Critical thinking skills profile in the ETNO-STEAM science learning model implementation in the university: A case study

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Students' ability to comprehend how concepts from science, technology, engineering, art, and mathematics can be used in the cultural setting in which they live can be improved through the study of Ethno-STEAM. Students that possess critical thinking abilities can solve complex issues, broaden their viewpoints, and make better decisions. This study's objective is to investigate the profile of critical thinking abilities among children who are learning science utilizing an Ethno-STEAM approach. The qualitative case study research approach was used in this study. 46 students were selected in the research sample using a non-probability purposive sampling technique. An open description test of critical thinking abilities was used as a test technique in this study, along with non-tests such as in-depth interviews and non-participatory observation. Data preparation, indexing, category and theme formatting, thematic analysis, and reporting are all aspects of data analysis. The study's findings suggest that students have good problem-solving abilities. Student communication abilities are also quite strong, as seen by their capacity to convey knowledge despite heavily relying on literature. Students' generalization skills have not yet been put to the test by generalizations that are narrowly focused on one scientific field. Reflection is now possible, although there are still a number of unidentified problems. Students have outstanding execution abilities when it comes to using their knowledge to solve challenges. The ability to blend information from other fields to recognize more intricate interrelationships when handling a case also contributes to student self-regulation. The results of this study provide important findings that students have demonstrated a profile of critical thinking skills that is extremely adequate through the application of the Ethno-STEAM science learning. So that they may continue to adapt to the times and preserve the culture around them, this can assist students in developing their skills in tying science, technology, and engineering to culture.

Keywords: Critical thinking skills; ethnoscience; ethno-STEAM; science learning model; STEAM.

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1. Introduction

In the era of Society 5.0, 21st-century skills have been increasingly relevant and essential in preparing individuals to face with technological changes and social complexities [1]. Developing these skills will help individuals adapt, innovate, collaborate, and actively participate in a digitally connected and technologically-based society [2]. Critical thinking skills are key factors in the era of Society 5.0, where abundant information and data are available [3] 2022). Analyzing information, evaluating valid resources, and making informed decisions are essential in addressing the complexities and challenges of a technology-driven society [4].

Critical thinking skills are the ability to analyze information objectively, identify persuasive arguments, make competent decisions, and deal with complex problems [5]. In the information-rich era, these skills are crucial for individuals to properly select, evaluate, and effectively use information [6]. Critical thinking involves actively analyzing, evaluating, and problem-solving in a rational, logical, and reflective manner. It requires deep thinking, critical examination of information, and the development of arguments or judgments based on strong evidence and also reasoning [7].

Several experts have presented indicators of critical thinking skills, including the ability to: (1) identify and clarify problems; (2) collect and evaluate information; (3) identify assumptions and implications of an argument; (4) develop strong arguments based on relevant evidence; (5) think logically and rationally; and (6) identify and overcome biases and perceptions that may influence its cognition [8,9]. Other experts have included indicators such as the ability to: (1) identify and classify various types of arguments; (2) identify the assumptions underlying the argument; (3) evaluate the validity and strength of supporting evidence; (4) identify and address logical errors or biases in thinking; and (5) develop strong and logically supported arguments [10,11]. In this research, the indicators of critical thinking skills encompass analyzing problems, communicating, generalizing, reflecting, implementing, and self-regulation.

Critical thinking skills are crucial in various contexts, including education, employment, and daily life [12,13]. Possessing these skills enables individuals to make better decisions, face complex challenges, and develop broader and more objective perspectives [14]. Critical thinking skills can be enhanced through interactive, collaborative, and participatory learning environments [15]. Learners can actively par-

ticipate, engage in discussions with peers, and collaborate on completing assignments or projects [16]. This supportive environments allow learners to practice their critical thinking through dialogue, critical thinking toward others' perspectives, and developing well-founded arguments based on evidence and strong logic [17].

Creating an innovative, interactive, collaborative, and participatory learning environment through a multidisciplinary approach is the essence of implementing the STEAM learning model. STEAM learning is an interdisciplinary learning approach that holistically integrates Science, Technology, Engineering, Arts, and Mathematics [18]. The aim is to integrate the understanding and application of concepts and skills from various disciplines in order to solve complex problems and to promote critical thinking, creativity, and collaboration [19]. Basically, the STEAM learning model seeks to break down barriers between disciplines and promote a holistic approach to learning [20]. This approach enables learners to develop the skills required in the real world, such as critical thinking, teamwork, communication, creativity, and problem-solving [21,22].

The Ethno-STEAM learning model combines ethnosciences with the STEAM approach [23]. The relationship between the Ethno-STEAM and STEAM models lies in the integration of disciplines, emphasis on cultural context, development of critical and creative thinking skills, and cross-cultural learning [24]. The Ethno-STEAM model enriches the STEAM approach by introducing cultural dimensions, values, and students' experiences into STEAM learning, thus enhancing the relevance and meaningfulness of learning in specific cultural contexts [25]. The Ethno-STEAM learning model allows learners to see the relationship between science, technology, and cultural aspects more integrated [25]. Learners can understand how scientific and technological concepts can be applied in their cultural context, and vice versa, how culture can influence the development of science and technology [26]. The Ethno-STEAM learning model also promotes cross-cultural learning, mutual understanding, and appreciation of cultural diversity. Learners can develop critical thinking, creativity, and teamwork while learning and bridging the understanding between science and culture [27-30].

Several studies have explored Ethno-STEAM [30-36] and critical thinking skills [36-44]. However, this study provides novelty by combining two concepts are called critical thinking skills and the Ethno-STEAM learning model, in the context of higher education in universities. This research explores the potential utilization of the Ethno-STEAM learning model to enhance students' critical thinking skills in science. Through this approach, we seek to explain the understanding of science learning, which focuses not only on conceptual aspects but also considers cultural contexts and creative aspects in developing students' critical thinking skills. Thus, this study provides a new contribution to higher education by integrating the Ethno-STEAM approach into science teaching and enhancing understanding of the potential of innovative learning models to strengthen students' critical thinking skills in the university environment. Therefore, this research aims to analyze the profile of critical thinking skills by applying the Ethno-STEAM science learning model to students.

2. Method

The qualitative method was used in this study. Qualitative case study research is an in-depth and detailed approach to studying a specific case or phenomenon [45]. This research aims to deeply understand a case's context, characteristics, processes, and significance within a broader social, cultural, or organizational context [35]. In qualitative case study research, the researcher collected rich and in-depth data through various techniques such as tests, observations, interviews, and document analysis. The main objective is to gain a comprehensive and complex understanding of students' critical thinking skills through the Ethno-STEAM learning model.

The limitations of this study lie in the generalizability aspect. It was conducted within a university context and environment, meaning the results may not be directly generalizable to other contexts and populations. Furthermore, the research sample is limited. The small number of participants or insufficient variation within the student population may affect the external validity and generalizability of the research findings. The limited duration of the study can also be considered a limitation since it may restrict the ability to observe long-term changes in students' critical thinking skills. The results of this study only reflect the short-term impact of the Ethno-STEAM Science learning model.

Sample and sampling technique

The research sample consists of 46 students. The sampling technique used in this study is non-probability purposive sampling. Purposive sampling is based on the researcher's judgment in selecting the most relevant, representative, and potentially informative samples related to the research objectives [48]. In this technique, the researcher selects samples with specific characteristics or qualities necessary to achieve the research objectives [44]. The study defined the sample criteria as follows: (1) students enrolled in the Physics Education, Madrasah Ibtidaiyah Teacher Education, Primary School Teacher Education, or Science Education Study Programs; (2) students attended in Physics, Biology, Basic Concepts of Science, Basic Physics, Basic Biology, Integrated Science, Integrated Science, and/or Innovative Science Learning; (3) students willing to participate as research subjects.

Data collection techniques

Data collection in this research used both test and non-test techniques. The test technique assesses students' critical thinking skills through open-ended questions. The test instrument has been validated and tested for reliability. Instru-

ment validity was examined through content validity, conducted by testing the instrument with language experts, science education experts, and evaluation/instrument experts. Whereas, reliability refers to the consistency of the test instrument in measuring the same variable when used repeatedly, a test-retest reliability test was conducted. The non-test technique has been used including in-depth interviews and non-participatory observation. In-depth interview data collection was used in qualitative research to gain a profound understanding of subjects' experiences, perceptions, views, and thoughts [25]. In this research, in-depth interviews involved direct interaction between the researcher and the respondents through semi-structured interviews. The interviews were conducted one-on-one between the researcher and the respondents. The researcher listened carefully and provided respondents to explain, explore, and elaborate on their experiences or perspectives. The researcher may also ask follow-up questions to gain a deeper understanding. During the interviews, the researcher can use recording devices (with respondents' permission) or take written notes to record respondents' responses and statements. These recordings will assist respondents in more detailed and accurate data analysis. Furthermore, data in this research were also collected through non-participatory observation. The data collection technique of non-participatory observation allows the researcher to directly observe events or behaviors without active involvement or influence [30]. This method helps deeply understand the context, interactions, and observed phenomena. The researcher used field notes, cameras, or audio/video recordings to record and document observations.

Data collection techniques

The data analysis technique used in this research employs the interactive data analysis technique by [11] which involves a series of structured steps to organize, categorize, and interpret the collected data [30]. The interactive data analysis technique stages are as follows: First is data preparation. The initial step is to prepare the data for analysis. This stage involves transcribing interviews, field notes from observations, organizing documents related to critical thinking skill tests, or categorizing data according to the data collection methods used. The second is indexing. The researcher indexes the collected data by labeling or coding relevant data units related to the research topics. Third is category and theme formation. The researcher begins to form categories or themes that emerge from similar data based on identified similarities or concepts. Fourth is thematic analysis. After forming categories and themes, the researcher conducts thematic analysis by identifying relationships between categories or themes, highlighting common patterns, differences, or interesting aspects of the data. Finally, report preparation. The last step is to compile the research report reflecting the analysis results.

3. Results and discussion

Data for this research was obtained through interviews, observations, and critical thinking tests in science lectures using the Ethno-STEAM model, indicating that the researcher employed a comprehensive approach to gather information and understand students' critical thinking abilities. By combining interviews, observations, and critical thinking tests in science lectures using the Ethno-STEAM model, the researcher could collect holistic data about the model's influence on students' critical thinking abilities. This approach allows the researcher to gain a better understanding of how the Ethno-STEAM model can stimulate and enhance students' critical thinking skills in science learning.

Problem analysis

Data were collected through a critical thinking skills test for the indicator of problem analysis in students' critical thinking skills. The test was conducted with open-ended answer questions as follows:

Question:

Observe the mask-making process in Fig. 1!

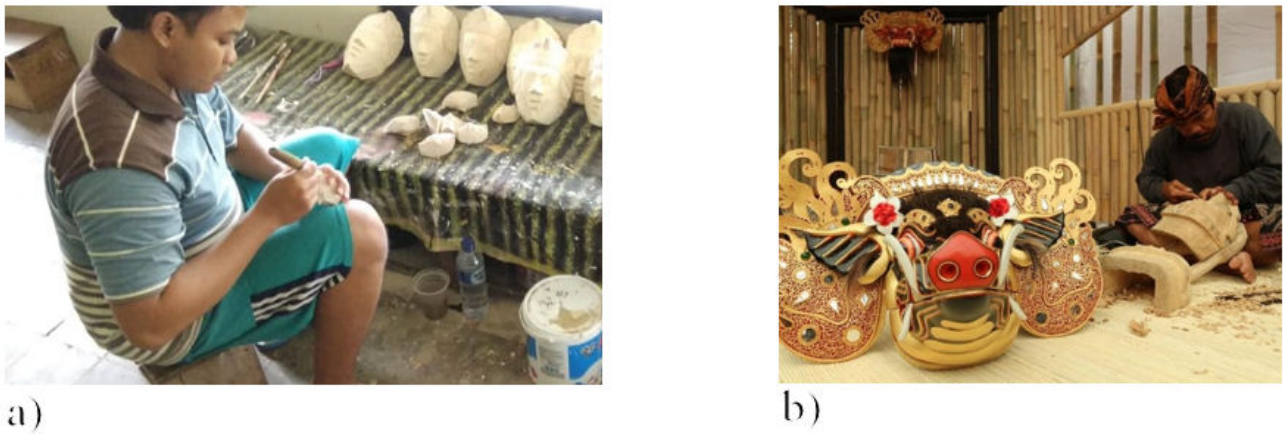

FIGURE 1. Mask-Making.

Analysis of Student's answer 1:

Unable to compare the two images even though they show different sitting postures. However, it does not identify which parts of the back body are affected and how it does.

Analysis of Student's answer 2:

This person has compared both images but has not identified the incorrect sitting posture on the upper back and neck (although, it was mentioned that the lower and middle back postures are good).

This is consistent with the interview results of some students who stated, "I did not see any difference. In my opinion, both images are similar because the sitting positions are both incorrect. Posture comparison: right: tailbone + knee; left: tailbone + knee".

On the other hand, some students said, "In my view, the impact caused by both sitting postures may be different. The cross-legged sitting position with folded legs under the body in the right image will have a unique impact. This position can provide stability and comfort for some people, especially in certain cultures that traditionally practice this posture. However, this position may not provide optimal support for the spine and can affect blood circulation if maintained for a long time. In addition, for some people, this position may be difficult to maintain or uncomfortable". Figure 1a) causes a tremendous amount of pressure on the back muscles and spinal discs, and Fig. 1b) causes increased stress on the back, neck, arms, and legs. Sitting in a slouched position can overstretch the spinal ligaments and strain the spinal discs. Based on observation results, it was found that students could not analyze problems well, as indicated by misinterpreting the problem. Some students could not differentiate the sitting positions, and others could determine them, but they could not examine the impact of both sitting positions.

The implementation of the Ethno-STEAM model has improved students' problem-analysis skills, since students can develop the ability to analyze complex and actual problems through Ethno-STEAM learning. This approach invites students to analyze problems from a multidisciplinary perspective, integrating ethnic, scientific, technological, engineering, artistic, and mathematical elements. Students are taught to identify assumptions, analyze relevant information, connect concepts, and draw conclusions based on their understanding [8-11]. Students' abilities to critically and comprehensively analyze problems can develop in this process. Ethno-STEAM encourages students to identify, formulate, and solve complex problems. In this context, the ability to analyze problems becomes essential. Students were trained to break down problems into smaller components, analyze cause-and-effect relationships, identify patterns or trends, and select appropriate problem-solving strategies. This process helps students to develop strong analytical skills [8-11]. Ethno-STEAM encourages students to identify, formulate, and solve complex problems. In this context, the ability to analyze problems becomes essential. Students are trained to break down problems into smaller components, analyze cause-and-effect relationships, identify patterns or trends, and select appropriate problem-solving strategies. This process helps students to develop strong analytical skills [8-12].

Communication skills

For the indicator of communication skills in students' critical thinking skills, data were collected through a critical thinking skills test. Communication skills can be assessed when students present projects or assignments in front of a forum. However, in this research, the test to measure the indicator of communication skills was conducted with open-ended answer questions as follows:

Question:

Osteoporosis is classified as a silent disease because it does not show specific symptoms. The analysis results from the Center for Research and Development of Nutrition Sciences, Ministry of Health of the Republic of Indonesia, with a sample size of 65,727 people in 16 provinces in Indonesia, showed a prevalence rate of 41.7 percent for osteopenia (early-stage osteoporosis) and a prevalence rate of 10.3 percent for osteoporosis. The prediction for the year 2050 estimates that there will be 6.3 million hip fractures worldwide yearly, and more than half of them will occur in Asia. Based on the explanation provided, what can you conclude? Look for several scientific literature about osteoporosis and create a simple mind map about the definition, causes, symptoms, consequences, and ways to reduce the risk of osteoporosis!

Analysis of Student's answer 1:

The structure of the mind map lacks "connections" between related parts. For example, prevention should be connected to the cause as they are directly related. It can be further explored why the student chose to connect prevention with consequences in their communication structure.

Analysis of Student's answer 2:

Counter-interpretation: the reading mentions "no symptoms", but "symptoms" are displayed in the mind map.

Analysis of Student's answer 3:

In the reading, there is no mention of an increasing or decreasing annual trend. However, some students added this in their conclusion, resulting in over-interpretation. This is consistent with the interview results of some students who stated, "In my opinion, mind maps or diagrams can be made freely. I don't think in detail about the interconnections between each box in my diagram".

Some other students stated.

"I wrote down the symptoms of osteoporosis in the diagram I made because I felt the need to elaborate on as much information as possible in my diagram to make it comprehensive". Observation results show that students conducted extensive literature searches and decided to provide as much information as possible in their diagrams. Students may need to search for and read much literature to better understand their research topic. The limitation of initial knowledge may drive them to broaden the scope of literature read and to achieve more comprehensive insight. Furthermore, to present diverse perspectives in their research, students may try to find literature from various sources. They hope to gather all the necessary information to support their arguments and findings by conducting extensive literature searches.

Ethno-STEAM involves a research and exploration process that involves the collected data. Students are required to process this data and present it effectively to the audience. Good communication skills are needed to compose clear and structured research reports, present research findings orally in presentations, and use media and visual communication tools to illustrate their conclusions clearly and attractively [10-14]. Furthermore, in practice, Ethno-STEAM encourages cooperation and collaboration in the context of learning. Students can work in groups or teams to solve problems and produce creative works. Good interpersonal communication skills are vital in communicating with team members, expressing ideas, listening to others' perspectives, and reaching a shared understanding. Effective communication skills in a collaborative context will influence the team's success in achieving common goals [15-18].

Generalization Ability

For the indicator of generalization ability in students' critical thinking skills, data were collected through a critical thinking skills test. In this research, the test to measure the indicator of generalization ability was conducted with open-ended answer questions as follows:

Question:

The following are the steps in making a "topeng tobung" mask:

i. Prepare a 50 cm long piece of dried wood by drying it under a tree and smoking it above the kitchen roof.

ii. Create patterns on the wood by carving and engraving ornaments according to the desired shape.

iii. Make the concave part of the mask using a "pethel". The standard size is 15 cm wide, 18 cm high, and 16 cm thick.

iv. Form the mask's front part according to the mask's pattern and character (nose, lips, teeth, and lower chin) using a "pisau pangot". The eye and nose parts are given holes.

v. Use a small chisel to carve the head crown ("jamang") containing geometric motifs such as lines, triangles, and diamonds.

vi. Smooth the surface of the mask (inside and outside) using sandpaper, typically done by mothers (women).

vii. Apply a base color of white or yellow (neutral color). Add colors according to the mask's character (paint) and include batik elements.

Based on the steps above in making the "topeng tobung" mask,

a. Summarize the tools and materials needed to make the mask.

b. Analyze the concepts of science viewed from the human body's movement system in making the "topeng tobung" mask!

Student 1's answer:
Tools needed:

1. 50 cm long wood (dried)
2. Carving and engraving knives
3. "Pethel" (for making the concave part of the mask)
4. "Pisau pangot" (for forming the front part of the mask)
5. Small chisel (for carving the head crown)
6. Sandpaper (for smoothing the surface of the mask)
7. Brushes and paint (for applying the base color and drawing motifs on the mask)
8. Additional batik materials (if wanting to include batik elements in the mask)

Materials needed:

1. 50 cm long wood (dried)
2. Base color paint (white or yellow)
3. Colored paint for drawing motifs and coloring the mask
4. Batik materials (if wanting to include batik elements in the mask)

In this case, most students forgot or omitted to mention the hammer. Student 2's answer: The student could not identify the correlation of scientific concepts related to the human body's movement system in making the "topeng tobung" mask. Student 3's answer: The student could identify scientific concepts in making the "topeng tobung" mask, but not related to the human body's movement system. For example, human anatomy on the mask's face, biomechanics of hand

and arm movement during carving, fine motor skills in carving details and ornament patterns on the mask, and the colors of the mask and their relation to pigments play a significant role in understanding and applying the mask-making process. The analysis of students' answers above was supported by the interview results of some students, indicating, "When I analyzed the steps of making the mask, I didn't find clear connections between scientific concepts and the process. For me, making the mask focuses more on the art aspect and craftsmanship rather than scientific concepts".

Some other students also stated, "I didn't see direct connections between scientific concepts and the process of making the mask. For me, making the mask is more about a personal artistic and creative activity that focuses on self-expression rather than applying scientific concepts". Based on observation results, it was found that students might not have a sufficient understanding of scientific concepts related to mask-making. They may not have seen or realized the connection between science and craft art, such as mask-making, because they are used to learning each discipline separately. Thus, they might find it challenging when faced with a multidisciplinary learning context. Students also seem to be more focused on technical or aesthetic aspects of making the mask, thus overlooking or not finding direct connections with scientific concepts. They might be more interested in carving techniques, color selection, or the overall design of the mask.

Using the Ethno-STEAM model, multidisciplinary learning facilitation can enhance students' generalization ability. The Ethno-STEAM model combines concepts and principles from various disciplines to create holistic learning experiences [38]. The Ethno-STEAM model encourages lateral thinking, which involves creative thinking and connecting unexpected concepts. Through the combination of ethnic elements and scientific disciplines, students are encouraged to see problems or topics from different perspectives and find unconventional solutions. This can develop students' ability to connect ideas from different fields. In projects or tasks involving ethnic elements, science, technology, engineering, arts, and mathematics, students must collaborate to combine their knowledge and skills [20-25]. This collaboration allows for the exchange of ideas, the use of different languages, and a deeper understanding of the contributions of each discipline [30-33].

Reflection ability

For the indicator of reflection ability in students' critical thinking skills, data were collected through a critical thinking skills test. In this research, the indicator measurement test of reflection ability was conducted with open-ended answer questions as follows:

Question:
Observe the X-ray results of bone abnormalities below!
Based on Fig. 2,

a. Analyze the bone abnormality in the image above!

b. Analyze from various literature the factors influencing bone abnormality!

c. Also, explain ways to avoid bone abnormalities!

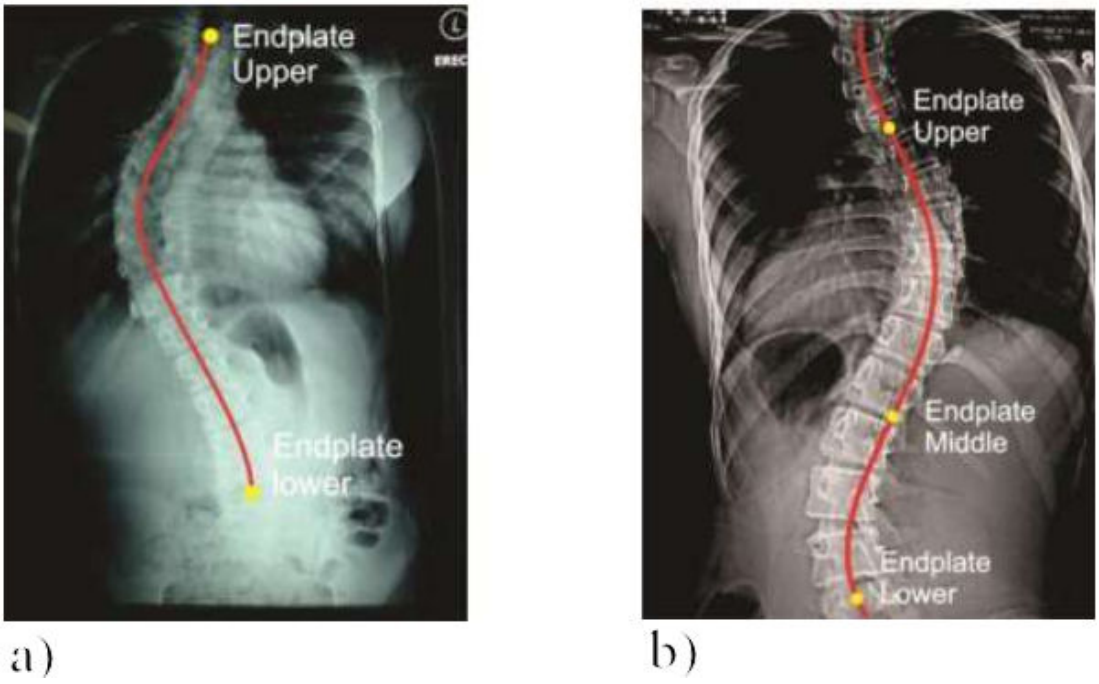

FIGURE 2. X-ray results of bone abnormalities.

Student 1's answer:

The students have not provided relevant reasons for scoliosis. Only advising to prevent "hunchback", but not providing advice, which is "more relevant" to the image (scoliosis).

Student 2's answer:

The student can provide relevant reasons for scoliosis but includes additional factors such as "dietary intake" even though it is not directly related or present in the information. Other students added less relevant advice, such as "drinking less water". This indicates the potential for mix-interpretation. Results from interviews with some students show, "In my opinion, one of the causes of scoliosis is an unhealthy or unbalanced diet. I have heard that a lack of certain vitamins or minerals in food can cause bone abnormalities like scoliosis. It might also be due to food not rich enough in calcium and other essential nutrients needed for healthy bone growth". Observation results also show that students obtained inaccurate or inadequate information about scoliosis and its causes. They received unverified information or based it on myths or false beliefs from unreliable websites or social media sources, spreading hoaxes. In this example, students have a misconception about the causes of scoliosis. They associate scoliosis with an unhealthy or unbalanced diet. However, it is essential to note that genetic factors and complex spine development typically cause scoliosis. This indicates that the student's reflection ability is not yet optimal.

The Ethno-STEAM (Ethnic, Science, Technology, Engineering, Arts, Mathematics) model can improve the reflection ability in the science subject. Ethno-STEAM emphasizes experiential learning. Students are exposed to real-life situations and issues relevant to their daily lives [26-29]. This allows students to reflect on the science concepts they have learned and apply them in real-life contexts [27]. Furthermore, students can connect science concepts with their culture and everyday life context, reflect on their problem-solving processes, and collaborate with others to explore more profound understanding. This will enrich students' learning experience in comprehending and reflecting on knowledge more holistically and integratedly [11-12].

The ability to implement

Data was collected through a test of critical thinking skills to indicate implementation ability in students' critical thinking skills. In this study, the test to measure the indicator of implementation ability was conducted with open-ended essay questions as follows:

Question:

Read the summary of the following research (see Fig. 3)!

Analysis of student 1's answer:

THE RELATIONSHIP BETWEEN SITTING DURATION AND SITTING POSTURE WITH LOWER BACK PAIN COMPLAINTS AMONG WOODEN BATIK CRAFTSMEN IN KREBET TOURISM VILLAGE, BANTUL, YOGYAKARTA

Veni Fatmawati, Siti Khotimah

Abstract

The activity of making wooden batik in Krebet tourism village is predominantly carried out in a sitting position, where the working hours start from 08:00 to 16:30, or a total working time of 8.5 hours. The activities performed include felling trees, cutting wood, carving wood, and sanding wood, all done in a sitting position. Due to the relatively long duration of sitting, they often experience pain, particularly in the lower back. The aim of this study is to determine the relationship between sitting duration and sitting posture with lower back pain complaints among wooden batik craftsmen in Krebet tourism village. The population in this research is batik makers in Krebet Pajangan tourism village, Bantul, with a sample size of 80 batik makers from 40 wooden batik workshops in the village, using a total sampling method. The data collection method used was the Visual Analog Scale (VAS). The data analysis technique used is bivariate analysis, and as the study involves 2 variables, ANOVA test with a significance level of 0.05 was used. The correlation coefficient between myogenic lower back pain complaints and sitting duration (hours/day) is -0.399 with a significance of 0.041 ($P < 0.05$), indicating a correlation between myogenic lower back pain complaints and sitting duration. The correlation coefficient between myogenic lower back pain complaints and sitting posture is 0.401 with a significance of 0.40 ($P < 0.05$).

Source: Journal of Physiotherapy Science

FIGURE 3. Based on the research summary above, write down the human health problems from the activity of making wooden batik and the causes of these problems! Propose suggestions to reduce the adverse health impacts that arise!

The student provided suggestions that are "less relevant" regarding changing schedules, which means they have not been able to provide an evaluation of the causes and appropriate solutions.

Analysis of student 2's answer:

The student cannot define "sitting for a long time" and "poor sitting posture". Interview results with students showed, "In my opinion, sitting for a long time and adopting an ergonomic sitting posture can contribute to lower back pain complaints in wooden batik craftsmen. Working in the same sitting position for a long time can lead to tension and fatigue in the back muscles. Additionally, if the sitting posture used is not ergonomic, such as a hunched position or lack of back support, it can exert additional pressure on the spine and cause discomfort and pain".

In this example, students identified the relationship between sitting for a long time and sitting posture with lower back pain complaints in wooden batik craftsmen. The students realized that prolonged sitting could lead to tension in the back muscles and cause fatigue. Furthermore, an ergonomic sitting posture can exert additional pressure on the spine and lead to discomfort and pain. However, some students could not propose suggestions to reduce the adverse health impacts of the mentioned conditions. The use of a learning model can influence the implementation ability of students' knowledge concepts. The Ethno-STEAM model often employs a project-based learning approach, where students apply knowledge concepts in real projects. Students can plan, implement, and evaluate their work results through these projects by applying relevant concepts. This process helps improve students' implementation ability of knowledge concepts [10-15]. Furthermore, students are exposed to complex situations and must integrate knowledge from various fields to find solutions. This process expands students' ability to implement integrated knowledge concepts and see how these concepts can be applied in multiple contexts. By integrating knowledge concepts from various disciplines, this model helps students see the relationships and connections between these concepts. This can enhance their understanding of how these concepts can be applied in different contexts [15-18].

Self-regulation

Data was collected through a test of critical thinking skills for the indicator of self-regulation in students' critical thinking skills. In this study, the test to measure the indicator of self-regulation ability was conducted with open-ended essay questions as follows:

Question:

Mrs. Haryati is a tobung mask craftsman who has practiced this craft for 30 years. Lately, Mrs. Haryati has been complaining of pain in her lower back. During her activities as a mask craftsman, Mrs. Haryati has never paid attention to her sitting position or the duration of sitting when making masks. Using Mrs. Haryati's story, create a simple infographic aimed at other tobung mask craftsmen regarding the impact of sitting position and duration on health! Include steps to reduce the health risks experienced by Mrs. Haryati!

Analysis of student 1's answer:

According to the student, "back pain" and "lower back pain" are the same. However, the student communicates the same thing at different points. This indicates an interpretation error or communication error.

Analysis of student 2's answer:

The student did not use "infographics" according to the instructions. The student used less concise and effective sentences in the infographic. The student also did not include suggestions to provide intervals of standing among activities done while sitting. The student did not focus on the question until providing information about a specific "brand" irrelevant to the study topic. Based on observations, students could create infographics that reflect their understanding of the context of sitting duration and position of tobung mask craftsmen and its impact on health. Students could depict information by directly linking it to tobung mask craftsmen, for example, by including illustrations of craftsmen in ergonomic and non-ergonomic sitting positions while working. The infographic also contains suggestions to reduce the risk of lower back pain specific to mask craftsmen. To present diverse perspectives in their infographics, students appeared to seek literature from various sources. Students also demonstrated the ability to design an attractive and aesthetic infographic layout. They used harmonious color combinations, easily readable fonts, and effective use of space to organize infographic elements in a structured and engaging manner.

The above facts prove that interdisciplinary learning can help improve students' self-regulation abilities. Interdisciplinary education in applying the Ethno-STEAM model allows students to understand a broader context more deeply. They can integrate knowledge from various disciplines to see more complex relationships and connections between the problems, issues, or topics being studied [14-17]. With a deeper understanding of the context, students can better regulate themselves in facing learning challenges and finding creative solutions. In applying the Ethno-STEAM model, interdisciplinary learning can involve deep reflection and evaluation of the learning process. Students are encouraged to consider their ways of thinking, monitor their understanding, organize effective learning strategies, and evaluate their progress [18-21]. This strengthens metacognition, self-awareness of how they learn, and self-regulation in understanding and addressing learning challenges [22-24]. Based on the findings of this research, several recommendations can be made for relevant stakeholders. Educators/instructors should develop more concrete and structured learning strategies to integrate the Ethno-STEAM science learning model

into the curriculum and adopt active, collaborative, and reflective pedagogical approaches to encourage student engagement in critical thinking. As for educational institutions, they should provide adequate support and resources for implementing and developing the Ethno-STEAM science learning model, including training, facilities, and teaching materials, and promote collaborations among different faculties to develop interdisciplinary programs that combine STEAM aspects with ethnographic approaches. Furthermore, future researchers should involve more extensive and diverse samples with different backgrounds and conduct longitudinal studies involving long-term monitoring of students' critical thinking skills.

4. Conclusion

Based on the findings and discussions of the research above, it can be concluded that: (1) students' problem analysis skills are already quite good, although there are some shortcomings in problem identification; (2) students' communication skills are also considered good, as they can effectively communicate knowledge and involve various literature in the process; (3) students' generalization skills are not yet evident, as the focus remains on single disciplines rather than multidisciplinary approaches; (4) reflective skills are noticeable, but there are some potential mix-interpretation issues; (5) implementation skills are fairly good, as students can apply their knowledge and turn it into solutions for the cases they encounter; (6) students' self-regulation is evident when they can integrate knowledge from various disciplines to comprehend complex connections in problem-solving. This study can provide insights for educators and policymakers to develop more effective learning strategies for honing critical thinking skills. Through this research, university lecturers and instructors can enhance their understanding of the Ethno-STEAM science learning model and how to apply it in their teaching. The study can also serve as a strong evidence base for further research on the Ethno-STEAM science learning model and its impact on students' learning outcomes. Moreover, these implications can foster the development of other innovative strategies in higher education.

5. Recommendations

The research results show that the model developed is a novelty from previous research. The Ethno-STEAM model can be used in the learning process by teachers. The suggestion for using this model is that the material is adapted to local culture near where students live so that it is easier to understand the material.

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1. D. Aguilera, and J. Ortiz-Revilla, Stem vs. Steam education and student creativity: A systematic literature review. *Educ. Sci.* **11** (2021) 331, https://doi.org/10.3390/educsci11070331.
2. W. A. Alamri, Effectiveness of Qualitative Research Methods: Interviews and Diaries. *Int. J. Eng. Cult. Stud.*, **2** (2019) 65, https://doi.org/10.11114/ijecs.v2i1.4302.
3. B. Alharbi, Saudi Teachers' Knowledge of Critical Thinking Skills and Their Attitudes Towards Improving Saudi Students' Critical Thinking Skills. Problems of Education in the 21st Century, **80** (2022) 395, https://doi.org/10.33225/pec/22.80.395.
4. J. Alvarez-Cedillo, M. Aguilar-Fernandez, R. Sandoval-Gomez, and T. Alvarez-Sanchez, Actions to be taken in mexico towards education 4.0 and society 5.0. *Int. J. Eval. Res. Educ.*, **8** (2019) 693, https://doi.org/10.11591/ijere.v8i4.20278.
5. S. Areljung, and A. Günther-Hanssen, STEAM education: An opportunity to transcend gender and disciplinary norms in early childhood? *Contemp. Issues Early Child.* **23** (2022) 500, https://doi.org/10.1177/14639491211051434.
6. A. Ariyatun, Analysis of Project Based Learning Integrated with Ethno-STEM on Students' Critical and Creative Thinking Skills, *J. Educ. Chem.* **3** (2021) 35, https://doi.org/10.21580/jec.2021.3.1.6574.
7. M. Bassachs *et al.*, Fostering critical reflection in primary education through STEAM approaches. *Educ. Sci.* **10** (2020) 1, https://doi.org/10.3390/educsci10120384.
8. P. Baxter and S. Jack, Qualitative Case Study Methodology: Study Design and Implementation for Novice Researchers, *Qual. Rep.* **13** (2008) 544, https://doi.org/10.46743/2160-3715/2008.1573.
9. S. Campbell *et al.*, Purposive sampling: complex or simple? Research case examples. *J. Res. Nurs.* **25** (2020) 121, https://doi.org/10.1177/1744987120927206.
10. S. K. Chung, and D. Li, Issues-Based STEAM Education: A Case Study in a Hong Kong Secondary School. *Int. J. Educ. Arts.* **22** (2021) 1, https://doi.org/http://doi.org/10.26209/ijea22n3.
11. J. W. Creswell *et al.*, Advanced Mixed Methods Research Designs, In Handbook of Mixed Methods in Social and Behavioral Research (Sage, 2003) pp. 209-240.
12. A. T. Daga, D. Wahyudin, and R. Susilana, An Investigation of Developing Indonesian Elementary School Students' Criti-

cal Thinking Skills: A Literature Review. *Int. J. Curric. Instr.*, **14** (2022) 1752,

13. L. E. Fajari, Sarwanto, and Chumdari, Improving elementary school's critical thinking skills through three different learning media viewed from learning styles, J. E-Learn. *Knowl. Soc.* **16** (2020) 55, https://doi.org/10.20368/1971-8829/1135193.
14. L. E. Fajari, Sarwanto, and Chumdari, Improving elementary school's critical thinking skills through three different learning media viewed from learning styles, J. E-Learn. *Knowl. Soc.* **16** (2020) 55, https://doi.org/10.20368/1971-8829/1135193.
15. L. E. W. Fajari, Sarwanto, and Chumdari, Influence of PBL-based multimedia and learning motivation on students' critical-thinking skills in elementary schools, *J. Phys.: Conf. Ser*. **1511** (2020) 012012, https://dx.doi.org/10.1088/1742-6596/1511/1/012012.
16. M. Gross, D. Latham, J. Underhill, and H. Bak, The peritext book club: Reading to foster critical thinking about STEAM texts. *Sch. Libr. Res.*, **19** (2016) 1,
17. A. L. Hamengkubuwono, I. Warsah, R. Morganna, and L. Adhrianti, The Effect of Teacher Collaboration as the Embodiment of Teacher Leadership on Educational Management Students' Critical Thinking Skills. *Eur. J. Educ. Res.*, **11** (2022) 1315, https://doi.org/https://doi.org/10.12973/eu-jer.11.3.1315.
18. H. Haryanto, S. Samsudi, M. Arbarini, Development of project-based learning model based on ethno-steam to improve numeracy literacy skills. *Inov Kurikulum* **21** (2024) 255, https://doi.org/10.17509/jik.v21i1.63400.
19. H. Jho, O. Hong, and J. Song, An analysis of STEM/STEAM teacher education in Korea with a case study of two schools from a community of practice perspective. *Eurasia J. Math. Sci. Tech. Ed.*, **12** (2016) 1843, https://doi.org/10.12973/eurasia.2016.1538a.
20. Y. Jia, B. Zhou, and X. Zheng, A Curriculum Integrating STEAM and Maker Education Promotes Pupils' Learning Motivation, Self-Efficacy, and Interdisciplinary Knowledge Acquisition. *Front. Psychol.*, **12** (2021) 1-10. https://doi.org/10.3389/fpsyg.2021.725525.
21. A. Kanmaz, Middle school teacher' critical thinking skills and awareness towards teaching critical thinking skills. *Int. Online J. Educ. Teach.* **9** (2022) 1648,
22. I. Marufi, M. Winahyu, and M. Ikram, An Implementation of Ethno-STEM to Enhance Conceptual Understanding. Al-Jabar: *Jurnal Pendidikan Matematika*, **12** (2021) 35, https://doi.org/10.24042/ajpm.v12i1.7834.
23. S. Mejias *et al*., The trouble with STEAM and why we use it anyway. *Sci. Educ.* **105** (2021) 209, https://doi.org/10.1002/sce.21605.
24. A. Mulhall, In the field: Notes on observation in qualitative research. *J. Adv. Nurs.* **41** (2003) 306, https://doi.org/10.1046/j.1365-2648.2003.02514.x.
25. M. Munawar, F. Roshayanti, and S. Sugiyanti, Implementation Of Steam (Science Technology Engineering Art Mathematics) - *Based Early Childhood Education Learning In Semarang City*, *CERIA* **2** (2019) 276, https://doi.org/10.22460/ceria.v2i5.p276-285.
26. M. D. Nasution, I. S. Nasution,S. P. Sari Students Collaborative Skills With an Approach Ethno-STEAM Project Otok-Otok Game Context In Mathematics Learning. *J. Tarb* **31** (2024) 17, https://dx.doi.org/10.30829/tar.v31i1.3059.
27. C. F. Pasani, and R. Amelia, Introduction of the integrative STEAM approach as a learning innovation in the COVID-19 pandemic in South Kalimantan. *J. Phys: Conf. Ser.* **1832** (2021) 012029, https://doi.org/10.1088/1742-6596/1832/1/012029.
28. R. Pearson, STEAM Based Learning Strategies By Playing Loose Parts For the Achievement of 4c Skills in Children 4-5 Years *International Journal of the Whole Child*, **7** (2022) 109.
29. T. Prameswari, and A. Lestariningrum, STEAM Based Learning Strategies By Playing Loose Parts For the Achievement of 4c Skills in Children 4-5 Years, *Efektor* **7** (2020) 24, https://doi.org/10.29407/e.v7i2.14387.
30. C. Primadianningsih, W. Sumarni, and S. Sudarmin, Systematic Literature Review: Analysis of Ethno-STEM and Student's Chemistry Literacy Profile in 21st Century. *Jurnal Penelitian Pendidikan IPA*, **9** (2023) 650, https://doi.org/10.29303/jppipa.v9i2.2559.
31. Pursitasari, I. D., Rubini, B., and Firdaus, F. Z. Feasibility of eco-literacy-based interactive teaching material to promote critical thinking skills. *Cypriot J. Educ. Sci.*, **17** (2022) 2105, https://doi.org/10.18844/cjes.v17i6.7505.
32. R. H. Ristanto, A. S. Ahmad, and R. Komala, Critical thinking skills of environmental changes: A biological instruction using guided discovery learning-argument mapping (GDL-AM). *Particip. Educ. Res.*, **9** (2022) 173-191. https://doi.org/10.17275/per.22.10.9.1.
33. C. A. Rodríguez-Nieto, and Á. Alsina, Networking Between Ethnomathematics, STEAM Education, and the Globalized Approach to Analyze Mathematical Connections in Daily Practices. *Eurasia J. Math. Sci. Tech. Ed.* **18** (2022) 1, https://doi.org/10.29333/EJMSTE/11710.
34. M. J. Sá, and S. Serpa, Higher Education as a Promoter of Soft Skills in a Sustainable Society 5.0. *J. Curric. Teach.*, **11** (2022) 1-12. https://doi.org/10.5430/JCT.V11N4P1.
35. Sarwanto, L. E. W. Fajari, and Chumdari, Open-Ended Questions to Assess Critical- Thinking Skills in Indonesian Elementary School, *Int. J. Instr*. **14** (2020) 615, https://doi.org/10.29333/iji.2021.14137a.
36. Sarwanto, Fajari, S. L. E. W., and Chumdari, Critical Thinking Skills and Their Impacts on Elementary School Students. *Malays. J. Learn. Instr*. **2** (2021) 161, https://doi.org/10.32890/mjli2021.18.2.6.
37. O. Shatunova, T. Anisimova, F. Sabirova, and O. Kalimullina, Steam as an innovative educational technology. *J. Soc. Stud. Educ. Res.*, **10** (2019) 131,
38. D. V. Sigit, R. H. Ristanto, and S. N. Mufida, Integration of Project-Based E-Learning with STEAM: An Innovative Solution to Learn Ecological Concept. *Int. J. Instr.*, **15** (2022) 23, https://doi.org/10.29333/iji.2022.1532a.

39. A. B. Starman, The case study as a type of qualitative research. *J. Contemp. Educ. Stud.* **1** (2017) 28,

40. L. J. W. Suen, H. M. Huang, and H. H. Lee, A comparison of convenience sampling and purposive sampling. *J. Nurs.*, **61** (2014) 105, https://doi.org/10.6224/JN.61.3.105.

41. W. Sumarni, and S. Kadarwati, Ethno-stem project-based learning: Its impact to critical and creative thinking skills. *Jurnal Pendidikan IPA Indonesia*, **9** (2020) 11-21. https://doi.org/10.15294/jpii.v9i1.21754.

42. K. Umam, and D. Susandi, Critical thinking skills: Error identifications on students' with APOS theory. *Int. J. Eval. Res. Educ.* **11** (2022) 182, https://doi.org/10.11591/ijere.v11i1.21171.

43. S. Wahyuningsih *et al*., STEAM Learning in Early Childhood Education: A Literature Review. *International Journal of Pedagogy and Teacher Education*, **4** (2020) 33, https://doi.org/10.20961/ijpte.v4i1.39855.

44. Y. Widiyawati, I. Nurwahidah, and A. Wahyuni, Ethno-Stem: Design Of A Cross-Major Course With Javanese Gamelan-Themed. *Edusains*, **14** (2022) 94, https://doi.org/10.15408/es.v13i2.27974.

45. N. Wittayakhom, and P. Piriyasurawong, Learning Management STEAM Model on Massive Open Online Courses Using Augmented Reality to Enhance Creativity and Innovation. *High. Educ. Stud.* **10** (2020) 44, https://doi.org/10.5539/hes.v10n4p44.

46. A. A. Yaki, Fostering Critical Thinking Skills Using Integrated STEM Approach among Secondary School Biology Students. *Eur. J. STEM Educ.*, **7** (2022) 1, https://doi.org/10.20897/ejsteme/12481.

47. A. Yamada, Japanese Higher Education: The Need for STEAM in Society 5.0, an Era of Societal and Technological Fusion. *J. Comp. Int. Higher Educ.* **13** (2021) 44, https://doi.org/10.32674/jcihe.v13i1.1980.

48. Z. Yaraş and F. K. Öztürk, Society 5.0 in Human Technology Integration: Digital Transformation in Educational Organizations. *Int. J. Progress. Educ.* **18** (2022) 458, https://doi.org/10.29329/ijpe.2022.426.26.