraneekij & Khlaisang, 2019). This proves to be highly beneficial as it empowers students to extract substantial insights from their engagement in these activities (Akiri et al., 2021).

On the other hand, the observation that students tend to ask fewer questions during STEM learning activities might initially appear as a negative outcome (Kim, 2020). The core function of a portfolio, in its capacity as an assessment tool, is to evaluate an individual's skills, knowledge, and performance within a specific field (Priatna et al., 2019). The scarcity of student-initiated questions may, on the surface, signal a lack of confidence in their understanding or a diminished interest in the realm of STEM learning activities (Ata-Aktürk & Demircan, 2021).

This observation might be attributed to various factors, including cultural or social influences, such as the misconception that asking questions implies weakness or reflects inadequacy in knowledge (Al Salami, Makela, & De Miranda, 2017). Consequently, the portfolio assumes a vital role in tracking and offering a comprehensive assessment of students' process science skills (Hiğde & Aktaşı, 2022). To provide a valid
rationale for this, it is imperative to recognize that students' performance in STEM learning activities may vary over time, even when they can consistently answer questions correctly in cognitive tests (Hiğde & Aktamuş, 2022; Hsiao & Su, 2021; Kim, 2020). Therefore, a portfolio can be used to track and provide a comprehensive view of a student's process science skills.

CONCLUSION AND RECOMMENDATIONS

In conclusion, this study was dedicated to investigating the efficacy of portfolio assessment as a tool to augment students’ science process skills within the dynamic sphere of STEM learning activities. The overarching aim was to enhance students’ proficiency in STEM education, arming them with the essential competencies required to tackle the complexities of the 21st century.

This endeavor entailed a comprehensive exploration of students' science process skills, which are progressively becoming paramount on a global scale, in alignment with the Indonesian Ministry of Education and Culture's mandate for a minimum of five hours of weekly science education.

In the context of STEM learning activities, students actively involved in data collection assume a role analogous to that in a scientific experiment, and the portfolio guides them effectively in clarifying their objectives and extracting profound insights.

Conversely, the observation that students tend to ask fewer questions during STEM learning activities may initially seem negative. However, this observation underscores the importance of the portfolio as an invaluable tool for evaluating and comprehensively assessing students' process science skills. It is crucial to recognize that students' performance in STEM learning activities may exhibit variations over time, even when they consistently provide correct answers during cognitive assessments.

Moreover, the study lacks explicit details on the criteria and metrics used for portfolio assessment, potentially impacting the reproducibility and comparability of results. To address these limitations, future research is recommended to explore the efficacy of portfolio assessment across various cultural and educational contexts. Additionally, this study recommends that future research should continue to explore the efficacy of portfolio assessment as a tool for enhancing students' science process skills within STEM learning activities. This investigation can be extended to different educational contexts and grade levels to evaluate its applicability and effectiveness in diverse settings.

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