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Why It's Important to Advance STEAM in Mathematics Classroom

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Abstract

This article explains about how is the positive impact in advancing STEAM Education in mathematics classrooms. The discussion starts with the fact that STEM education has received much attention to achieve the competencies needed in the 21st century in the last decades. However, STEM education, which tends to override arts education, encourages reforms in this approach. Seeing the importance of art education as a basis for developing creativity and character in society gives a chance for STEAM education and integration of STEM education with art education, which is believed to impact students' learning achievement and engagement positively. As one of the integration components in STEAM, mathematics will get a positive impact too. Mostly by looking at the fact that the students' ability in mathematics competence is still low refers to the result of the national exam, AKSI, PISA, and TIMSS. Some of the main reasons why it's important to advance STEAM education in mathematics classroom include honing high order analytical thinking skills (HOATS), honing students' C2PC abilities, and enhancing students' engagement in the mathematics classroom.

Key word:

STEM Education, STEAM Education, HOATS, C2PC.

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1. Introduction

Science, Technology, Engineering, and Mathematics (STEM) is a learning approach that combines the four disciplines into one interdisciplinary. STEM found in the 1990s by National Science Foundation (NSF), Unites States. Then, STEM used as a label for many policy, activity, or program that involves one or more of the STEM field. Since its appearance, STEM education has been promoted to adapt student competencies to the 21st century's challenges with STEM literacy characteristics to face global problems (Kang, 2019; Kerdthaworn & Chaichomchuen, 2019).

STEM education has received much attention in the last two decades in various parts of the world. Several educational studies have shown an inclination of students' motivation and interest in STEM learning in many countries (Kelley & Knowles, 2016). Education that integrates four different disciplines has been remarkably developed in various developed countries such as England, Germany, and South Korea (Kang, 2019). STEM education provides students with a new paradigm of a problem by removing the barriers between science, technology, engineering, and mathematics that are still adhered to in schools. With everyday problems and a multidisciplinary perspective, STEM education can provide students with broader opportunities to apply theoretical knowledge, innovation, and creativity in creating products. Therefore, STEM as educational reform becomes a focus on educational research for continuous improvement (ATA-AKTÜRK & DEMİRCAN, 2017; Kang, 2019). One outcome of improving STEM education achievement in many countries is preparing a workforce to enhance national economies and sustain leadership within the constantly shifting and expanding globalized economy (Kelley & Knowles, 2016).

The rapidly growing STEM education trend in various countries perceives STEM as a vital part of the core field. As a result, this trend represents several branches of art in education (Yakman, 2008). Not

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infrequently, schools that adopt the STEM Education approach only add focus to two of the four art branches, namely language arts and liberal arts. Meanwhile, the other two branches of art (pure art and physical art) also impact creativity as a base for innovation (ATA-AKTÜRK & DEMİRCAN, 2017; Kang, 2019). The strengthening increasingly sees arts education as an important part of supporting students' creativity, caused by the more evident influence of language arts and liberal arts in the educational curriculum. Strengthening art education is also supported by students' character building and attitudes (Kang, 2019; Yakman, 2008). This condition underlies the formation of a new movement called STEAM (Science, Technology, Engineering, Arts, and Mathematics) Education.

STEAM Education integrates STEM education that is objective and logical, with Art education that is subjective and intuitive. Although STEM education and Art education have different characteristics, they are two things that complement each other and cannot be compared. Scientific abilities, such as drawing and spatial thinking, are part of art education (ATA-AKTÜRK & DEMİRCAN, 2017). STEAM education gives students many opportunities to make practical innovations. It emphasizes students' creativity competencies such as systematics problem solving and analytical thinking through planning, design, teamwork, and communication needed in the 21st-century era (Ruangsiri *et al.*, 2020).

Not much different from STEM education, STEAM education has also received much attention in developed countries in the last decade (Herro *et al.*, 2017). One of them is South Korea, which emphasizes STEAM in three main components, namely (1) integration and convergence of content, (2) creative design, and (3) emotional touch (Park *et al.*, 2016). Hence, STEAM education combines convergent thinking, by art education, with integrated thinking, by STEM education. Convergent thinking is needed to maximize the creative competencies to produce something new that does not exist yet. STEAM education also stresses to create value by connecting society system and getting empathy with design and liberal art (Choi & Hwang, 2018a).

Based on the growth needed for STEAM education across the world, Indonesia also needs to take action to implement this approach. Especially in the mathematics classroom, STEAM education is expected to solve problems that arise in mathematics classrooms. Thus, we need to see closer why it's important to advance STEAM in the mathematics classroom.

2. Discussion

There are two points of view that we used in seeing closer to the reason why it's important to advance STEAM in the mathematics classroom. The first is the condition of mathematics learning that requires changes adjusting to the development and changing era. In this case, we can see the facts and data on how the results of mathematics learning assessment in Indonesia and what underlies the importance of making changes in mathematics learning in the classroom. The second is how the positive impact of STEAM can give changes to math learning in the classroom. In this case, we will look at three things: (1) STEAM's contribution in providing many points of view of thinking ability, (2) the influence of STEAM in the improvement of C2PC, and (3) the increase in students' engagement in mathematics learning.

2.1. Students' Mathematical Ability

To see how the condition of students' mathematical abilities in Indonesia, we can look at some of the assessments carried out by various institutions at various levels. For example, at the national level, we can refer to the National Examination (UN) results and the Indonesian Student Competency Assessment (AKSI) conducted by the Ministry of Education and Culture of the Republic of Indonesia. Meanwhile, at the international level, we can refer to the results of the PISA (Program for International Student Assessment), which is carried out every three years by the OECD, TIMSS (Trends In Mathematics and Sciences Study), which is carried out every four years, and RISE (Research on Improving System of Education) (OECD, 2018b; Sumardyono, 2020).

Based on national exam results, the average mathematics score is always in the lowest position among the subjects tested (Puspendik, 2019b). In fact, more than 70% of the problem indicators have absorption capacity less than or equal to 55. This result shows that the mastery of math concepts and applications of Indonesian students is still low. Meanwhile, the AKSI, which was carried out in 2016, showed that 77.13% of elementary school students lacked mathematical competence. As for the 2019 AKSI, 79.44% of junior

high school students lacked mathematics competence. This result shows that Indonesia's students still lack applications and mathematical reasoning in solving problems (Puspendik, 2019a).

Furthermore, at the international level, based on the 2018 PISA results, Indonesia was ranked 74th out of 79 participating countries. The average score for Indonesian students' mathematics performance is 379, even though all participating countries' average score is 489. Even in the 2018 PISA Country Note, it was stated that only 28% of Indonesian students managed to reach level 2 or more in mathematics, and only around 1% of Indonesian students reach level 5 or above in mathematics. The ability at level 2 represents a simple situation mathematically, while level 5 represents the ability to model complex situations. This result means, many Indonesian students still have difficulty solving simple problems mathematically. Finally, the trend for Indonesian students' mathematics performance in PISA 2018 is lower than in PISA 2015 (OECD, 2018b, 2018a).

Like PISA, Indonesian students' TIMSS results on mathematical ability were ranked 44 out of 49 participating countries with 397. Indonesia is still far from being ranked first, namely the neighboring country, Singapore, with 618. These results indicate poor mathematical performance skills of Indonesian students (Mullis *et al.*, 2015).

Students' low mathematical ability in Indonesia, especially from international assessments, is because students are not accustomed to math problems that hone mathematical literacy (Wardono & Mariani, 2018). However, the ability of mathematical literacy is one of the crucial requirements to face the challenges of the 21st century (Dewanti *et al.*, 2020). Mathematical literacy itself is related to the three primary abilities, namely (1) formulating and interpreting mathematics in many contexts, (2) reasoning mathematically by using mathematical tools to predict case, and (3) habituating to apply mathematics in various contexts (Wardono & Mariani, 2018). This condition reflects the lack of optimal mathematics learning in schools. The lack of students with math problems that develop mathematical literacy skills is also an indication of learning that is still not adjusting to rapid and massive changes. Meanwhile, on the teacher side, the teacher's test instrument has not promoted students' mathematical literacy as one of the 21-st century skills needed (Dewanti *et al.*, 2020). Based on Ausubel's theory of learning, mathematics learning in Indonesia tends to still be in the category of memorization learning where learning focuses on making students recognize and understand concepts, without being helped in establishing a strong connection between the prior knowledge they already have and the one being studied. The teacher sometimes focuses on measuring students' memorizing and calculating capabilities, not solving simple and complex problems. Therefore, it is very important to make innovations in mathematics learning especially with the rapid technological advances and changes in the era of disruption that is volatile, uncertain, complex, and ambiguous. On the student side, students' anxiety in mathematics correlates with low engagement in learning mathematics. It happens because of most of mathematics material are not well-understood by them. The mathematics learning that are not joyful also increase students' anxiety.

2.2. STEAM Education and High-Order Analytical Thinking Skills in Mathematics Classroom

Education 4.0 provides space for the integration of science, which results in a variety of thinking models. One of them is analytic thinking (Ruangsiri *et al.*, 2020). Analytical thinking is defined as building systematic and logical thinking, differentiate, connect learning sources, and solve problems to produce accurate results and application knowledge under the 21st century's abilities. In analytical thinking, high order analytical thinking skills (HOATS) are the ability to think analytically at a higher level in terms of processes. There are four essential components of HOATS: (1) Component analysis, which includes the ability to identify, differentiate, and record information, (2) Relationship analysis, which includes the ability to search and connect it logically and conforming, (3) Principle analysis, including the ability to perform marking goals, steps, and linking comments as well as synthesizing conceptual principles, and (4) Analysis of results or possibilities, including the ability to create new knowledge that is useful as a basis for work innovation (Ruangsiri et al., 2020). HOATS itself has been developed a lot in engineering education. This condition is because engineering education focuses a lot on things that are creating innovation and creation. So having and developing HOATS is very necessary (Ruangsiri *et al.*, 2020). One way to promote HOATS in engineering education itself is by implementing STEAM education.

In a study conducted by Ruangsiri *et al.* (2020), the application of STEAM education can improve students' HOATS abilities in engineering classrooms. With improved HOATS abilities, students will

become more able to solve various daily problems in various ways. Besides, it also changes students' views to understand the concept of lifelong learning better.

Thus, it is important to apply STEAM education in mathematics class. This is because the world is continually changing, and new challenges that continue to emerge demand improvements in problem-solving abilities (Salmon, 2019). Moreover, mathematics application that is close to everyday life needs to support student HOATS so that it can better prepare students to face global competition. Besides, HOATS also supports the improvement of mathematical literacy skills because HOATS supports the ability to correlate information and process it as part of the problem-solving process. Thus, the application of STEAM education to improve HOATS will impact increasing students' mathematical literacy skills.

2.3. STEAM Education and C2PC's Abilities in Mathematics Classroom

One of the reasons students' mathematical literacy is low is caused by students' less able to be creative and confident when solving problems and collaborating. Creativity, confidence, problem solving, and collaboration (C2PC) are essential skills in the 21st century. Hence, it is essential to promote them in the learning activities, without exception, in the mathematics classroom (University Online, 2019).

Sometimes, our mathematics classroom does not allow students to be creative or think out of the box. Some learning approaches give students a limited chance and facility to try a new approach to the tasks or problems. But, it would not happen if STEAM education is adopted. It is because students' will be enriched by many ways of thinking in solving the problem. By using STEAM, students' will be challenged to solve the problem mathematically and in the view of science, technology, engineering, or even art. The example is about enhancing HOATS that is usually applied in engineering education. By learning many ways of thinking, students will have more opportunities to solve mathematics problems or even daily problems, not only in one way but also by making them more creative. It is also enhancing students' problem-solving skills, especially in facing a new challenging problem and situation.

Our mathematics classroom students' also have a problem with confidence. Since mathematics taught logically and systematically, some students feel it is hard to be understood. Then, applying STEAM education will increase students' confidence. Because integrating art in the classroom will train students to express and deliver a message. Hence, it will give impacts the enhancement of students' confidence directly. Also, STEAM education can promote the collaborative skills of students. Because STEAM education provides a project incorporating multiple disciplines, it will push students to collaborate positively with others. Students would learn how to share work and compromise in the learning activity.

2.4. STEAM Education and Students' Engagement in Mathematics Classroom

One of the important things in student-centered learning is students' engagement. Applying STEAM education in the classroom was fun, making curiosity and motivation to joining learning activity (Choi & Hwang, 2018b). It was an excellent point to make students' engagement better in the classroom. In addition, STEAM education activities were believed to enhance formal educational teachings by providing fun activities with content-rich education (Kney *et al.,* 2016). STEAM education also allows students expression and creativity to make students show their capabilities more (Helms *et al.*, 2017).

STEAM education also gives students real-experience in learning. The integration with art education provides students chances to advance their divergent thinking and creativity. It is also giving students experience how the classroom concepts can be well-projected in society by solving a complex problem. It is also providing enough working about how STEAM education can advance their career after school since the increase of STEAM fieldworks' demand. STEAM education gives students a place to habituate the good character needed in this era (Park *et al.,* 2016). STEAM education also gives teachers another way to educate students about character building, which has become a critical thing in education without exception in the mathematics classroom.

3. Conclusion

Mathematics classrooms, as a forum for developing students' mathematical abilities, need to make improvements. The low mathematical ability of Indonesian students based on national and international assessments reminds mathematics classrooms to make improvements in all matters, including the learning approach. STEAM education as part of strengthening STEM education by integrating art education is worth

trying. During the last decade, research on how STEAM education states STEAM brings good changes in the Indonesian national curriculum's three main aspects, namely knowledge, skills, and affection.

The application of STEAM education is becoming increasingly crucial in mathematics classrooms for three main reasons. First, STEAM education provides more opportunities for students to develop various thinking skills, including HOATS (high order analytical thinking skills). HOATS, which are usually developed in technical education, can also improve students' mathematical literacy skills. This is expected to improve the overall mathematical abilities of Indonesian students. Second, STEAM education provides opportunities for the development of students' better C2PC abilities. With the integration of various fields that have various approaches, STEAM education allows students to develop creativity. STEAM education also allows students to be freer to express themselves through the arts, thereby increasing their confidence. In addition, the ability to collaborate and solve problems is also something that can be achieved with STEAM through interdisciplinary project activities. Finally, STEAM activities make mathematics learning more fun and meaningful for students to attract attention and increase students' engagement in the mathematics classroom.

However, it should be noted that the benefits of STEAM education in mathematics classrooms will be more pronounced if you pay attention and focus on the right portion, especially for M in STEAM. It is essential to understand that the role of mathematics in STEAM will be increasingly felt if mathematics is given a clear focus, especially in terms of the use of concepts and their specifications. Because by doing so, STEAM education will bring more meaning to students in the mathematics classroom (Bush *et al.*, 2016; Petrick *et al.,* 2016).

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