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Open Inquiry Module on Energy Transformation to Improve Creative Thinking and Collaboration

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Abstract

The current energy transformation module does not support the application of the open inquiry approach, thus inhibiting students' skills. So, this study aims to develop an open inquiry energy transformation practicum module to improve creative thinking and collaboration skills. The development method used is research and development with the ADDIE model. Limited time and resources were considered, so a more in-depth evaluation was conducted in a follow-up study to evaluate the long-term impact of this module. The research was conducted at SMP IT Qurrota A'yun Palu in November 2024. The sample used was 1 class, namely class VIII D, totaling 30 students. The instruments used are tests, observations, and questionnaires. The test is in the form of a description to measure creative thinking skills. The researchers use observations to assess collaboration skills. Questionnaires for peer assessment of collaboration skills. Questionnaires are also for teacher and learner responses. The study found that the module's validation was 82.15%, categorised as valid. Teacher and student responses were 86.36% and 86.08%, respectively, in the very feasible category. Small group trials rated 92.01%, which was also very feasible, with some suggestions. Large group trials showed that the module improved creative thinking skills with an N-gain of 59% in the moderate category. Collaboration skills were assessed with an observer sheet (85.34% in very collaborative) and peer assessment (73.41% in collaborative). In conclusion, the module is valid and feasible for enhancing creative thinking and collaboration skills.

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INTRODUCTION

Physics learning requires practicum-based activities where students solve real-world problems. These practicum activities provide an opportunity for students to test theories through direct observation and experimentation, making abstract concepts more tangible and understandable. Such hands-on learning is critical because it helps students better grasp difficult concepts by linking theory to real-life applications (Newman & Park, 2024).

However, many physics practicums still rely heavily on verification modules designed to confirm established theories (DeStefano & Widenhorn, 2024). While these modules can help demonstrate known principles, they often limit student engagement and exploration depth. Argue that the focus on verification in many practicum designs has notable weaknesses. Research by Gomez-del & Rodriguez (2022), Gunada et al. (2023), and Leung et al. (2020) further suggests that these modules may hinder the development of deeper

scientific understanding and critical thinking. In contrast, open-ended exploratory modules, which encourage students to investigate concepts freely, have been shown to promote more dynamic learning and deeper comprehension (Goldsack et al., 2020). Students' curiosity and ability to explore new ideas are inhibited by narrowing the focus to verification.

This issue is particularly evident in teaching complex topics such as energy transformations. Studying changes in energy forms can be difficult for students to understand, as it involves abstract concepts and phenomena that are not always directly observable. The challenge is even greater because the changes in energy often occur at a scale that students cannot easily perceive (Zulaiha & Kusuma, 2020). As a result, students may struggle to connect physics principles to their everyday experiences. However, research shows that students are more likely to engage with and understand the material when they are allowed to explore topics based on curiosity and guided by open inquiry. This topic should be interesting to students if they are given the freedom to explore based on curiosity, according to the findings of Abaniel (2021) about momentum material using an open inquiry approach.

Recent studies (2023-2024) further support the effectiveness of open inquiry in physics education. These studies emphasize that students who can design their experiments, pose questions, and explore different outcomes can better grasp complex scientific concepts. DeStefano & Widenhorn (2024) highlight how inquiry learning improves engagement and comprehension. This demonstrates that shifting away from verification-based approaches toward open inquiry can enhance student learning in physics. This shift is crucial, especially for abstract topics like energy transformations, where students benefit from the freedom to explore and experiment with the concepts in a more flexible and engaging environment.

Open inquiry differs from other types of inquiry, such as guided inquiry, structured inquiry, and basic inquiry. The basic thing that differentiates them is that the open inquiry approach allows practitioners to explore experiments. This opportunity prevents students from being fixated on the procedures in the module. However, it should be noted that even though the open inquiry approach provides freedom in experiments, students are still given guidelines so that the experiments remain relevant to learning. The research results conducted by the team DeStefano & Widenhorn (2024) showed that the open inquiry structure in optics experiments was effective because it offered learners a choice of experiments and data analysis tasks that ultimately improved their skills.

While open inquiry offers many advantages, it requires students to possess certain skills, such as creative thinking and collaboration. Meanwhile, a study by Meitiyani et al. (2022) reveals that Indonesian students, in particular, exhibit low levels of creative thinking, with an average proficiency of only 48%. This creativity gap can hinder students' problem-solving abilities and limit their capacity for innovation. Furthermore, students' lack of collaboration skills impedes the effectiveness of group-based learning activities (Le et al., 2018). Collaboration is essential for enhancing learning outcomes, as it allows students to contribute diverse perspectives and share knowledge, enriching the overall learning experience (Song et al., 2022).

The lack of these crucial skills highlights a gap in the current practicum modules and points to the need for a more integrated approach. Developing an open inquiry practicum module focused on energy transformation could address this gap by fostering curiosity and a deeper understanding of scientific concepts and enhancing students' creative thinking and collaboration skills.

Therefore, the primary aim of this research is to develop an open inquiry practicum module for energy transformations that promotes creative thinking and collaboration skills. The anticipated outcome of this study is to contribute to developing more engaging and

effective physics learning strategies, aligning with current educational needs and fostering the necessary skills for students' success. The results of this research can also serve as a valuable reference for future studies, contributing to the broader discourse on improving physics education through innovative teaching methods.

METHODS

This type of research includes development research or Research and Development (R&D). The research was conducted at SMP IT Qurrota A'yun Palu in November 2024. The sample used was one class, class VIII D, which totaled 30 students. The selection of Class VIII D was based on several considerations. It represents a homogeneous group in terms of academic ability, with the students showing similar performance levels in previous assessments, and the students were willing to participate actively in the research.

The type of design in this development research follows the model by Dick & Carey (1996), namely ADDIE (Analysis, Design, Development, Implementation, and Evaluation). The limited time and resources in this study are also a consideration, considering that the final evaluation and improvement of the product require further data collection, which can be done in a follow-up study after implementation. Therefore, a more in-depth and comprehensive evaluation of the long-term impact of this module needs to be conducted in future studies, as this research merely reaches the implementation stage.

Analysis Stage

The analysis stage in developing an open inquiry practicum module involves the identification of student needs, learning objectives, and learning contexts relevant to the material to be delivered. This analysis begins with a review of previous studies and an analysis of the characteristics of the target students, which shows that they tend to need a more interactive approach and are based on independent exploration to deepen their understanding of scientific concepts. In addition, an analysis of the independent curriculum reveals the importance of active student involvement. Based on the results of this analysis, it was determined that the focus of the material in the practicum module is changes in energy forms, which are adjusted to the real-world context so that students can see the relevance of scientific concepts in everyday life. The analysis also includes selecting media and learning resources that support open inquiry learning, such as PowerPoints, and questions that train creative thinking.

Design Stage

The first step is to formulate the title, objectives, experiments, and framework that is prepared. The second step, the initial draft of the module, is made using Microsoft Word software and the Canva application. The third step is to create a test plan. The module design focuses on developing learning objectives, determining material content, and arranging the sequence of activities that support the open inquiry approach. The module structure is designed so that students can be actively involved in the learning process, starting from observing scientific phenomena through formulating questions to experiments to test the proposed hypothesis. In addition, the module design also considers collaborative aspects by including group discussion activities, reflection, and compiling experimental reports that allow students to analyze and communicate their findings systematically. Thus, the module design aims to convey scientific concepts and involve students in the research process and direct knowledge development, using the principles of open inquiry.

Development Stage

The module that has reached the initial draft is developed and validated by the validator team, consisting of 2 expert validators. Furthermore, the trial is limited to classes consisting of 8 class VIII C SMP IT Qurrota A'yun Palu students. The open inquiry practicum module, designed at the design stage, began to be realized as a prototype that could be tested. Module development was carried out by considering the results and analyzing previous designs and the integration between content, instructions, and media used. This module includes examples of experiments and instructions for processing and analyzing data obtained from practicum activities. After prototype development, the module was tested on a small group of Class VIII C to identify potential deficiencies or difficulties in implementing the practicum in terms of instructions, completeness of materials, and the suitability of the tools and media used. The trial results at this stage provided valuable input that was used to improve and refine the module before the further implementation stage. Suggestions for improvement include integrating learning technology, such as explanatory videos or short videos and simulations of energy conversion experiments via QR or barcodes, which aim to provide visual illustrations of scientific concepts that are difficult to understand theoretically.

Implementation Stage

This stage is the application of the practicum module, characterized by open inquiry. Previously, students were given a pretest and a post-test to determine creative thinking skills. The assessment of students' collaboration skills during the learning process uses an observation sheet by the researchers or an observer assessment. Upon completion of the practicum, the collaboration assessment is carried out by colleagues within the same practicum group (peer assessment). Following the implementation stage, the science subject teacher and students receive a response questionnaire to evaluate the feasibility of the module used during the practicum. In this practicum module, there are sufficient instructions so that students are free to design experiments independently and in various ways, but they remain relevant to the concept of changes in energy forms.

The researchers used an essay test of creative thinking, Observation, and Collaboration skills, and a teacher and student response questionnaire.

1. Essay Test of Creative Thinking Skills

   The essay test consists of 6 items with indicators of creative thinking skills according to Guilford (1967); what was measured in this study were (1) fluency, (2) flexibility, (3) originality, and (4) elaboration. The selection of these indicators is based on the consideration that these indicators provide a fairly comprehensive basis for evaluating the level of creative thinking in the context of learning. The division of questions and indicators can be seen in Table 1.

Table 1 Division of questions on changes in energy form and indicators

Question Number	Question Topic	Indicator
1.	Types of energy changes in the cooking process and their efficiency.	Fluency
2.	Utilization of natural resources to produce renewable energy and application of technology.	Flexibility
3.	Innovation in the use of kinetic energy for urban sustainability.	Originality
4.	Designing a tool that utilizes two renewable energy sources, namely wind energy and tidal energy,	Elaboration
5.	Renewable energy solutions for remote areas and taking into account the limitations of existing technology and resources.	Originality

Question Number	Question Topic	Indicator
6.	The process of converting mechanical energy into electrical energy that can be used to charge cell phone batteries, as well as innovations to increase efficiency.	Flexibility

Furthermore, the creative thinking skills test is assessed using the assessment rubric modified from the rubric for creative thinking in a research study by Luthfia (2024), which can be seen in Table 2.

Table 2 Creative thinking skills rubric

Indicator	Response	Score
Fluency	Generate four or more ideas.	(4)
	Generate three ideas.	(3)
	Generating two ideas.	(2)
	Generate at least one idea.	(1)
Flexibility	Provide more than 1 idea and from different points of view.	(4)
	Providing 1 correct or true idea from another point of view.	(3)
	Give 1 wrong idea, but give another point of view.	(2)
	Giving 1 wrong idea and not providing another point of view.	(1)
Originality	The ideas presented are unique or different.	(4)
	The ideas presented are adapted from other people's ideas and contain novelty.	(3)
	The ideas presented are adapted from other people's ideas and contain nothing new.	(2)
	The ideas presented are common or the same as others.	(1)
Elaboration	Able to understand problems, provide detailed and coherent problem-solving, and use scientific principles appropriately.	(4)
	Able to understand problems, provide detailed and coherent problem solving, using scientific principles, but less precise.	(3)
	Able to understand problems, provide detailed and coherent problem solving, but does not use scientific principles.	(2)
	Able to understand problems, provide solutions that are not detailed, not coherent, and do not use scientific principles.	(1)

2. Observation Collaboration skills

   Observations use observation sheets filled out by the researchers and colleagues in one group. Both have the same goal, measuring and improving collaboration skills, but with different perspectives. Observer assessment provides an assessment from the outside, while peer assessment provides a perspective from fellow students. The indicators of collaboration skills by Trilling & Fadel (2009), namely (1) effective communication, (2) working in a team, (3) collaborative problem solving, (4) respect for diversity, and (5) social and ethical responsibility. The division of collaboration skills indicators can be seen in Table 3.

Table 3 Division of aspects of collaboration skills

Statement number	Aspects observed	Indicator
3 & 10	Able to convey ideas and information clearly. Draw conclusions and be able to report the results of the experiment.	Effective communication
2 & 7	Working with various types of individuals. Leading yourself during the practicum.	Work in a team
5 & 9	Contribute to problem-solving with a sense of responsibility. Discuss with the group to find a solution together.	Collaborative problem-solving

Statement number	Aspects observed	Indicator
4 & 8	Adapt to work with team members who have different backgrounds. Willing to accept joint decisions and appreciate criticism and suggestions.	Respect for diversity
1 & 6	Prepare and bring experimental materials. Responsible for the division of each task.	Social responsibility and ethics

3. Teacher and student response questionnaire.
   In this study, a closed questionnaire with a Likert scale was used. The closed questionnaire has answers that have been provided and does not provide an opportunity for the research sample to provide other information.

Validity assessment data in the form of quantitative data includes content validation and construct validation that includes material aspects, presentation aspects, and linguistic aspects, with a scale of 1-4, where each scale has a different category. The scores obtained are then calculated as the average score of each using the equation taken from Nuri et al. (2023).

$$V_{ah} = \frac{T_{Se}}{T_{Sh}} \; x \; 100\% \quad \ldots \quad (1)$$

Information:
V_{ah}: Expert validation
T_{Se}: Total empirical score achieved
T_{Sh}: Total expected score

After obtaining the validity percentage results, they are compared with the validity category based on the appropriate criteria (see Table 4). These validity criteria are taken from Nuri et al. (2023).

Table 4 Validity criteria

Criteria (%)	Validation Level	Information
85-100	Very valid	Can be used without revision
70-85	Valid	Can be used after minor revisions
50-70	Less Valid	Can be used after major revision
<50	Invalid	Major revisions should not be used

The feasibility test of the practical module is based on the results of the creative thinking skills description test, which uses N-Gain to determine the increase in creative thinking skills. The N-Gain formula is according to Hake (1999). Then, the results are compared with the N-gain category based on the criteria taken from Hake (1999), which is presented in Table 5.

Table 5 N-Gain criteria

Criteria	Category
$g \geq 0.7$	High
$0.3 \leq g < 0.7$	Moderate
$g < 0.3$	Low

Data for students' collaboration skills were obtained by filling out questionnaires by peers between students (peer assessment) in one team and direct observation by the researchers (observer). The results of the questionnaires were accumulated and calculated to obtain the percentage of collaboration skills.

The score categories obtained are compared with the categories adapted from Widyoko (2009), which can be seen in Table 6.

Table 6 Collaboration skills categories

Percentage (%)	Category
80-100	Very Collaborative
60-80	Collaborative
40-60	Moderately Collaborative
20-40	Less Collaborative
0-20	Uncollaborative

The researchers used a statement questionnaire to determine teachers' and students' responses to the open inquiry module. The results were then analyzed using the same formula as the collaboration skills instrument. The criteria for teacher and student responses, taken from Nurfitasari et al. (2024), can be seen in Table 7.

Table 7 Teacher and student response criteria

Percentage (%)	Category
81-100	Very good
61-80	Good
41-60	Enough

The reliability of this research instrument in the small group test is in a different class, namely Class VIII C. Further, more in-depth reliability trials can be carried out in further research.

RESULTS AND DISCUSSION

Validity

The first validation process was the validation of the practicum module. This validation covers various aspects, including the relevance of the material, the suitability of the open inquiry syntax, the encouragement of collaboration skills, and the suitability to learning objectives. Based on the validation results of 2 validators, each is included in the valid category. Therefore, improvements need to be made based on the suggestions given by the validator. The validation results can be seen in Table 8.

Table 8 Results of validation of practical modules

Description	Validator 1	Validator 2
Total score	66	72
Percentage	78.60	85.71
Interpretation	Valid	Valid
Average Percentage	82.15%	
Interpretation Percentage	Valid	

After the module was validated, a small group test was conducted in a different class, Class VIII C. This was intended to avoid potential bias, achieved by ensuring that the feedback gathered in the early stages of the process was specifically aimed at improving the design, rather than being influenced by other factors. Additionally, the large group test needed to remain independent and unaffected by the experiences or outcomes of the smaller group tested earlier. By separating the stages and controlling for external influences, the integrity of both the feedback and the test results was maintained, leading to more reliable and unbiased findings.

In addition, separating these two groups allowed the module to be tested and improved gradually, ensuring that when it was finally implemented in the large class, the module was ready to improve learning on a wider scale. The module view can be seen in Figure 1.

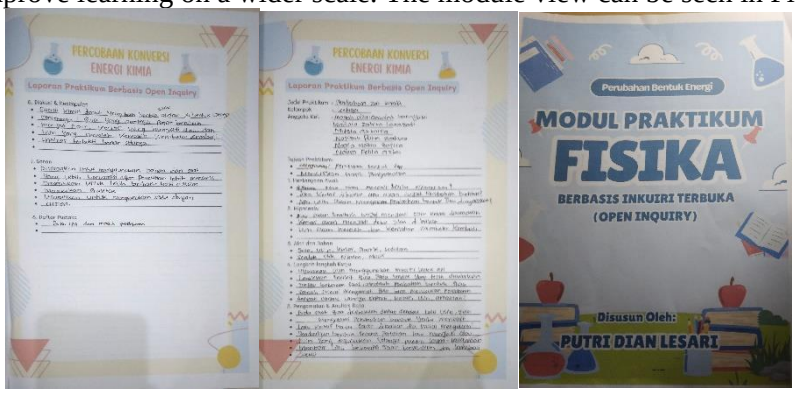

Figure 1 Practicum module view

The second is to validate the creative thinking skills instrument. This creative thinking skill consists of six essay questions covering four indicators: fluency, flexibility, originality, and elaboration. Fluency is the skill to generate many ideas or solutions quickly. Flexibility is the skill to think differently, see problems from different perspectives, and adapt. Originality is the skill to generate new, unique, and different ideas from what other people usually think. And elaboration is the skill to develop and expand ideas with additional details. The result is that validator 1 was obtained with a valid category, and validator 2 was very valid. However, improvements still need to be made based on the suggestions given by the validator.

Then, validate the collaboration skills instrument. This study uses research observation (observer) and peer assessment. The validation results obtained from the collaboration skills observation sheet validator 1 are valid, and validator 2 is very valid, based on the indicator criteria in Table 3. Improvements are made based on the suggestions for improvement given by the validator.

Product Eligibility

The feasibility of the practical module from the teacher response questionnaire to the product after learning activities using the developed open inquiry-characterized practical module. The teacher response questionnaire sheet for the product contains three aspects: introduction, core activities/open inquiry syntax, and alternative practical exploration. Based on the teacher response analysis results, the category is very feasible. Three science subject teachers filled out the questionnaire. The results of the questionnaire can be seen in Figure 2.

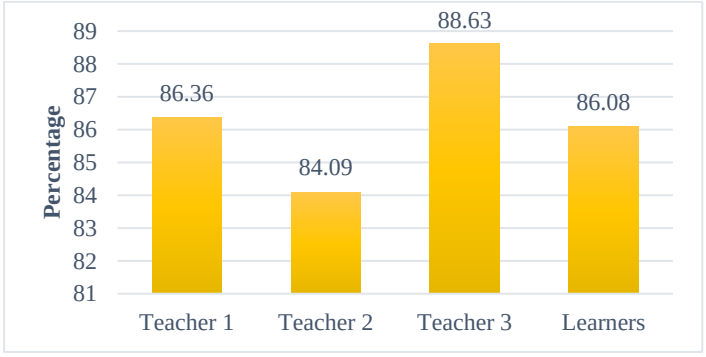

Figure 2 Response results to the module

The feasibility of the module during the practicum, based on the results of the creative thinking skills test, is seen in the results of the large group trial. The study was conducted in one class, VIII D, with three meetings. The three-session structure allows students to engage in a comprehensive learning process. In the first meeting, students began with a pretest to assess their prior knowledge of energy transformations. Following the pretest, they were introduced to the topic, sparking their curiosity and preparing them for the upcoming exploration. The second meeting focused on delivering the core material on energy transformations. After learning the theoretical concepts, students formulated research questions, designed experiments, and conducted small-group investigations. They also analyzed their data during this session, engaging actively in learning. Finally, the third meeting began with a discussion where students shared their findings, experiences, and how their understanding had evolved. This was followed by a post-test to measure students' understanding after the practicum. The implementation stages are shown in Figure 3.

Figure 3 Implementation stage

The results were an average pretest score of 43.76 and a post-test of 76.86. Then, the data was analyzed using the SPSS ver.21 application to find the N-Gain value, 0.59, or the N-Gain percent, which was 59%. Based on Table 5, the N-Gain criteria are in the moderate category. The details of each score indicator are presented in Figure 4.

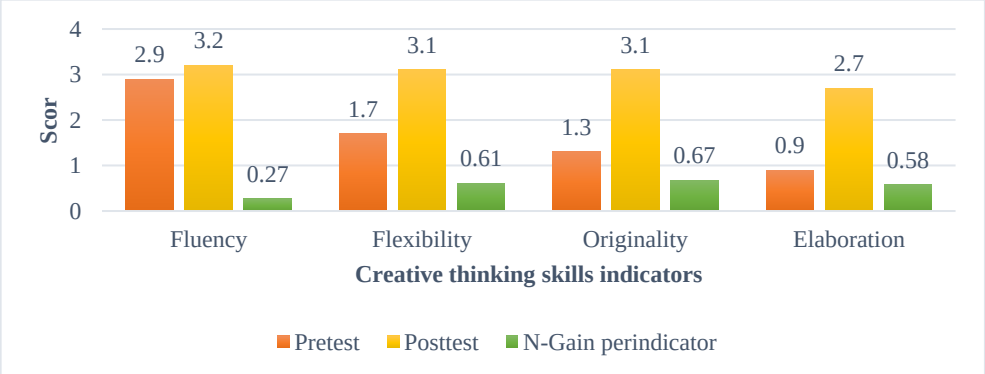

Figure 4 Results of the analysis of creative thinking skills indicators

Based on Figure 4, although the fluency indicator is in the low improvement category, there is an increase in the flexibility, originality, and elaboration indicators in the moderate category. This indicates that students experience substantial development in creative thinking skills, both in generating ideas and thinking flexibly, creating original ideas, and developing ideas further after the learning process. The greatest increase occurred in the originality and elaboration indicators, which show that students can increasingly produce

more innovative ideas and develop these ideas in more depth. The researchers provide adequate scaffolding and ensure learners have sufficient guidance during learning.

This research is in line with several previous investigations by Muhamad et al. (2024), which showed that open inquiry-based learning can significantly improve creative thinking skills. This is because students are free to explore their ideas, ask questions, and design experiments that encourage them to think critically and originally. In addition, research by Pöntinen et al. (2019) also revealed that open inquiry can strengthen collaboration skills, as students work in groups, share ideas, and solve problems together. This approach facilitates open discussion, allows students to learn from each other, and improves communication and collaboration skills in achieving common goals.

Students' creative thinking skills show varying results in various aspects. The fluency aspect is good, with students being able to produce many ideas in a short time, in accordance with research by Xu et al. (2022), which suggests that fluency mediates the relationship between creative thinking and cognitive abilities. However, the investigation by Alfitriyani et al. (2021) is different, with low fluency due to irrelevant ideas. The flexibility aspect is in the good category, seen from the skills of students to think from various perspectives, in accordance with the research of Candra et al., (2019), although the findings of Handayani et al. (2021) are different, which is low flexibility due to lack of courage in trying new approaches. The aspect of originality was assessed as good, with students producing new and unique ideas, such as on the kinetic energy problem, which reflects their creativity, in accordance with research López Martínez et al. (2024), although Luthfia (2024) found a different result, that the originality aspect is the most difficult to improve because students often follow predetermined patterns or answers, thus reducing the space for original creativity. The elaboration aspect in the good enough category, although students sometimes have difficulty detailing problems using scientific principles, in accordance with Biazus & Mahtari (2022), in contrast to exploration by Dumas et al. (2021), elaboration can be enhanced through discussions and creative projects that support more critical thinking.

In addition to using practical modules to improve creative thinking skills, students are actively involved in group practicals, which also improve collaboration skills. The observation sheet and peer assessment questionnaire contain the same 10 assessment aspects. This is so that the assessment consistently maintains the similarity of assessment aspects between the observation sheet and peer assessment. The results of the observation sheet analysis showed an average score of 3.41 with a percentage of 85.34%, and the peer assessment showed an average score of 2.96 with a percentage of 73.41%. The average collaboration skill score from the observer sheet analysis and peer assessment results can be presented in Figure 5.

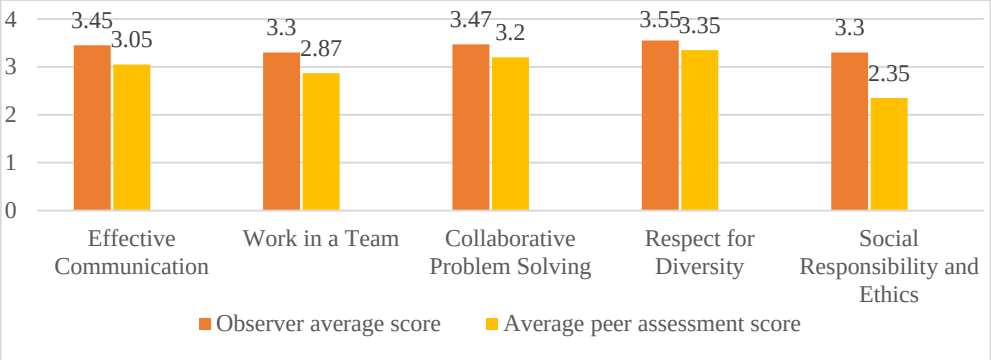

Figure 5 Results of the collaboration skills indicator analysis

The difference in results on the indicators of working in a team and social responsibility is caused by the difference in assessment focus. Observers provide objective assessments based on group dynamics, while peer assessments provide subjective views on individual contributions. These collaborative skills assessments complement each other, providing a more complete, fair, and accurate assessment.

The analysis of collaboration skills through observer sheets and peer assessments showed differences in several indicators. In the effective communication indicator, the average score showed a good category, with students being able to convey ideas clearly and listen well, although still less than optimal. This is in line with a research study by Aflah & Sabrina (2024), which shows students' concerns in conveying ideas. In the indicator of working in a team, the observer's sheet assessment showed a good category, while the peer assessment was in a fairly good category. This was influenced by the familiarity between group members, which made peer assessments more subjective and focused on individual contributions, while observers assessed the dynamics of the group as a whole (Breuer et al., 2020). The collaborative problem-solving indicator also received a good category. Although the reliance on a few individuals in the group to steer the discussion or generate solutions also caused the problem-solving process to run more slowly. This reflects the challenge of achieving optimal problem-solving collaboratively, although learners have shown good engagement in the process, according to the findings by Sun et al. (2022) about the importance of individual contributions in collaborative problem-solving. On the indicator of respect for diversity, although students show mutual respect, they do not fully understand cultural differences or perspectives, as expressed by (Abacioglu et al., 2020). Finally, the social and ethical responsibility indicators show differences in categories, with the observer sheet rating good and the peer assessment quite good, due to a lack of awareness of social implications and a lack of maturity in social skills in the adolescent phase. This is in accordance with research by O'Reilly et al. (2021) that the level of social responsibility and ethics is still in development in the adolescent phase. The difference in results reflects the influence of social interaction and individual perceptions of peer performance.

The difference in the analysis of the observer sheet and peer assessment results is due to differences in perception and interpretation of social and ethical responsibility in the context of collaboration. The observation sheet conducted by the researchers assesses from a more comprehensive objective perspective, where social and ethical responsibility is seen as a whole in group dynamics, in the willingness to share tasks, prepare, and bring experimental materials. Meanwhile, the more subjective peer assessment can be influenced by social interactions between learners. In addition, social proximity or personal preferences between learners may also influence how they assess their peers' performance regarding social and ethical responsibility. Learners, although demonstrating social and ethical responsibility, are not yet fully consistent in these behaviors, so there are more visible shortcomings in peer assessment.

The advantages of this research are: 1) Improving creative thinking skills. This module enhances creative thinking skills by encouraging students to ask open-ended questions and design their own experiments. The research study by Circony (2023) shows that inquiry-based learning can stimulate students' creativity, enabling them to produce innovative solutions that apply both in practical work and in everyday life. 2) Opportunities to improve critical thinking skills. This module has the opportunity to develop critical thinking skills through open and directed investigations. This finding is in line with research by Pols et al. (2023), which shows that critical thinking can be stimulated through inquiry and argumentation learning in physics, and 3) Facilitating collaboration skills. Practicums characterized by open inquiry encourage collaborative interaction between students in

solving problems. Research Song et al. (2022) emphasizes the importance of collaboration in project-based learning or practicums to achieve optimal results, 4) Encouraging independent learning. The open inquiry module encourages students to be more independent in seeking information and formulating research questions. Research by Cai et al. (2021) shows that this approach enhances students' learning independence, as they are trained to explore and validate knowledge actively. 5) Contextual application of concepts. Learning with open inquiry helps students apply scientific concepts in the context of experiments. This is in line with Pulgar et al. (2021), who found that contextual learning was more effective in improving student understanding than more structured approaches.

However, the researchers experienced several obstacles during the implementation stage: 1) class management. The open inquiry approach causes chaos because some students are more active, while others have difficulty. The solution the researchers apply involves active participants to help the passive ones, creating an inclusive learning environment. 2) Dependence on learner skills. Not all students have the same skills for independent experiments. The researchers' problem-solving is to provide discussion-provoking questions and opportunities to explore their abilities, 3) a Lack of self-confidence, and fear of being wrong. Students are afraid of making mistakes because they do not master the material. The solution is to create a safe and supportive atmosphere and emphasize that mistakes are part of the learning process to increase their confidence.

CONCLUSION

Based on the research, this module received a validation of 82.15% (valid category) and a teacher response of 86.36% (very feasible). The small group trial obtained a score of 92.01% (very feasible), although there were some suggestions. The results of the large group test showed that this module can improve students' creative thinking skills with an N-Gain score of 59% (moderate category). The analysis of collaboration skills showed an observer sheet score of 85.34% (very collaborative category). And a peer assessment of 73.41% (collaborative category). Overall, the open inquiry energy transformation practicum module developed was proven valid and feasible to use in learning and can improve creative thinking and collaboration skills. The researchers hope that further research will be carried out on developing an open inquiry practicum module on the material of energy transformation to measure other creative thinking sub-skills and other 21st-century 6C skills besides creative thinking and collaboration.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

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AUTHOR CONTRIBUTIONS STATEMENT

Conceived of the presented idea, PH and N; developed the theory, PH; verified the analytical methods, JA; HN encouraged P to investigate and supervised the findings of this work. All authors discussed the results and contributed to the final manuscript.

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