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Development of STEM-Based Student Worksheets through a Fly Repellent Project to Foster Students' Creative Thinking

Defi Elvina*, Saminan Saminan, Evendi

Science Education Study Program, Postgraduate School, Syiah Kuala University, Banda Aceh, 23111, Indonesia

**Corresponding author: defielvina@gmail.com*

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Abstract *– Creative thinking is one of the key competencies needed in twenty-first-century physics education. Yet, many classrooms still rely on traditional, teacher-centered instruction that leaves little space for student creativity or real-world application. At SMAN 4 Langsa, observations revealed that students often struggled to connect physics concepts with practical problems, underscoring the need for more context-based learning approaches. This study aimed to develop and evaluate STEM-based student worksheets centered on a fly repellent project to engage students in creative and applied problem-solving. Using a Research and Development (R&D) design guided by the ADDIE model Analysis, Design, Development, Implementation, and Evaluation the study involved 24 tenth-grade students. Data were gathered through expert validation, creative thinking tests administered before and after implementation, classroom observations, and response questionnaires. The worksheets were judged highly valid, with an average expert score of 90.5%, and proved effective in improving students' creative thinking skills, with an average N-Gain score of 0.73, categorized as high. Significant progress was seen across all four indicators of creative thinking: fluency, flexibility, originality, and elaboration. Student responses indicated that 87% found the worksheets engaging and useful in linking physics concepts to real-life issues, while teachers valued them as innovative and effective learning tools. The novelty of this research lies in embedding an environmental health problem into physics learning, providing students with a meaningful context in which to apply their knowledge. These findings highlight the potential of STEM-based, project-oriented worksheets to make physics learning more relevant, engaging, and effective in fostering twenty-first-century skills.*

Keywords: *creative thinking; fly repellent; project-based learning; STEM education; student worksheets*

I. INTRODUCTION

In the rapidly advancing world of education, fostering 21st-century competencies such as creative thinking, problem-solving, and innovation is essential. The need for these competencies is particularly significant in the context of Science, Technology, Engineering, and Mathematics (STEM) education, as these subjects are at the heart of technological advancements and societal development. Within the realm of science education, particularly physics, the ability to think

creatively is paramount. However, despite the growing emphasis on these skills, many educational practices still rely on traditional, teacher-centered methods that stifle student creativity and engagement (Jusman & Parisu, 2025; Wahyuaji & Suparman, 2019). Such instructional methods often focus on rote memorization and passive learning, which hinders the development of higher-order thinking skills necessary for real-world problem-solving.

Recent studies have shown that integrating innovative teaching methods into the curriculum can bridge this gap and better prepare students for the challenges of the future (McLure et al., 2022). Project-based learning (PBL) and inquiry-based learning (IBL) are two instructional strategies that have gained prominence for their potential to foster critical thinking, creativity, and collaboration (Oktaviyani et al, 2020; Yusal & Nurazmi, 2024). By engaging students in real-world, problem-solving scenarios, these methods align learning with the practical application of scientific concepts. However, while various studies highlight the potential benefits of such approaches, the integration of environmental and community-related issues in STEM education has not been adequately explored. For example, the application of STEM to address local environmental problems, such as pest control in schools, remains underutilized in educational settings, despite its ability to make learning more relevant and engaging for students (Alifah & Abidin, 2025; Amalia, 2024; Rahmawati et al, 2025; Sari et al., 2024; Nasution & Setyaningrum, 2024).

One of the most pressing challenges in contemporary physics education is how to make abstract scientific concepts more accessible and engaging for students. In many classrooms, the teaching of physics is still disconnected from students' daily experiences, limiting their ability to see the relevance of the subject. This lack of connection not only diminishes students' interest in the subject but also restricts their ability to apply theoretical knowledge to real-life situations. A case in point is the learning environment at SMAN 4 Langsa, where physics instruction primarily relies on textbooks and teacher-centered lectures. Observations at the school suggest that student engagement in physics lessons is low, and students frequently struggle to apply what they learn in class to real-world problems. This gap underscores the pressing need for innovative teaching methods that can engage students by connecting science education to issues directly relevant to their lives.

To address this issue, a possible solution lies in the development of STEM-based student worksheets that incorporate real-world challenges into the learning process. These worksheets provide students with opportunities to apply scientific concepts to real-world problems, encouraging them to think critically and creatively. Specifically, integrating a project-based approach where students design solutions to real-life problems, such as creating fly repellent devices, can enhance their understanding of physics concepts while also fostering the

development of creative thinking skills. This approach not only improves conceptual understanding but also aligns with the goals of the Merdeka Curriculum, which emphasizes student-centered, contextual, and project-based learning (Bybee, 2013; Nurazmi & Bancong, 2021; Wahyuni & Witarsa, 2023).

Previous studies have explored various teaching strategies designed to enhance students' creative thinking and problem-solving skills. For instance, STEM-integrated teaching models and PBL approaches have been shown to improve students' critical thinking, collaboration, and creativity (Khalisah & Mahmudah, 2022; Sukmagati et al., 2020). Similarly, research by Alam et al (2023) demonstrated that the integration of environmental issues in the classroom can enhance students' engagement and cognitive abilities. However, a significant gap exists in the application of STEM-based worksheets that address local environmental health problems, such as fly infestations, in physics education. This gap underscores the need for further research into how STEM-based student worksheets can be developed and implemented to make physics learning more contextual, engaging, and effective in promoting higher-order thinking skills.

The literature on STEM education highlights several promising approaches for fostering creative thinking. However, few studies have focused on the use of contextual, real-world problems, such as environmental health issues, as the basis for STEM-based worksheets in physics education. While some studies have explored the integration of project-based learning and inquiry-based learning into the STEM curriculum, they often overlook the potential of local environmental issues to serve as learning contexts that are both relatable and meaningful to students. This is where the current study seeks to contribute. By developing a STEM-based worksheet that guides students in designing a fly repellent device, this research aims to explore how contextual issues can be effectively integrated into physics lessons to foster creativity, critical thinking, and problem-solving skills.

This study aims to develop and evaluate the feasibility of a STEM-based student worksheet that incorporates a fly repellent project to enhance students' creative thinking skills. The worksheet is designed to engage students in identifying real-world problems, applying scientific principles, and designing functional solutions. By examining the effectiveness of this worksheet in improving students' creative thinking abilities, this research aims to fill a critical gap in the literature and provide evidence-based recommendations for enhancing physics education through innovative, contextual, and project-based learning strategies. The novelty of this study lies in its integration of environmental health issues into the physics curriculum, providing a tangible and relevant context for learning that enhances both student engagement and academic achievement. The research is guided by the hypothesis that STEM-based worksheets incorporating real-life

problems can significantly improve students' creative thinking skills and promote a deeper understanding of physics concepts.

II. METHODS

This study follows a Research and Development (R&D) design with the aim of creating a STEM-based student worksheet centered on a project to develop a fly repellent device. The study is grounded in the ADDIE model, a widely used instructional design framework that comprises five stages: Analysis, Design, Development, Implementation, and Evaluation (Branch, 2009). The ADDIE model is particularly effective in providing a structured approach to developing educational materials while allowing for iterative refinement based on continuous feedback. In this study, the model was employed to ensure that the developed worksheet is both pedagogically sound and effective in enhancing students' creative thinking skills in physics.

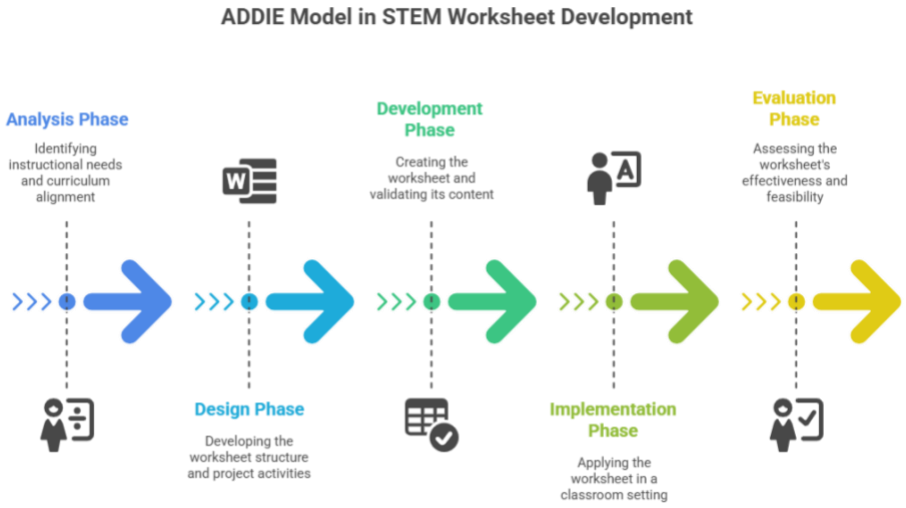

Figure 1. ADDIE model research flow

The research was conducted at SMAN 4 Langsa during the second semester of the 2024/2025 academic year. A total of 24 students from class X.1 were selected as the study subjects. The choice of these subjects was primarily based on academic considerations and the ease of access during the implementation process. The development process was carried out in alignment with the ADDIE model, as detailed in Table 1. Each phase of the model was designed to contribute systematically to the creation of the STEM-based worksheet, culminating in its real-world application in the classroom.

The Analysis phase involved identifying the instructional needs, aligning the worksheet with the curriculum, and considering the characteristics of the learners, as well as addressing local

issues relevant to the students' environment. One such issue identified at SMAN 4 Langsa was the high prevalence of flies in the school cafeteria, a problem that could serve as a practical, real-world context for learning. In this phase, a comprehensive review of the curriculum was conducted to ensure that the worksheet met the educational standards while making the learning process more relatable and engaging for the students. The outcomes of this stage were a set of identified learning needs and a clear understanding of how the worksheet could address these needs.

During the Design phase, the structure of the Student Worksheet was developed, focusing on project-based activities that would allow students to engage with scientific concepts in a hands-on manner. The project-based approach was chosen as it is well-documented for fostering higher-order thinking, particularly creative thinking, and problem-solving abilities in students (Sukmagati et al., 2020). The worksheet design incorporated several key elements, including an outline of the fly repellent device project, the integration of relevant physics concepts, and clear indicators of creative thinking skills fluency, flexibility, originality, and elaboration (Guilford, 1950). The research instruments, including a creative thinking skills test and validation tools for content and media, were also developed during this phase.

In the Development phase, the student worksheet and associated instruments were created. Expert validation was a critical component of this phase, as it ensured the content and media of the worksheet were of high quality. Both content experts in physics and media experts reviewed the materials, providing feedback on aspects such as alignment with curriculum standards, clarity of instructions, and the visual appeal of the worksheet. The results of the expert validation were overwhelmingly positive, with the worksheet receiving high scores in terms of content validity (92%) and media quality (89%). Based on the experts' suggestions, revisions were made to enhance clarity, simplify instructions, and incorporate more visuals to aid in understanding. The final version of the worksheet, refined through expert feedback, was then ready for implementation in the classroom.

The Implementation phase involved the practical application of the worksheet in a classroom setting. The worksheet was administered to 24 students from Class X.1, who participated in two sessions of physics instruction. During these sessions, students used the worksheet to design and test a fly repellent device. A pretest and posttest on creative thinking were administered before and after the implementation of the worksheet, respectively. The pretest and posttest consisted of open-ended questions designed to assess students' ability to think creatively and apply physics concepts to solve real-world problems. These assessments were essential in measuring the improvement in students' creative thinking skills. Additionally, an observation sheet was used to track student engagement and task performance during the classroom activities. This

observational data was crucial for evaluating how actively students participated in the project and how well they applied scientific principles in their work.

In the Evaluation phase, data analysis was conducted to assess both the feasibility and effectiveness of the worksheet. The feasibility of the worksheet was evaluated using expert validation scores, which indicated that the worksheet was highly suitable for the classroom setting. The effectiveness of the worksheet in enhancing students' creative thinking was measured using the N-Gain score. The N-Gain scores were then classified into three categories: high ($g > 0.7$), moderate ($0.3 < g \leq 0.7$), and low ($g \leq 0.3$). The analysis revealed that the average N-Gain score was 0.73, which placed the worksheet in the high category of effectiveness. This finding indicated a significant improvement in students' creative thinking skills as a result of using the STEM-based worksheet. Additionally, feedback from both students and teachers was collected through response questionnaires, which assessed the perceived effectiveness, practicality, and usability of the worksheet. The students' responses were largely positive, with 87% stating that the worksheet helped them understand physics concepts in a practical, applied manner. Teachers also expressed high satisfaction with the worksheet, noting that it provided an innovative and engaging approach to physics education.

III. RESULTS AND DISCUSSION

This study followed the ADDIE model to develop and evaluate a STEM-based Student Worksheet designed to enhance students' creative thinking skills. The findings from each stage of the ADDIE model Analysis, Design, Development, Implementation, and Evaluation are presented below, highlighting the process of designing and refining the worksheet, as well as assessing its impact on student learning.

1. Analysis

The analysis phase began with preliminary observations at SMAN 4 Langsa to identify existing problems in the physics learning environment. Observations revealed that physics instruction was largely conventional, relying on teacher-centered methods that led to low student engagement and suboptimal learning outcomes. Students were predominantly passive recipients of knowledge, and there was limited opportunity for them to apply theoretical concepts to real-world situations. Furthermore, the study identified a relevant environmental issue within the school: a high population of flies in the canteen. This problem was selected as the authentic context for the development of the STEM-based worksheets. Interviews with physics teachers confirmed the absence of learning media that encouraged direct scientific exploration through real-life projects. This finding highlighted the need for an instructional approach that integrated

real-world issues into the learning process, fostering both engagement and the application of scientific concepts.

2. Design

Based on the identified needs, the design phase focused on creating a STEM-based worksheet that employed a project-based learning approach. The worksheet was structured around the creation of a fly repellent device, allowing students to engage in a hands-on project that connected physics concepts with a real-world problem. The design of the worksheet incorporated several key activities: students were tasked with identifying the problem of fly infestation in the school canteen, designing a fly repellent device based on scientific principles, conducting experiments, and drawing conclusions based on their results. The goal was to encourage students to think critically and creatively, applying their understanding of physics concepts in the process.

The worksheet design also included indicators of creative thinking, based on Guilford's (1950) theory, which emphasizes the development of fluency, flexibility, originality, and elaboration. These indicators were incorporated into the worksheet activities, ensuring that students would have opportunities to exercise their creative thinking skills throughout the project. In addition, research instruments were developed to assess the effectiveness of the worksheet, including a validation questionnaire, creative thinking essay questions, and observation sheets designed to capture student engagement and task performance.

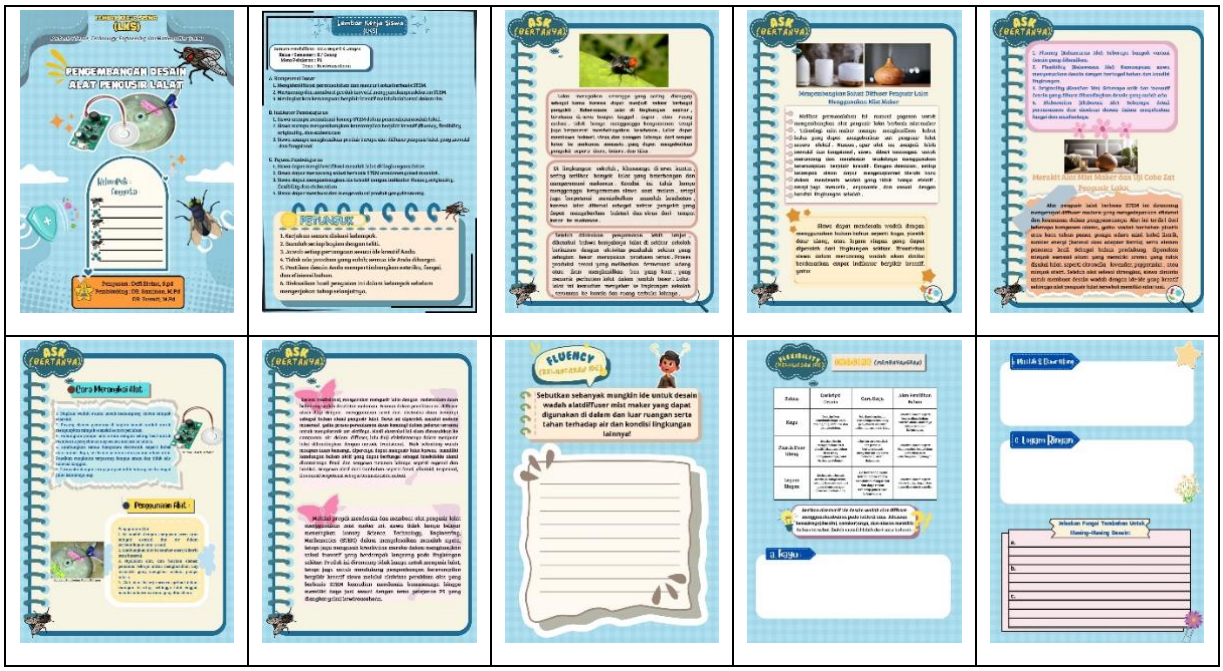

Figure 2. Display of the final design results of the student worksheet

3. Development

The development phase produced the first version of the student worksheet, which was then subject to expert validation. The validation process was conducted by both subject matter experts in physics and media experts to ensure that the worksheet met academic and pedagogical standards. The expert validation results were highly positive, with an average score of 90.5% across all assessed aspects. As shown in Table 2, the worksheet received particularly high marks for content alignment with the curriculum (92%) and the integration of STEM activities (90%). The visual appearance and layout also received strong ratings from media experts, with scores of 89% and 91%, respectively. These results indicated that the worksheet was well-constructed, both in terms of its content and its ability to engage students visually and pedagogically.

Table 2. Expert validation of STEM-based student worksheet

Aspects Assessed	Validator	Score (%)	Category
Content alignment with the curriculum	Subject expert	92%	Highly valid
Clarity of learning objectives	Subject expert	88%	Valid
Integration of STEM in activities	Subject expert	90%	Highly valid
Visual appearance	Media expert	89%	Valid
Layout appearance	Media expert	91%	Highly valid
Alignment of activity flow	Media expert	93%	Highly valid

Revisions were made to the worksheet based on expert feedback. These revisions included simplifying instructions, adding images of the tools required for the project, and adjusting the assessment rubric to ensure clarity and consistency. Once these revisions were completed, the final version of the student worksheet was ready for implementation in the classroom.

4. Implementation

The implementation phase was conducted in class X.1 at SMAN 4 Langsa with 24 students participating. Over the course of two 90-minute learning sessions, students engaged with a STEM-based worksheet designed to enhance their creative thinking skills. Prior to the intervention, a pretest was administered to assess students' creative thinking abilities. After completing the activities in the worksheet, a posttest was given to measure any improvements in their creative thinking skills.

Table 3 presents the pretest and posttest scores along with the N-Gain scores, which indicate the improvement in students' creative thinking skills after the implementation of the worksheet.

Table 3. Analysis of the improvement of students' creative thinking skills

	Score	Percentage	Maximum Value	N-Gain	Category
Pretest	121	25.21	480	0.73	High
Posttest	382	79.86			

As shown in Table 3, the pretest score of 121 out of a maximum of 480 indicates that students' creative thinking skills were initially at a relatively low level. However, the posttest score of 382 reflects a significant improvement in their abilities. The N-Gain score of 0.73, categorized as high, demonstrates that the intervention was highly effective in enhancing students' creative thinking skills.

Further data analysis was conducted by examining the changes in students' performance across the indicators of creative thinking. Figure 3 shows the comparison of pretest and posttest scores for each creative thinking indicator, revealing how students' creative thinking evolved in terms of fluency, flexibility, originality, and elaboration after completing the worksheet activities.

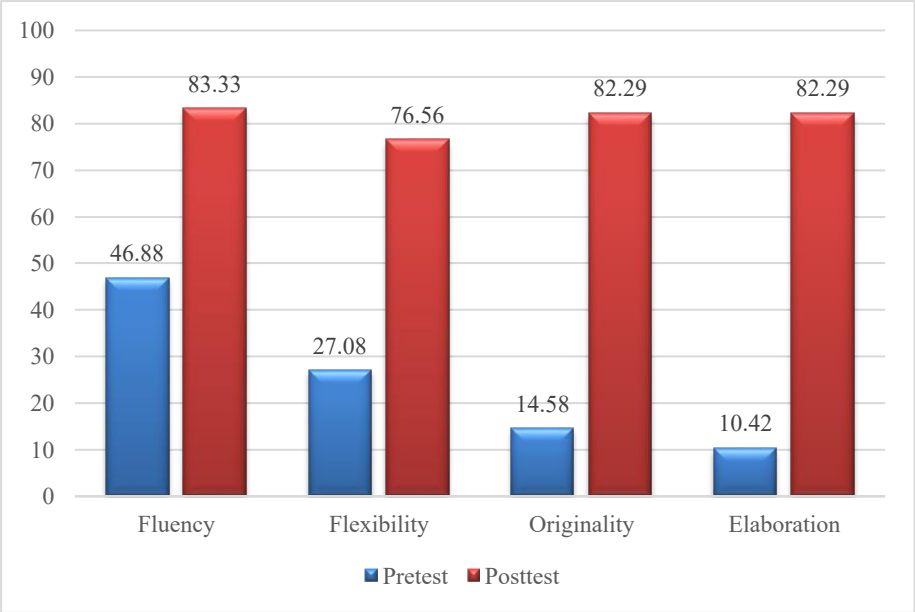

Figure 3. Comparison of pretest and posttest scores for students' creative thinking skills based on indicators

The analysis of the N-Gain results for each creative thinking indicator, as depicted in Figure 4, confirms significant improvement across all areas of creative thinking. The N-Gain scores for fluency, flexibility, originality, and elaboration indicate that the STEM-based worksheet effectively fostered the development of these essential creative thinking skills.

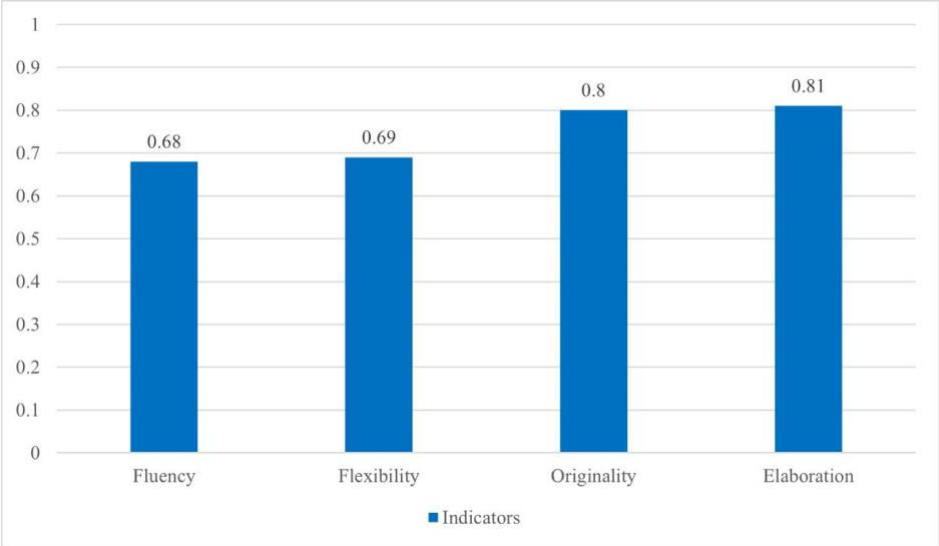

Figure 4. N-Gain chart of creative thinking skills

The substantial increase in posttest scores, as indicated by the N-Gain analysis, reflects the effectiveness of the STEM-based student worksheet in improving students' creative thinking abilities. This improvement is attributed to the design of the worksheet, which integrated project-based learning activities that encouraged students to engage in critical thinking, experiment with different solutions, and reflect on their work.

One key factor contributing to the development of comprehensive thinking, an essential component of creative thinking, is the inclusion of reflection and evaluation activities in the worksheet. According to Khalishah & Mahmudah (2022), STEM-based project learning not only focuses on producing tangible products but also provides opportunities for students to reflect on their creations. This reflection process helps students refine their ideas and develop more innovative solutions. By reflecting on their fly repellent device designs, students developed a deeper understanding of the concepts they had applied and made adjustments based on their evaluations.

Additionally, the implementation of the worksheet fostered adaptive thinking in students. When their initial designs did not yield the desired results, students were encouraged to modify their prototypes and try alternative solutions. This iterative process is a crucial aspect of creative thinking, as it enables students to recognize failure as an opportunity for improvement and innovation. Ulfa et al. (2019) argue that project-based learning encourages students to rethink and innovate when faced with challenges, thus improving their flexibility and creative problem-solving skills. The iterative nature of the fly repellent device project allowed students to experiment, reflect, and refine their designs, thereby enhancing their creative thinking abilities.

5. Evaluation

The evaluation phase involved collecting feedback from both students and teachers to assess the effectiveness and practicality of the STEM-based student worksheet. Response questionnaires were distributed to gather data on how well the worksheet met the learning objectives and its perceived impact on students' creative thinking. The student responses were overwhelmingly positive, with 87% of students reporting that the worksheet helped them think more creatively and understand the material in a practical, applied context. Students appreciated the opportunity to work on a real-world problem, and many noted that the project-based approach made the learning process more engaging and relevant to their daily lives.

Teachers also expressed strong approval of the worksheet, emphasizing its potential as a contextual learning tool. According to the teacher's feedback, the worksheet not only facilitated creative thinking but also encouraged students to think critically and develop practical solutions to real problems. The integration of STEM concepts into the worksheet was viewed as a valuable approach for promoting higher-order thinking skills, and teachers believed it could serve as an effective model for future physics instruction.

The findings of this study indicate that the implementation of a STEM-based student worksheet, centered around a fly repellent project, significantly enhanced students' creative thinking skills, particularly in the areas of fluency, flexibility, originality, and elaboration. This outcome aligns with existing research on the benefits of STEM-integrated project-based learning (PBL), which has been shown to foster higher-order thinking skills, including creativity and problem-solving (Bancong & Song, 2020; Nasution & Setyaningrum, 2024). By engaging students in a real-world problem, such as fly infestations in the school canteen, this study successfully bridges the gap between abstract physics concepts and practical applications, facilitating a deeper understanding and greater student engagement. The use of such a contextual problem allowed students to connect theoretical knowledge with tangible outcomes, reinforcing the relevance of physics in their daily lives. This finding is consistent with Haris et al. (2024), who highlighted the role of real-life contexts in enhancing student understanding of complex scientific concepts and increasing motivation.

The integration of real-world problems into the learning process is a fundamental component of STEM education, which not only promotes creativity but also cultivates 21st-century skills such as critical thinking and communication (Khalisah & Mahmudah, 2022; Parno et al, 2019; Rahmat & Suparman, 2019). The results of this study reflect the iterative, hands-on nature of the STEM learning process. The students' ability to design and revise their fly repellent prototypes mirrors the core principles of creative problem-solving, where students engage in cycles of experimentation, reflection, and revision. This iterative process of designing and improving

prototypes aligns with the educational philosophy that emphasizes the importance of learning from failure and adapting ideas, which is central to both creative thinking and STEM pedagogy. The hands-on activities provided opportunities for students to apply scientific principles to solve real-world challenges, reinforcing the idea that learning should be dynamic and responsive to real-life contexts.

Further validation of these findings comes from the work of Alam et al (2023), who emphasized that STEM-based worksheets enhance students' thematic thinking and practical competencies. In their research, they found that students benefit significantly from the integration of real-world tasks into the learning process, as it helps bridge the gap between theoretical knowledge and practical application. This study corroborates those findings, showing that students' engagement with a practical, hands-on STEM project not only improves their creative thinking skills but also fosters a deeper conceptual understanding. The development and application of the fly repellent worksheet in this study are therefore consistent with the findings of other researchers who argue for the effectiveness of STEM-based learning tools in enhancing both creativity and practical competence in science education (Aiyesi et al, 2025; Gunawan et al., 2025).

What distinguishes this study from much of the existing literature is its focus on integrating environmental health issues into physics education through a tangible, school-based project. While many studies have explored the use of digital modules or guided inquiry approaches to foster student creativity (Anjani & Mayasari, 2022; Ishaq, 2013), this research uniquely contributes to the field by demonstrating how environmental health problems can serve as a rich, context-based medium for teaching physics. This approach fills a critical gap in the literature by demonstrating that real-world, community-relevant issues can be effectively integrated into physics learning to promote creative thinking, without relying on complex technological tools. The hands-on, low-tech nature of the fly repellent project made it particularly accessible and engaging for students, offering an alternative to more technology-dependent approaches in STEM education (Batrisyia et al., 2024; Fahlevi et al., 2024; Putri et al, 2020).

The implications of this research for physics education are significant. First, it shows that contextual STEM projects can make abstract physics content more accessible by tying it to practical, everyday problems. By integrating real-world issues into the curriculum, educators can help students understand the relevance of scientific concepts beyond the classroom and foster a deeper connection to the material. Moreover, such approaches promote critical thinking, creativity, and collaboration, all of which are essential 21st-century skills outlined in educational frameworks, such as the Pancasila Student Profile, as promoted by the *Kurikulum Merdeka*. The curriculum's emphasis on developing student autonomy, creativity, and problem-solving skills is

mirrored in the positive outcomes observed in this study, which highlighted increased student engagement, curiosity, and a more active role in the learning process (Pribadi & Marzuki, 2023; Utami et al., 2024; Purwanti & Indriani, 2024).

Feedback from both students and teachers further supports the value of the STEM-based worksheet as an effective instructional tool. An overwhelming majority of students reported that the worksheet helped them think more creatively and understand physics in a practical context. Similarly, teachers expressed that the worksheet provided an innovative and contextual approach to teaching, allowing students to work on real problems and apply their knowledge in a meaningful way. This positive feedback reinforces the shift from traditional, teacher-centered approaches to more student-centered learning models, which emphasize active participation, collaboration, and problem-solving. The success of this worksheet suggests that it could serve as a valuable tool for future physics instruction, and its approach could be expanded to other topics and educational levels.

IV. CONCLUSION AND SUGGESTION

The findings of this study highlight the effectiveness of the STEM-based student worksheet with a fly repellent device project, developed through the ADDIE model, in enhancing students' creative thinking skills. The worksheet was validated by both subject matter and media experts, receiving an average score of 90.5%, indicating its high suitability for educational use. The implementation of the worksheet resulted in a significant improvement in students' creative thinking abilities, as evidenced by an average N-Gain value of 0.73, categorizing the improvement as high. Students demonstrated increased fluency, flexibility, originality, and elaboration, confirming that the worksheet effectively stimulated their creativity and engagement with real-world contexts. Both students and teachers provided positive feedback, with students finding the activities engaging and challenging, and teachers appreciating the worksheet's ability to promote critical and creative thinking in alignment with the Pancasila learner profile.

While the results of this study are promising, there are several limitations that warrant consideration. The study was conducted with a small sample size of 24 students from a single school, which may limit the generalizability of the findings. Future research should involve a larger and more diverse sample across different schools and educational levels to further validate the effectiveness of the STEM-based worksheet further. Additionally, future studies could explore the application of similar worksheets in other science subjects or topics to assess their broader applicability in STEM education. Despite these limitations, this study makes a significant contribution to the field of physics education by demonstrating that contextual, project-based

learning materials can be an effective tool for fostering creativity and problem-solving skills. The use of real-world problems, such as environmental health issues, enhances student engagement and helps bridge the gap between abstract scientific concepts and their practical applications, making the learning process more relevant and meaningful.

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