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ORIGINAL ARTICLE

Strengthens the Student Collaboration and Decision-making Skills through Integrated STEM Education: A Research and Development Study

Bevo Wahono[1]*, Astrino Purmanna[2], Rizki Ramadhani[3], Marison Sudianto Manalu[4]

[1]Department of Biology Education, Faculty of Teacher Training and Education, University of Jember, Jember, Indonesia, [2]Department of Science Education, Faculty of Teacher Training and Education, University of Jember, Jember, Indonesia, [3]Department of Islamic Education, Sekolah Tinggi Ilmu Tarbiyah Al-Quraniyah, Bengkulu, Indonesia, [4]Graduate Institute of Science Education, National Taiwan Normal University, Taipei, Taiwan

***Corresponding Author:** bevo.fkip@unej.ac.id

ABSTRACT

This research investigates students' decision-making and collaborative skills within the science teaching and learning process through integrated Science, Technology, Engineering, and Mathematics (STEM) education. Although collaborative skills and effective decision-making are vital in the 21st century, many students still lack proficiency in these areas. To address this issue, a structured methodology has been adopted to enhance the development of these skills in science education. The study involves designing and validating an instructional unit for integrated STEM (IUI-STEM) education, which is implemented directly in the classroom. Sixty-four seventh-grade students from two different schools participated in the research. Improvements in decision-making and collaborative skills were analyzed using the Wilcoxon rank-sum test. A valid IUI-STEM education unit was developed specifically for this case study. The findings indicate that learning through integrated STEM education, facilitated by the IUI-STEM unit, significantly improves decision-making skills in science ($p < 0.001$; $Z = -4.644$; $d = 1.421$). Additionally, there is a notable improvement in students' collaborative skills before and after the integrated STEM education ($p < 0.001$; $Z = -5.102$; $d = 1.85$). By nurturing collaboration and decision-making skills through integrated STEM education, students will be better prepared for success in future academic pursuits and careers that demand strong teamwork and problem-solving abilities.

KEY WORDS: Decision making; science classroom; STEM education; student' collaboration

INTRODUCTION

Decision-making and collaboration are the essential skills for students to effectively navigate the challenges of the 21st century. Decision-making involves choosing and implementing an action from the various options to solve the specific problems. Developing this skill can enhance students' resilience in confronting obstacles and overcoming difficulties (Hamizah et al., 2021). Students who possess strong decision-making abilities often demonstrate a higher level of resilience. In contrast, those with limited skills in this area may struggle to tackle the challenges and resolve issues (Siribunnam et al., 2018).

Collaborative skills are defined as a partnership between two or more students. These skills aim to share responsibility and play a role in achieving a shared understanding of issues and solutions (Li et al., 2023). According to Mertz et al. (2023), collaboration offers different advantages compared to student problem-solving since the process enhances additional skills as well as the creativity and quality of solutions obtained from each group member's ideas. Even though collaborative and decision-making skills in science are essential in the 21st century, students' proficiency in the areas remains deficient (Davis et al., 2018). Based on this issue, an applicable approach is needed to develop students' collaboration and decision-making skills in science through STEM education. To enhance global competitiveness, the National Science Foundation launched the Science, Technology, Engineering, and Mathematics (STEM) innovation as educational reform movement in the 1990s (American STEM). Based on several research, integrated STEM education is highly suitable for implementation in Asian countries, including Indonesia (Wahono et al., 2020).

In the past decade, integrated STEM education has shown a moderate to strong effect on student learning outcomes in its implementation in Asia. This positive effect indirectly shows the importance and necessity. However, the related references and implementations in Indonesia and Asia are still lacking (Le et al., 2023; Wahono et al., 2020). Previously, some teaching materials have been developed on various topics and subjects (Almuharomah et al., 2019; Wahono et al., 2023). The development of Instructional Unit for Integrated STEM (IUI-STEM) education specifically enhancing students' decision-making and collaboration skills is still very limited. Therefore, this research is expected to serve as a foundation for developing innovative instructional units to promote the advancement of STEM education and help learners master 21st century educational competencies.

The investigation focuses on enhancing students' decision-making and collaboration skills through a well-structured curriculum in the science teaching and learning process. This research begins with the development of IUI-STEM education, which integrates various components designed to improve these skills. The anticipated results aim to serve as a key reference for policymakers as they consider the formal integration of STEM into the national education systems of Indonesia and other countries. Furthermore, this research provides a solid foundation to support the availability of valid and relevant references.

THEORETICAL FRAMEWORK

Science Decision-making Skills

Decision-making involves selecting among various alternatives to achieve desired outcomes (Aladwan, 2023). It can be defined as the process of identifying one option from numerous possibilities when faced with different situations in life (Dauer et al., 2022). This process includes recognizing options and choosing one while considering several criteria. In this context, every student should have the opportunity to develop decision-making skills to solve the complex problems. These skills are influenced by a student's perspective in identifying observed issues (Wong and Watt, 2019).

The decision-making process consists of three main elements (Lunenburg, 2010). First, the process begins with generating choices from several alternatives related to the issue at hand. Second, among the generated alternatives, one is selected as the most suitable final decision to address the problem. Third, the objectives and targets in problem-solving can be achieved using the previously selected final decision. Moreover, decision-making skills in science are crucial for 21st century students due to the complex and interconnected nature of modern societal and personal issues. The ability to make informed decisions based on scientific evidence is essential for tackling challenges related to health, the environment, and technology. Integrated STEM education plays a significant role in developing these skills by enhancing critical thinking, problem-solving, and information literacy. Research has shown that students who engage in integrated STEM learning experience an increase in self-efficacy when it comes to finding, evaluating, and using technical information in decision-making (Dauer et al., 2022). Instruction that combines integrated STEM with socio-scientific issues can significantly impact students' decision-making by incorporating diverse worldview perspectives (Wahono et al., 2021). Additionally, evidence suggests that students who participate in integrated STEM activities tend to connect their experiences with these activities and make decisions about pursuing STEM-related fields (Dawes et al., 2015). Furthermore, the National Research Council emphasizes the importance of science literacy, which includes decision-making skills necessary for participation in civic and cultural affairs, as well as economic productivity (Dauer et al., 2022). Therefore, equipping students with science decision-making skills is essential for their future roles as informed citizens and professionals.

The development of science decision-making skills is important for students to face an increasingly complex and technology-driven world effectively. These skills include critical thinking, creativity, and applying scientific knowledge to the real-life situations. Decision-making in science and engineering often requires the consideration of probabilities and uncertainties to develop a strong foundation in these areas (DEF, 2023). Moreover, integrating science decision-making skills with 21st century learning objectives, such as critical thinking and problem-solving, is essential for the demands of the modern workforce. In this context, integrated STEM education has been identified as a powerful tool for enhancing complex thought processes and problem-solving skills, which are integral to effective decision-making (Wahono et al., 2021). Therefore, integrated STEM education prepares students for future careers in science and technology to make informed decisions (Wahono et al., 2022).

Collaboration Skills

Collaboration skills are essential for 21st century students preparing for the workforce and navigating an increasingly interconnected world. These skills include the ability to work effectively with peers, share ideas, and achieve common objectives (Mertz et al., 2023). Collaboration comprises active listening, communication, critical thinking, and skills to contribute to group discussions and problem-solving (Wengrowicz et al., 2018). The learning experiences such as group projects and class discussions allow students to develop skills and enhance academic performance (Fransen et al., 2011). By engaging in collaborative activities, students can learn from one another, develop a deeper understanding of the subject matter, and improve social and emotional skills (Zhang and Wang, 2024). These skills are transferable to various aspects of life, including the workplace and personal relationships. The components include contributions, time management, problem-solving, working with others, and investigative techniques (Hermawan et al., 2017). Additionally, teachers can enhance collaboration skills by creating an environment that promotes open communication, providing opportunities for students to work together, and offering guidance on effective strategies.

Collaboration skills are crucial in classroom learning activities due to the ability to enhance students' knowledge and experiences in achieving learning objectives. Typically, student groups working collaboratively tend to produce more knowledge. The application can be completed by conducting learning activities that encourage the sharing of tasks fairly, motivate members to take responsibility for tasks, and use social skills effectively (Mertz et al., 2023). Collaboration has been among the most widely accepted forms of learning in professional education for several decades (Wengrowicz et al., 2018). By developing these skills, students enhance academic learning and develop social and emotional skills essential for effective collaboration in the workplace and beyond (Hermawan et al., 2017).

Prior research on integrated STEM utilizing robotics has been shown to enhance students' collaborative skills, particularly in participation, perspective-taking, and social regulation (Latip et al., 2020). Furthermore, as elementary teachers often struggle with teaching integrated STEM, Asim et al. (2025) propose an online professional development program designed to support teachers in fostering student collaboration, interaction, and reflection. Therefore, this research aims to explore the dynamics through integrated STEM education.

Developing collaboration skills requires a significant investment of time and different challenges have the potential to constrain the effectiveness of teams. According to Da Fonte and Barton-Arwood (2017), the implementation of systematic procedures becomes important for successful collaboration. An initial measure to be carried out includes the execution of teacher preparation programs. These programs assume a crucial role in equipping teachers with the necessary tools to facilitate students' refinement of collaboration skills. Therefore, teachers are expected to deploy strategies aimed at mitigating potential barriers and enhancing favorable outcomes. The cultivation of effective collaboration mandates that students acquire proficiencies such as communication, active listening, feedback provision, and inclusivity (Fransen et al., 2011). Teachers can enhance effective collaboration by forming small groups of four or five students, ensuring a high level of accountability and providing complex learning activities (Zhang and Wang, 2024). Furthermore, effective collaborative work should be cultivated by establishing collaboration expectations, assigning specific roles, and providing opportunities to practice (Da Fonte and Barton-Arwood, 2017).

Integrated STEM Education

STEM has become a prime consideration and necessity in the 21st century era, serving as a philosophical foundation in the development of an instructional unit. Integrated STEM education is a learning innovation that combines concepts and theories with real-world lessons by applying science, technology, engineering, and mathematics principles (Wahono et al., 2020). Specifically, the integration can support the enhancement of student learning outcomes, particularly in improving achievements in science and technology (Altan et al., 2018). Moreover, integrated STEM education enhances students' science decision-making skills. A contemporary and innovative approach to learning is enhanced, encouraging students to use creative skills and think in problem-solving by integrating science, technology, engineering, and mathematics. Research has shown that STEM learning promotes critical thinking, curiosity, persistence, and decision-making (Le et al., 2023). Additionally, the concept enhances students' higher-order thinking skills in solving engineering problems, directly contributing to developing decision-making (Abe and Chikoko, 2020).

Integrated STEM education empowers students to become confident problem solvers and enhances skills to solve and prevent modern societal problems. Curiosity and innovative thinking are also fundamental for effective decision-making in science and related fields. STEM-focused activities cultivate creativity and motivate students to use imagination and resources to interpret and solve complex problems (Topsakal et al., 2022). Therefore, integrated STEM education enhances academic achievement and significantly contributes to developing reflective thinking skills toward problem-solving and lifelong learning (Şahin, 2021).

Given the importance of decision-making and collaboration skills for students, it is essential to explore how students develop these competencies through Instructional Units for Integrated STEM Education (IUI-STEM). Developing well-structured instructional units is fundamental to fostering meaningful learning experiences. Studies has shown that instructional unit development has been shown a significant importance for the students learning as the promote students engagement, collaboration, and decision-making. For instance developing integrated STEM curriculum unit on middle school improving students learning outcomes in science (Anwar et al., 2022). Furthermore, specifically for teachers, Wieselmann et al. (2022) developed STEM-PBI curriculum units for grades one through eight, which help students engage in authentic contexts, enhance communication, and produce meaningful final products. Through an effective instructional units (IUI-STEM) development, we hope students enhance their collaboration skill and decision-making which is essential in the 21st century skill.

RESEARCH METHODS

Research Type

The research is structured as a pre-experimental design, specifically using a collective group pre-test-post-test approach in line with a quasi-experimental methodology. In the initial phase, teaching materials were developed and validated in the form of IUI-STEM education. The results were followed by classroom implementation aimed at investigating students' science decision-making and collaboration skills. In the classroom implementation stage, 63 students came from two schools and were ranked to have the same quality level (BANSM, 2019). Moreover, no significant difference between pre-test scores from both schools was reported. These pre-tests were collected to assess students' basic knowledge before the intervention and determine the background. All students gave informed consent before the inclusion in the research.

Research Procedure and Instruments

In the initial stage, the research and development followed the ADDIE model, which consisted of five stages, namely Analysis, Design, Development, Implementation, and Evaluation. ADDIE is one of the most favored models in developing instructional units to produce effective designs. This systematic development model aimed to solve problems related to learning resources to meet student's needs (Moro and Billote, 2023).

The results were followed by classroom implementation to investigate science decision-making and collaboration skills. The sample comprised students from two schools in Jember Regency, East Java Province, Indonesia, particularly student studying Biotechnology in the second semester of 2022/2023. The topic of biotechnology focused on DNA recombination through the design of Genetically Modified Organism (GMO) products in the form of recombinant DNA models as a solution to the stunting case. The instruments used included IUI-STEM, pre-post test questionnaires for science decision-making, and collaboration observation sheets. The designed instrument adopted the concept of construct validity, as suggested by (Yang et al., 2018). Subsequently, the content validity was evaluated using a panel of experts consisting of professors in biotechnology as well as designing assessments and STEM education. The biotechnology experts evaluated each item for biotechnology/genetic accuracy, relevance, and clarity. Meanwhile, the assessment and STEM education experts evaluated each item for comprehension, understandability, and relevance. The instruments were modified to improve the quality of items based on the experts' comments and suggestions.

The classroom testing procedure started with administering a pre-test, followed by an initial introduction to the taught material by the teacher. Additionally, literature reviews were conducted using the learning module on DNA recombination. After understanding the material on DNA recombination, four large groups were formed to work on activities in student's worksheets. The worksheet included in the instructional unit served as a valuable tool designed to cultivate science decision-making and collaboration skills. This presented a pertinent problem concerning the high prevalence of stunting in Jember and proposed a potential solution for the creation of GMO or transgenic plants engineered to possess elevated nutrient content. The task was to position students as bioengineers to create a GMO product for reducing the stunting population. The worksheet provided steps to decide on one GMO product for solving the problem. After decision, students were tasked with creating a recombinant DNA model of the product based on the principles of recombination. Subsequently, a post-test was carried out to assess the improvement in decision quality compared to the previous pre-test.

Data Analysis

The field trial of the IUI-STEM education scale was analyzed using quantitative descriptive data analysis. The measurement of the improvement in students' decision-making skills was observed before the use of the instructional unit. This is evident by the answers in the pre-test, compared to the quality of decisions in the post-test after the use of the instructional unit. For the assessment of collaboration skills, scores obtained from observations were calculated using a formula to compute the average of students. Specifically, the components focused on assessing collaboration skills such as contributions, time management, problem-solving, working with others, and investigative techniques. The learning effectiveness was tested using the Wilcoxon Rank Sum Test with the Statistical Package for the Social Sciences (SPSS) for Windows application. This test was used to measure the significance of the difference between paired ordinal and numeric data groups. According to Cohen et al. (2018), the results of the difference were observed through negative ranks and positive ranks. The negative and positive ranks table showed the pre-test and post-test results, respectively. After the determination, the two data sets were ranked, resulting in the Sum of Ranks. The Sum of Ranks was considered significant when the data result was less than 0.05. The final step included the analysis of Cohen's d effect size to determine the extent of the effect of learning with IUI STEM.

RESEARCH RESULTS

This research started with developing and validating teaching tools, namely an IUI-STEM education. The tool is a planned material as part of efforts to strengthen students' decision-making and collaboration skills.

The IUI-STEM Education Development Process

The development procedure of IUI-STEM education uses the ADDIE development model. This model consists of five stages, namely Analysis, Design, Development, Implementation, and Evaluation. Generally, an overview of the process and results of these stages is as follows.

Analysis

In this stage, the analysis process assesses the need to develop instructional materials to achieve learning objectives. The analysis phase is conducted through field surveys comprising an assessment of instructional material requirements among teachers using a questionnaire, an evaluation of students' instructional material needs via a dedicated questionnaire, and an examination of content standards through literature reviews of student textbooks and syllabi. In several high schools in East Java Province, there is no IUI-STEM education material, and teachers intend to use the materials. Subsequently, an analysis of the instructional material needs of four students was conducted. The results stated that 75% of students had difficulty understanding the material from the textbooks and would not feel bored when learning using instructional materials. Students who filled out the questionnaire felt the need to develop instructional materials besides textbooks to enhance critical 21st century skills. Another example is the analysis of the learning unit's content standards, resulting in the formulation of competency achievement indicators and learning objectives. The results of the analyses serve as references in designing and developing a well-designed curriculum.

Design

In this stage, an initial design for developing IUI-STEM education is developed. The stage in the design process includes determining the type of instructional materials, designing the material, and preparing the validity instruments. For example, the designed instructional unit includes components such as learning modules, student worksheets, and Lesson Implementation Plans (RPP) supplemented with pre-tests and post-tests. The learning module is designed explicitly for DNA recombination, which features enhancing students' decision-making and collaboration skills. For instance, a feature to improve decision-making skills is evident in the style of the worksheet, which depicts a framework for making good decisions. The module's content is tailored to the Competency Achievement Indicators (IPK) and learning objectives. The instructional unit is designed with a B5 format (7.17 in × 10.12 in), using Lato font size 10 and 1.5 spacing. The IUI-STEM education in this research comprises a total of 42 pages.

Development

The development stage started with developing the learning materials to be included in the principles of integrated STEM education. After developing and organizing the learning materials, the instructional unit is produced or printed in the physical form. However, this unit is validated through validity and revisions can be made to the product when deficiencies need to be addressed. Face and content validity are conducted by three experts in STEM approach theory, instructional material development, and biotechnology. Meanwhile, the validity sheet provides comments and suggestions for improving the developed instructional unit. The content validity is adjusted based on theories existing in the literature and the average inter-rater agreement score from the validators is 87%. This score shows that the developed tool is valid and can be used. The experts also provided some notes as comments and suggestions to improve the developed instructional unit. For example, a validator's comment is, "The operational verb *"understand"* should be changed to *"explain."*" Based on the notes provided, improvements have been made to the instructional unit by addressing unsuitable points and adding materials to enhance the curriculum.

Implementation

In this stage, the instructional unit developed in the classroom learning process is applied. A total of 64 twelfth-grade high school students are included in the implementation to assess the contribution of the developed instructional unit to students' decision-making and collaboration skills. Detailed results can be seen in the elaboration of decision-making and collaboration skills to address the objectives.

Evaluation

The evaluation stage serves as a comprehensive reflection on the process, starting from the development of learning tools and ending with the implementation in the classroom. Specifically, this stage evaluates the achievements of the initial objective, which is to determine the strengthening of students' scientific decision-making and collaboration skills through a science teaching and learning process with a well-designed curriculum.

Students' decision-making and collaboration skills

Classroom teaching has been conducted using the IUI-STEM, a well-designed curriculum, to enhance decision-making and collaboration skills. The teaching is performed by a model teacher in two different schools. Integrated STEM education is the hallmark of learning, as reflected in the instructional unit developed in this research. Figure 1 shows some examples of learning activities to enhance students' decision-making and collaboration skills.

Table 1 shows the analysis results for the effectiveness of students' decision-making skills. The obtained results include pre-test and post-test scores analyzed using SPSS data analysis software. Meanwhile, prerequisite analyses such as normality and homogeneity tests have been conducted. The normality test shows that the pre-test scores are not normally distributed ($p = 0.004$). Data transformation using the Square-Root method has also been attempted, but the processed data show non-normality. Given this, the Wilcoxon Test for paired samples was used when data does not follow a normal distribution. As it is a non-parametric alternative that suitable for analyzing the data that do not meet the normality assumption. Therefore, the pretest and posttest scores are analyzed using Wilcoxon nonparametric methods.

Based on the Wilcoxon test in Table 1, the obtained sig. (2-tailed) value is < 0.001; $Z = -4.644$. Therefore, there is a significant difference between pre-test and post-test scores, showing a difference in the quality of decisions before and after learning. This suggests that learning through integrated STEM education facilitated by the use of IUI-STEM affects the quality of students' scientific decision-making skills.

The magnitude of the effect of learning through integrated STEM education facilitated by the use of IUI-STEM on scientific decision-making skills is calculated using effect size (Cohen's d). The Cohen's d statistical test results show a large effect size ($d = 1.42$). Meaning that the post-test scores are much higher than the pre-test scores, with a considerable magnitude of change. This imply that the effectiveness of the intervention to the students.

In another school, a test is conducted to determine the effectiveness of learning through integrated STEM education facilitated by the use of IUI-STEM. The scores obtained based on learning observation results are analyzed to assess collaboration skills. Since the obtained data does not follow

Figure 1: Activities of students engaging in integrated STEM education

Table 1: Statistical test results of students' decision-making skills

n	Scores				sig.(2-tailed)	Z	d
	Mean pre-test	SD	Mean post-test	SD			
30	66.2133	14.85966	82.6100	6.73966	<0.001	−4.644	1.421

a normal distribution (p = 0.023), a non-parametric test using the Wilcoxon test is also conducted. Before the non-parametric test, efforts to transform the data are first made using the Square-Root Transformation method. The results of the Wilcoxon test and Cohen's d-effect size analysis are presented in Table 2.

Based on the Wilcoxon test results, the z-value is −5.102, and the sig. (2-tailed) value is <0.001. Therefore, there is a significant difference between students' collaboration skills before and after learning through integrated STEM education facilitated by the use of IUI-STEM. Subsequently, an effect size test is conducted to assess the magnitude of integrated STEM education treatment on collaboration skills. Similarly, the results shows a large effect size (d = 1.85) of students collaboration skill which indicated that the post-test scores are much higher than the pre-test scores, with a considerable magnitude of change. This imply that the effectiveness of the intervention to the students.

Table 2: Statistical test results of students' collaboration skills

n	Scores				Sig.(2-tailed)	Z	d
	Mean pre-test	SD	Mean post-test	SD			
34	52.794	7.295	80.588	6.273	<0.001	−5.102	1.85

DISCUSSION

Integrated STEM Education Improves Students' Decision-making and its Related Skills

The implementation of IUI-STEM education has been effective in enhancing students' scientific decision-making skills. This approach provides students with a unique learning experience by allowing them to apply concepts and theories learned through problem-based learning in real-world scenarios. As a result, their decision-making abilities improve when tackling assigned problems. According to Leung (2022) and Wahono et al. (2021), one effective method for assessing students' critical thinking is to familiarize them with the decision-making process in complex learning situations. Students are also tasked with designing recombinant DNA models using the tools and materials provided, which encourages them to think critically when making decisions. Furthermore, IUI-STEM education is integrated into biotechnology education, particularly on topics related to GMOs. This includes module components that cover DNA recombination material. In this context, students have access to worksheets designed to help them apply their knowledge by creating GMO products in the form of recombinant DNA models.

IUI STEM is suitable for application in science learning because the implementation promotes the design, development, and usage of technology. Students also need to think critically in analyzing problems, formulating, and evaluating alternatives, as well as in making decisions to provide solutions. Therefore, IUI STEM indirectly enhances cognitive, affective, and motor skills. Students are able to apply knowledge and cultivate convergent and divergent thinking, which are the basis for students' decision-making skills (Wahono et al., 2021; Wahono et al., 2020).

Several research attempted to implement the concept of IUI-STEM education in learning. According to Wahono et al. (2023), a learning approach with integrated STEM education learning units focused on accessing students' system thinking skills. System thinking skills were formulated to describe and solve problems through the use of the learning units. A Physics IUI-STEM module based on local wisdom, "Beduk," had been developed to enhance creative thinking skills (Almuharomah et al., 2019). Therefore, students' decision-making also serves as a foundation for acquiring other essential skills required in the 21st century (systematic, critical, and creative thinking).

Strengthens Student Collaboration Skill

An instructional unit integrated STEM education strengthens students' collaboration skills by providing opportunities to work on complex and engaging projects that require effective teamwork, communication, and problem-solving. In this unit, students can develop a deep understanding of the subject matter while enhancing skills to collaborate with peers (Pasani and Amelia, 2023). Key strategies to enhance collaboration in integrated STEM education unit include five factors (Kazu and Yalcin, 2021; Pasani and Amelia, 2023; Wahono et al., 2020). First, creating complex learning activities and challenging tasks that require positive interdependence promotes collaboration and helps students learn from one another more effectively. Second, promoting discussion and consensus can lead to a more thorough understanding of the subject matter as well as improve social and emotional skills. Third, assigning a specific role and responsibility within the group can help students understand unique contributions to the team. Fourth, providing opportunities for practice and giving time and opportunities to work on collaborative projects develops leadership, decision-making, and trust-building skills. Finally, setting clear expectations and establishing clear guidelines for collaboration help in understanding the importance of teamwork. Therefore, the benefits of this approach are the potential to improve collaboration skills among students.

Integrated STEM education provides a ground to develop and refine collaboration skills. By working on complex and real-world problems during IUI-STEM implementation, students learn the subject matter and essential skills for successful teamwork, communication, and problem-solving in future academic and professional endeavors. Integrated STEM education often includes hands-on projects, requiring students to work in teams. Collaboration allows students to learn how to communicate, cooperate, and coordinate efforts toward a common objective effectively. This interdisciplinary process exposes students to diverse perspectives and approaches, enhancing open-mindedness and appreciation for the value of teamwork (Mertz et al., 2023). Collaboration on a complex STEM project requires students to think critically and analyze the different aspects of the problem (Sayılgan et al., 2022). Through group discussions and brainstorming sessions, different ideas are challenged to obtain innovative solutions. Additionally, conflicts may arise due to differing opinions or approaches when working in teams. Integrated STEM education provides opportunities to learn conflict resolution skills, promoting a positive and productive group dynamic (Wahono et al., 2020). Working on the projects provides a sense of purpose and motivation, enhancing the commitment to shared goals. After completing the project, students can engage in reflection exercises and provide feedback to teammates. The practice promotes self-assessment and continuous improvement in collaboration skills. Therefore, the approach enhances academic performance and prepares students for future careers.

CONCLUSION AND RECOMMENDATION

In conclusion, this study highlights the positive impact of integrated STEM education in fostering both decision-making and collaborative skills among seventh-grade students. The large effect size for both collaboration skill and decision-making indicate a significant improvement. The improvement in decision-making and collaborative skills demonstrates that IUI-STEM is well-designed IUI-STEM which may enhance 21st-century skills that are critical for student success in academic and future professional settings. While the IUI-STEM in this study was tailored to the Indonesian context, the positive outcomes underscore its broader applicability in other educational settings.

Nevertheless, as we encountered a small sample size in this study, further research is needed to investigate the same phenomenon across different grade levels, such as elementary school and high school students. In addition to expanding the sample size, future studies could also explore other variables that contribute to the development of collaboration and decision-making skills in integrated STEM education.

Based on the findings, the IUI-STEM could be implemented in similar contexts or educational settings with confidence that it will lead to meaningful improvements. Additionally, policymakers should support the development and implementation of instructional units like IUI-STEM, which focus on developing critical 21st century skills. Finally, investing in teacher training to design and execute such curricula would be crucial to fostering an environment where students are equipped with the skills needed to succeed in an increasingly complex world.

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ETHICAL DECLARATIONS

The authors confirm that all ethical guidelines were followed throughout this research, including the proper acquisition of informed consent from all students involved. In addition, the authors stated that the ethical requirement of this research was approved by the Institute for Research and Public Services, the University of Jember, on March 30, 2023 (code: 3486/UN25.3.1/LT/2023). All participants were informed of the purpose of the study and their rights, including their right to withdraw at any time without consequence. Additionally, any images used in the study were obtained with explicit consent, ensuring that all participants' privacy and confidentiality were respected.

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