

STEAM and Local Wisdom in Mathematics Learning to Improve 4Cs Skills

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Abstract. This study aims to explore the effects of implementing STEAM-based mathematics learning integrated with local wisdom on enhancing 4C skills. A case study method was conducted at SMP Negeri 1 Stabat, collecting data through classroom observations, interviews with teachers and students, and analyzing learning outcomes before and after implementing STEAM learning. Qualitative descriptive analysis was used to evaluate the data. The findings indicate that mathematics learning integrated with STEAM and local wisdom effectively supports junior high students in developing essential 21st-century skills, including critical thinking, creativity, collaboration, and communication, with an average skill improvement above 3.5 across all aspects. Moreover, integrating local wisdom into math lessons fosters more meaningful and contextualized learning. This study's implications highlight a substantial contribution to enhancing learning management at the junior high level, preparing students with essential skills for their future.

Keywords: Local wisdom, STEAM, 4Cs (critical thinking, creativity, collaboration, and communication)

1 Introduction

According to the World Economic Forum [1], 65% of children starting primary school today will end up in jobs that currently do not exist. This prediction highlights the need to equip students with various 21st-century skills, including entrepreneurial abilities. [2] emphasize the need for a paradigm shift in teaching and learning approaches to align with the demands of the industrial revolution, which calls for these essential skills. A key area of focus is on insights into STEAM education and its crucial role in preparing students for the evolving demands of the industrial revolution.

The STEAM concept includes four types of disciplinary integration: transdisciplinary, interdisciplinary, multidisciplinary and cross-disciplinary [3]. As a transdisciplinary approach, STEAM incorporates various disciplines as a whole and is based on authentic problems or inquiry [4]. As interdisciplinary, STEAM brings together several disciplines under one common theme, although each discipline remains independent [5]. In a multidisciplinary approach, STEAM involves collaboration between two or more disciplines without fully unifying them [6]. Meanwhile, the cross-disciplinary approach allows the observation of one discipline through the perspective of another, such as physics in music [7]. The integration of the five

disciplines-science, technology, engineering, arts and mathematics-has been recognized as an effective teaching strategy that motivates students to master 21st century skills [8].

STEAM encourages project-based and exploratory learning that gives students the opportunity to apply theory in a real context, nurturing their creativity and innovation [9,10]. The implementation of STEAM in junior high schools has become a concern in educational research and practice, especially in relation to its impact on enhancing students' creativity and innovation [11]. Project-based STEAM learning has proven effective in honing critical thinking skills [12] and developing 21st century skills [13]. This is because STEAM integrates subject matter with a transdisciplinary approach that involves student creativity and innovation. STEAM learning helps students master skills that are relevant in the modern era, such as critical thinking, problem solving, and decision making [14].

In junior high schools, the application of STEAM faces challenges, including in the aspects of relevance and contextuality of education. For example, at SMP Negeri 1 Stabat, teachers already understand the concepts and benefits of STEAM, but have not fully implemented it in the classroom because there is still a misperception that STEAM is more suitable for higher education. In addition, limited resources and facilities are also an obstacle to STEAM implementation. Observations also show that although teachers utilize local wisdom as a learning resource, the approach is still too general and does not integrate local cultural wealth specifically. In fact, local wisdom-based learning brings many benefits, including making the material more relevant to students by linking it to everyday life [15]. In addition, local wisdom-based learning helps students understand and appreciate their culture, strengthen cultural identity, and foster a sense of pride in their heritage [16,17].

STEAM approach based on local wisdom in mathematics learning is an effort to build mathematical knowledge through a learning process that utilizes local objects, noble values of the surrounding environment, and integration of disciplines in STEAM. In mathematics learning, the implementation of STEAM can be done by understanding the relationship between mathematical concepts and other disciplines covered in STEAM, while local wisdom serves as a medium or literacy object. The STEAM approach and local wisdom are applied in an integrated manner, namely by connecting STEAM disciplines with mathematical concepts to generate ideas, solutions or products, and at the same time preserving local cultural values.

The implementation of STEAM based on local wisdom can be a solution to these challenges. This approach not only improves students' understanding of science, technology, engineering, art, and math, but also fosters appreciation for local cultural wealth. Students are expected to develop critical, creative and innovative thinking skills relevant to their local context. This study aims to examine the impact of learning mathematics with a STEAM approach based on local wisdom in developing 4C skills (Critical Thinking, Creativity, Collaboration, and Communication) in the 21st century.

2 Research Method

This research adopted a case study approach to explore the implementation of the local wisdom-based STEAM model at SMP Negeri 1 Stabat. The case study method was chosen because it allows researchers to conduct an in-depth exploration of the context, process and outcomes of the implementation of this approach. This approach is appropriate for exploring complex phenomena in real contexts, where various variables interact dynamically.

Data in this study were collected through observation, interviews, and documentation. Observations were made to observe the implementation of STEAM learning based on local wisdom by teachers and to see students' activities and participation during the learning process. Interviews aimed to find out the responses of teachers and students to STEAM learning. In addition, documentation is used to collect information related to schools and preparation of teaching materials. The primary data of this study involved teachers, principals, and students of SMP Negeri 1 Stabat.

Data analysis was conducted in the following stages namely: (1) Data Reduction, which is summarizing data obtained from observations, interviews, questionnaires, and documentation based on their relevance to the research. (2) Data Presentation, which is compiling data that has been reduced in the form of tables and descriptive narratives to facilitate understanding and interpretation. (3) Drawing Conclusions, namely making conclusions based on the pattern and analysis of the data obtained. Data triangulation was used to ensure the validity and reliability of the research results. The indicators of 21st century skills evaluated and measurement classification in this study [18] can be seen in the following table 1 and table 2:

Table 1. Skills Indicator of 4Cs

Aspect	Indicator
Critical Thinking	• Students are able to analyze information from STEAM-based activities that have been carried out • Students are able to interpret data and analysis results from STEAM-based activities that are followed • Students are able to build arguments or opinions based on STEAM-based activities carried out
Creativity	• Students are able to generate interesting and relevant idea concepts • Students can design and create creative works
Communication	• Active in discussions and contribute to group activities • Dare to express opinions through STEAM-based activities • Skilled in delivering presentations of products produced
Collaboration	• Demonstrate a cooperative • Responsive • Responsible attitude in working together

Table 2. 4C Skill Measurement Classification

Interval	Category
≤ 2.00	Very Less
2.00 – 2.49	Less
2.50 – 2.99	Adequate
3.00 – 3.49	Good
3.50 – 3.99	Very Good

3 Results and Discussion

STEAM approach based on local wisdom in mathematics learning is a process of mathematical knowledge construction carried out in a learning process using local objects, noble values of the surrounding environment and followed by disciplinary ideas contained in STEAM.

In learning mathematics, STEAM implementation can be done by understanding the relationship between existing mathematical concepts and other disciplines contained in STEAM and local wisdom as a medium / object of literacy. The implementation of STEAM and local wisdom is carried out in an integrated manner, meaning that the approach taken is to connect the disciplines contained in STEAM with existing mathematical concepts to produce an idea, idea, solution or product; While preserving the values of local wisdom.

The research conducted shows that the implementation of STEAM integrated mathematics learning based on local wisdom has a significant positive impact on students' creative thinking and effectively improves students' 4 Cs skills. Based on the results of observations made, it was found that there was a development of 21st century skills in students as indicated by an increase in the average score of each skill shown in the following table 3.

Table 3. Average scores for improving 4Cs skills in integrating STEAM and Local Wisdom in learning math

Aspect	Before	After
Critical Thinking	2,274	3,682
Creativity	2,481	3,725
Collaboration	2,375	3,750
Communication	2,333	3,825

The table 3 above shows that there is an increase in 4 Cs skills, seen from the increase in the average value of each skill category displayed in the table above. Learning activities are integrated with the STEAM approach which includes introductory, core and closing activities. In learning activities, the teacher acts as a facilitator, tasked with encouraging students to carry out meaningful learning through learning stages that have been integrated with STEAM. With this STEAM activity, students are expected to understand the value of local wisdom in the production process, develop critical and creative thinking, and practice digital communication skills. Students' skills are assessed using student skill sheets that have been made previously. In addition, teacher activities were observed and recorded using a special sheet to ensure alignment with the research objectives. The learning activities carried out can be seen in the following figure 1.



Fig. 1. STEAM-integrated math learning activities based on local wisdom in SMP 1 Stabat

In detail, the results of the research conducted on improving 21st century skills through learning that has been integrated with STEAM based on local wisdom are as follows.

3.1 Critical Thinking

These skills are developed through thinking, analyzing, seeking information and constructing arguments. Students try to do critical thinking to understand and determine complex choices. The activities used to trigger critical thinking skills begin with activities to analyze the problems given by the teacher. In critical thinking skills, learning begins with giving STEAM problems to student groups as follows:

Kegiatan menganyam dengan memanfaatkan bahan baku purun yang dilakukan oleh ibu-ibu di Desa Mekar Jaya merupakan contoh praktik kearifan lokal yang memiliki potensi besar untuk dijadikan cenderamata unik dan bernilai.



Sebelum dianyam, purun terlebih dahulu diolah menjadi bahan baku. Mengambil purun biasa ketika siang hari saat air sedang surut. Setelah itu, purun dijemur sampai kering, bagian pangkal dan ujung dipotong agar bersih. Purun bersih siap diwarnai agar menghasilkan anyaman beraneka warna. Pewarnaan purun dengan merendam ke air mendidih dan sudah ditambah pewarna. Guna memperkuat daya tahan dan pewarna tak mudah pudar, setelah direndam, purun-purun kembali dijemur atau diangin-anginkan beberapa jam.

AKTIVITAS STEAM

- 1. Mathematic:** Analisis Pesanan dan Waktu Produksi
 - Tugas: Siswa diajak untuk menganalisis pesanan tas yang diterima oleh Kelompok Usaha Barokah.
 - Studi Kasus:
Kelompok Barokah menerima pesanan 120 tas yang harus diselesaikan dalam waktu 20 hari.
Beri tanda "Benar" atau "Salah" untuk setiap pernyataan berikut:
 - a. Waktu rata-rata pembuatan 5 buah tas adalah 2 hari.
 - b. Waktu penyelesaian semua pesanan bisa tepat waktu jika dalam sehari dihasilkan 2 buah tas.
 - c. Jika pesanan bertambah 25 tas, lama penyelesaian bertambah 2 hari.
 - d. Jika dalam sehari dapat dihasilkan 8 tas, waktu penyelesaian seluruh pesanan menjadi 5 hari lebih cepat.
- 2. Science:** Studi Ekosistem Purun
 - Aktivitas: Siswa melakukan kajian literatur untuk memahami manfaat purun bagi ekosistem gambut.
 - Sumber: Buku atau internet.
 - Fokus:
 - a. Manfaat purun dalam menjaga ekosistem gambut, seperti membantu mengatasi erosi dan menyimpan karbon.
 - b. Peluang pengembangan purun dalam aspek kehidupan lain, seperti bahan baku ramah lingkungan atau alternatif produk berbasis purun yang lebih luas.
- 3. Engineering dan Art:** Desain Tas atau Dompet dengan Pola Geometri
 - Tugas: Siswa merancang dan membuat tas atau dompet dari bahan purun atau bahan alami lain di sekitar mereka.
 - Spesifikasi:
 - a. Rancangan harus mencerminkan pola geometri tertentu, misalnya pola simetris atau mosaik, agar tas memiliki nilai estetika yang tinggi.
 - b. Siswa diharapkan memanfaatkan bahan yang ada di sekitar sebagai bentuk kearifan lokal.
- 4. Technology:** Presentasi Hasil Desain
 - Aktivitas: Siswa mempresentasikan hasil kerja mereka menggunakan aplikasi Canva atau PowerPoint
 - Fokus: Presentasi harus mencakup penjelasan tentang bahan yang digunakan, proses pembuatan, pola desain geometri yang dipilih, serta alasan memilih pola tersebut.
 - Tujuan: Siswa belajar menyusun informasi secara visual dan mempraktikkan keterampilan komunikasi digital.

Fig. 2. Critical Thinking

Based on the observation results, it can be seen that students critically respond to and carry out every instruction given by the teacher. This skill is also evident from the average score which increased from 2.27 before the application of STEAM to 3.68, with a very good category. These results are in line with several previous studies, such as those showing that the integration of STEAM learning can improve students' critical thinking skills and their science literacy [19]. Other research also supports that STEAM learning significantly improves students' critical thinking skills [20]. This is because the STEAM approach fosters holistic thinking through linking science, technology, engineering, art and math, which encourages students to look at problems from multiple perspectives and seek comprehensive solutions [10]. In addition, projects and assignments in STEAM learning involve complex problem solving, which requires critical thinking skills such as problem identification, data analysis, and evaluation [21]. The

STEAM approach also encourages students to experiment, innovate and learn from failure, making it effective in improving their critical thinking.

Furthermore, local wisdom-based learning allows students to learn contextually by understanding the phenomena that occur around them [15]. Students involved in this learning are more motivated to learn, understand the causes and impacts of problems, and seek solutions [22]. This happens because students can immediately connect with the learning context and solve real challenges, which ultimately trains them to think critically [23].

3.2 Creative

In learning activities, students are advised to come up with original concepts that are different from pre-existing concepts, either in the form of new works or combinations of existing works. In this research, high creativity is needed when students determine the design of a bag or wallet by utilizing their knowledge of the potential in their environment. In learning activities. Teachers provide opportunities for students to express their ideas and appreciate every student activity by making technology projects by utilizing existing local potential. This activity can trigger the creativity of students with their groups.

STEAM learning rooted in local wisdom, enhances student creativity by combining knowledge, resources, and disciplines, thus fostering creative skills that are essential for future success [24]. In addition, flexible and adaptive learning allows students to explore their ideas and utilize local wisdom so as to foster creativity [25]. The work produced through a project in STEAM learning is considered effective in increasing student creativity [12]. STEAM learning encourages students to appreciate how art and science complement each other, with both requiring a range of skills such as critical thinking, creativity and imagination in understanding and solving a range of real problems [26]. Art encourages students to think creatively and expressively [27]. Art also helps students develop visualization and imagination skills, which are important in the creative process [28].

3.3 Collaboration

Collaboration skills are enhanced through learning-focused group activities. These develop when students work together during the learning process. The task of designing purses and bags is created through project activities and discussions that foster collaborative abilities. Strong collaboration, accountability and responsiveness of group members is required for this project. Efforts to achieve a common goal, exchange ideas, and communicate with each other to complete the assigned project [9]. This increases their capacity for productive teamwork. Collaboration skills can be shown by the ability to work together in completing tasks or completing projects in groups and being optimistic and polite in these situations [11].

3.4 Communication

Communication occurs when students participate in group conversations. Through group and class presentations, students in these activities improve their communication skills. Success in social interaction, the workplace, and organizations also depends heavily on effective communication. Based on the research results described above and reinforced by relevant research, it can be concluded that the application of STEAM integrated learning based on local wisdom is proven to help elementary school students achieve the 21st century skills they need. This conclusion is reinforced by research findings including, STEAM approach is the right way to help students acquire 21st century skills, especially in elementary schools [29]. Project-based learning combined with STEAM can help students develop critical thinking skills, and student collaboration [30], while making the learning environment fun [23]. Therefore, the results of this study make a valuable contribution to the provision of innovative learning options, particularly in the area of 21st century skills development.

4 Conclusion

Based on the research results presented and strengthened by relevant studies, it can be concluded that the application of STEAM-based mathematics learning with the integration of local wisdom is effective in helping junior high school students master the necessary 21st century skills, namely critical thinking, creativity, collaboration, and communication. This can be seen from the average increase in the score of each skill which reaches more than 3.50 with an excellent category. In addition, STEAM learning that integrates math concepts also encourages the creation of ideas, solutions or products while preserving local wisdom values. This approach allows students to learn contextually and understand phenomena in their surrounding environment, thus making the learning process more meaningful.

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