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Promoting STEM (Science, Technology, Engineering, and Mathematics) for Young Learners of Indonesia

Novi Nur Lailisna<sup>1</sup>, Muhamad Ansori<sup>2</sup>

Badrus Sholeh College for Islamic Studies Kediri, Yayasan Sahabat Berdikari Kediri

[nophy18@gmail.com](mailto:nophy18@gmail.com)<sup>1</sup>, [anshory2019@gmail.com](mailto:anshory2019@gmail.com)<sup>2</sup>

**ABSTRA  
CT**

*This paper describes youth as the next generation of Indonesia who must be understood and inspired for their subsequent learning and career STEM (Science, Technology, Engineering, and Mathematics) based. STEM discipline is commonly an inconvenient subject for youth, especially young learners. Collecting research papers that prove STEM had positively supported youth for their learning and career, this paper will recommend young learners become inspiring and produce a product in the future. Generally, it explores new trends overseas that Indonesia also has a chance for needed-promoted youth's skills for further education.*

**Keywords:** Promoting, STEM, Young Learner.

## 1. Introduction

Science, mathematics, engineering, and technology (STEM) are cultural achievements that reflect people's humanity, power the economy, and constitute fundamental aspects of our lives as citizens, workers, consumers, and parents (STEM & Council, 2011). The United States is widely believed to perform poorly in STEM education (B.Gonzales & J.Kuenzi, 2012). Meta-analysis was employed to address the research questions of this study. Twenty-eight studies were selected, and thirty-three effect sizes were calculated to examine the effects of integrative approaches among STEM subjects. The impact of integrative approaches on the grade levels showed the most significant effect size at the elementary school level and the smallest effect size at the college level.

Regarding the types of integration, STEM, the integration of four subjects, presented the most prominent effect size. E-M and M-S-T showed the smallest effect size (EBSCOhost | 72320466 | *Effects of Integrative Approaches among Science, Technology, Engineering, and Mathematics (STEM) Subjects on Students' Learning: A Preliminary Meta-Analysis*, n.d.). On the other hand, the Attitudes

towards Science, Technology, Engineering, and Mathematics (AT-STEM) questionnaire was developed in the Indonesian language and validated through an exploratory factor analysis of participants' responses (Suprpto, 2016). The results indicated that, first, the instrument used in this study had satisfactory validity and reliability. The construct validities of the AT-STEM varied from .60 and .96 and explained 86.84% of the variance. Overall, the Cronbach's alpha coefficient of the instrument was .94. Second, the dimension of Mathematics came in the first rank and was followed by science and the degree of attitudes towards STEM. Last, the results also showed a significant interrelationship among dimensions of attitudes towards STEM (Suprpto, 2016). Based on the studies mentioned, STEM has become part of human development to improve their quality of life, especially education.

In Indonesia, the process of learning mathematics with STEM approach in Indonesia is aspects of preparation include prepare media and learning resources, prepare activity sheet, design tools and materials of practice, parts of learning implementation are introduction has

prepare students psychologically and physically before the learning process, asking questions about previous knowledge related to the material to be studied, using the STEM approach in the lesson, the content includes using the learning approach based inquiry, linking matter with daily life, practice, involving students in training, students actively engage practice in Classroom, guiding students in practice, utilizing technology (computers, internet), using active learning strategy, communicate actively to students during learning, giving tasks in groups, using problem solving learning method, combining STEM in one subject (at least 2 STEM disciplines), students are motivated to like mathematics, develop teaching materials, teach according to the field, there is no gap between learners (Milaturrahmah et al., 2017). Other studies another study was done to depict Project Based Learning (PjBL) integrated with science, technology, engineering, and mathematics (STEM), to enhance elementary school students' science literacy (Afriana et al., 2016; Kholis & Aziz, 2019). In addition, creativity is an important capability that should be held to competitive standards in the 21st century in entering the era of information and knowledge. It requires a creative

generation that can innovate to meet the challenges of an increasingly complex future. This study examines the student's creativity level by integrating STEM (Science, Technology, Engineering, and Mathematics) knowledge to make creative products in renewable energy (solar energy) (Mayasari et al., 2016). On the other hand, students most likely become users rather than producers of STEM's product development. By taking this reason, it is needed to make young learners aware of it.

Subject areas involving mathematics, science, engineering, and technology, and lists of jobs connected to each subject area (physicist, chemist, astronomer, biological scientist, mathematician, lab technician, analyst, veterinarian, etc.) need to be explored. This study also motivates K-12 schools, community colleges, and universities to implement new STEM and 21st-century skills programs. Students in Indonesia have performed below those of other countries (Suprpto, 2016). According to predictions, the STEM (Science, Technology, Engineering, and Mathematics) sectors will increase more than jobs in other sectors in the next decade. Therefore, the importance of STEM education has been realized by academia, government, society, and industry (Bybee,

2010). The students possibly do not work based on their educational background in the future. The role of education as basic-career advancement has been aimed in the international setting (Mayo, 2009). Therefore, STEM education could be a way to bridge the gap between education and required workplace of 21st-century skills (Mutakinati et al., 2018). STEM-based instructional material developed is valid enough to be used as educational materials necessary for effective STEM education (Gustiani et al., 2017). The teachers quite well understand STEM education. We must focus on the teachers as they play a crucial role in the success of new reforms. The implication is that there is a considerable need for awareness-raising at both government and teacher levels to embrace STEM education (Nugroho et al., 2019). These trends presented that STEM could be included in the curriculum, by then how to make those learners visible to learn more than become their inspiration and further-career

## II. Research Method

### Research Design

This study applies the qualitative inquiry model. It interprets or explains the meaning of events, actions, and so forth; they generally use the following types of

interpretation: construction of patterns through analysis and re-synthesis of constituent parts. This interpretation may lead to the generation of theories, be guided by existing approaches or concept maps, or seek to further explicate or expound upon an idea (Ary et al., 2010). Practically, this study explores the STEM advantages towards learnings and careers. Data collected such as experiences, beliefs, and values the researcher will be the modal of promoting STEM for young learners in Indonesia.

## III. Result and Discussion

The result of this is going to be presented. The presented material to promote STEM is adopted from National STEM Learning Centre or accessible on (*Being Engaging and Inspiring in STEM - Inspiring Young People in STEM: Planning and Organising Practical Activities - National STEM Learning Centre*, n.d.). The first step is to engage and inspire young learners in STEM, such as Clyde's project in the Classroom. It is a project where kids are given fish eggs to rear in the school for about seven weeks. During that time, they learn about fish biology. They are very hands-on, looking after the eggs. And then, at the end of the project, they release the eggs into their local bit of

river (Inspiring Young People in STEM: Planning Activities Being Engaging and Inspiring in STEM, n.d.). As common sense, science, technology, engineering, and math are complex subjects for young learners; the students' scores may not be good enough for those subjects. Planning and organizing STEM to learning is homework if the facilities is completely support. Facilities support that teaching-learning process. Simply, today young learners were familiar within gadget such mobile phone and laptop. Accessible materials from teachers better get inside on learners' phone.

Three examples of activities are engaging and inspiring young people about STEM. They are Shopping Centre-Chemistry science busking, Classroom visit-Clyde in the Classroom, and Skype call to researchers in LIGO (Laser Interferometer Gravitational-Wave Observatory)(Examples of Activities - Inspiring Young People in STEM: Planning and Organising Practical Activities - National STEM Learning Centre, n.d.). Those three activities are promoting for young learners in voluntary activities.

If it applies to formal education, the next one to engage STEM to the curriculum; the link it with employability skills. There are four steps you need to identify an area of

the curriculum that links to your work and volunteering activity (Engaging with the STEM Curriculum - Inspiring Young People in STEM: Planning and Organising Practical Activities - National STEM Learning Centre, n.d.). They are: firstly, find the relevant key stage and age in your country; secondly, find the national curriculum or similar (countries have different terminology) for that age; thirdly, find the subject heading, e.g., science, technology, design, etc.; fourthly, find the sentence/s relating to the syllabus and learning outcomes. In addition, to connect with employability skills is needed, such as knowledge, technical skills, and attitude. Those soft skills would help learners bargain themselves in the following professional level.

This is particularly important if you aim to complement curricula or other frameworks (Activity Objectives and Learning Outcomes - Inspiring Young People in STEM: Planning and Organising Practical Activities - National STEM Learning Centre, n.d.). At least, it must have activities objectives and learning outcomes set in the learning scenario.

On the other hand, it should also be concerned about risk and hazards. An obvious starting point to the process of

developing risk assessments is to understand what we mean by risk (Risks and Hazards - Inspiring Young People in STEM: Planning and Organising Practical Activities - National STEM Learning Centre, n.d.). The Institute of Risk Management defines it as ‘the combination of the probability of an event and its consequences. These events and consequences can benefit (upside) or threaten success (downside). Our party popper can add to the sense of fun and celebration at an event. But, it might scare your dog!

On the other hand, The UK Health and Safety Executive defines a hazard as something with the potential to cause harm, including ill health and injury, to persons or to cause damage to property or equipment. A risk is the likelihood of a hazard causing harm in practice (Risks and Hazards - Inspiring Young People in STEM: Planning and Organising Practical Activities - National STEM Learning Centre, n.d.). Then, the risk assessment process is an essential part of risk management, and risk assessment can also be used as a valuable tool for activity planning.

After understanding all, the planning is the next. Practically, planning is deeply paying attention to the previous underlined

terms. Planning also needs to be shared, so the paper airplane plans are better. It is applicable for teachers for learners are impressed with STEM inside materials they have been learning.

The final points are how young learners have the best career-related STEM after being inspired by STEM activities and volunteering. This study will note getting better learners to find “figure” or introduce figures who succeeded in STEM. Come in for the Indonesian context; BJ Habibie represents that figure, and he had focused on airplane projects for better vehicles for Indonesia.

#### **IV. Discussion**

STEM is not a difficult and rich subject, but it is an enjoyable one. It needs teachers, examples, models, and a supporting system. Policymakers must also be provoked to up line and decide Indonesia's future by seeing globalization atmosphere. Young learners get better at practicing their understanding of STEM, limited to the theoretical framework and practical activities helped by teachers' airplane plans. In addition, it is becoming better to adopt other countries' STEM Success, such as UK and US. Young learners would like very helpful for having this; because it will provide new trends vacancies for them in the future.

Last but not least, concerning Islamic

education, STEM should be introduced earlier. Common perspectives realized that young learners who take education at Islamic education are not good enough in mastering STEM even though they work towards STEM. So, it is essential to comprehend earlier. Islamic education should add code-of-conduct of these terms to avoid misleading usage. Those four disciplines: Science, Technology, Engineering, and Mathematics, could be the difficult subject the first time students know it. After some semesters, they might be familiar with them; then they understand and comprehend these terms little by little, supported by teachers' creativity.

### The Importance of STEM in Early Childhood Education

STEM (Science, Technology, Engineering, and Mathematics) is more than just a set of subjects—it is a powerful approach to learning that fosters critical thinking, creativity, and problem-solving skills in young learners. In today's rapidly evolving world, early exposure to STEM education is crucial in preparing children for future challenges, particularly in the digital era and the Fourth Industrial Revolution (Industry 4.0). By encouraging hands-on exploration and experimentation, STEM not only enhances cognitive development but also nurtures a mindset that values inquiry, resilience, and innovation.

One of the key benefits of STEM education

is its ability to enhance critical thinking. Unlike traditional learning methods that rely on rote memorization, STEM encourages children to analyze, evaluate, and synthesize information to solve problems effectively. For instance, when building a simple bridge using blocks, children must consider balance, weight distribution, and design stability. Through this process, they test hypotheses, refine their approach, and learn from trial and error—an essential practice for cognitive growth. STEM also fosters logical reasoning, as children engage in inquiry-based learning where they experiment, observe, and draw conclusions based on evidence rather than assumptions.

In addition to critical thinking, STEM plays a significant role in developing creativity. Contrary to the misconception that STEM focuses solely on rigid formulas, it actually encourages innovative thinking and out-of-the-box problem-solving. Activities such as coding exercises, robotics, and engineering challenges allow children to experiment with different solutions and develop original ideas. For example, a child designing an animation using basic programming tools like Scratch is not only learning how to code but also expressing creativity through storytelling and interactive design. The integration of art into STEM—often referred to as STEAM—further emphasizes the importance of creativity in scientific and technological fields, proving that innovation requires both technical knowledge and imaginative thinking.

As technology continues to shape industries and daily life, the demand for digital literacy and technical skills has never been greater. The Fourth Industrial Revolution is characterized by automation, artificial intelligence, and data-driven decision-making, all of which require a workforce proficient in STEM-related fields. By introducing STEM concepts at an early age, we equip children with the foundational skills needed to navigate this digital landscape confidently.

One of the most valuable skills children gain from STEM education is computational thinking, which is essential for coding, data analysis, and digital problem-solving. Many countries have recognized this need and have introduced coding into their school curriculums to ensure students develop logical thinking and adaptability. Programs such as Python for kids, robotics kits, and educational apps make learning programming fun and accessible, helping children develop problem-solving skills while fostering a deeper understanding of technology.

However, despite the growing importance of STEM careers, there remains a significant skills gap, particularly in countries like Indonesia. Many students, especially girls, shy away from STEM fields due to the perception that they are too difficult or require exceptional intelligence. This gender disparity highlights the need for early STEM education to normalize these subjects and make them more approachable. By providing children with role

models—such as female scientists, engineers, and innovators—we can break stereotypes and encourage more diverse participation in STEM.

Beyond career preparation, STEM education enhances children's ability to tackle real-world challenges. In an era marked by climate change, cybersecurity threats, and health crises, young minds must develop problem-solving abilities to find innovative solutions. STEM activities, such as creating models of renewable energy sources or designing water purification systems, encourage children to think critically about global issues and take an active role in shaping a better future.

One of the most effective ways to teach STEM is through hands-on learning. Unlike passive learning methods that rely on textbooks and lectures, STEM education emphasizes experimentation and active engagement, aligning with how young children naturally learn—through play, observation, and trial-and-error. When children participate in experiments, they engage multiple senses, reinforcing their understanding of scientific and mathematical concepts.

For instance, a simple baking soda and vinegar experiment can teach children about chemical reactions in a way that is both fun and educational. Instead of merely reading about reactions in a textbook, they witness the process firsthand, making learning more memorable. Similarly, engineering activities, such as constructing paper bridges or

assembling simple electrical circuits, allow children to test their ideas, troubleshoot problems, and refine their designs. These experiences foster a growth mindset, where mistakes are viewed as opportunities for learning rather than failures.

In addition to experimentation, inquiry-based learning plays a crucial role in STEM education. Rather than providing direct answers, educators encourage children to ask questions, make predictions, and test their hypotheses. For example, when exploring magnetism, children might be prompted with questions like, “What do you think will happen if we bring two magnets close together?” or “Why do some objects stick to the magnet while others don’t?” This approach not only deepens their understanding but also nurtures curiosity and independent thinking.

Another benefit of STEM education is the development of collaboration and communication skills. Many STEM projects require teamwork, where children must share ideas, listen to different perspectives, and work together to find solutions. Whether designing a model car in pairs or coding a game in a group, these activities enhance social interaction and problem-solving abilities. Furthermore, presenting findings from an experiment helps children develop confidence in articulating complex ideas—an essential skill for any profession.

STEM education is more than just an academic discipline; it is a critical foundation

for lifelong learning and success in a technology-driven world. By integrating STEM into early childhood education, we nurture critical thinkers, creative problem-solvers, and future innovators who are prepared to adapt to rapid technological advancements. With the rise of Industry 4.0, digital literacy and problem-solving skills are becoming essential, making early exposure to STEM education more important than ever.

Through hands-on exploration, experimentation, and inquiry-based learning, STEM provides young learners with engaging and meaningful experiences that foster curiosity and resilience. Moreover, by addressing the skills gap and promoting inclusivity in STEM fields, we can ensure that all children—regardless of gender or background—have the opportunity to pursue careers in science, technology, engineering, and mathematics. Investing in STEM education today means investing in the next generation of leaders and innovators who will shape the future.

### **Challenges in Implementing STEM Education in Indonesia**

STEM (Science, Technology, Engineering, and Mathematics) education is essential for preparing young learners for the demands of a rapidly evolving world. In Indonesia, where technological advancements and digital transformation are becoming increasingly significant, integrating STEM into the education system is more crucial than ever.

However, despite the growing awareness of its importance, Indonesia faces several significant challenges in implementing STEM education effectively. These challenges range from inadequate infrastructure and limited access to resources to a lack of qualified educators and societal perceptions that hinder student engagement, particularly among girls. Addressing these issues is critical to ensuring that Indonesian students can compete on a global scale and contribute meaningfully to the country's technological and economic development.

One of the most pressing challenges in implementing STEM education in Indonesia is the disparity in infrastructure and access to resources across different regions. Indonesia, as an archipelago with thousands of islands, struggles with uneven distribution of educational facilities. While urban schools in major cities like Jakarta, Surabaya, and Bandung may have access to modern laboratories, computers, and internet connectivity, many rural and remote schools lack even the most basic resources. This digital divide prevents students in underprivileged areas from experiencing hands-on STEM learning, limiting their exposure to scientific experimentation and technological advancements.

Moreover, many schools, particularly in rural areas, lack adequate funding to invest in STEM-related materials such as laboratory equipment, robotics kits, and digital learning tools. Without proper infrastructure, students

are often limited to theoretical learning from textbooks rather than engaging in practical applications, which are crucial for fostering interest and understanding in STEM subjects. The government and private sector must work together to bridge this gap by investing in technology infrastructure, providing internet access, and ensuring that all schools, regardless of location, have access to quality STEM resources.

Another significant challenge is the lack of educators who are adequately trained in STEM teaching methodologies. Teaching STEM subjects requires a different approach from traditional education. Instead of focusing solely on rote memorization, effective STEM teaching emphasizes hands-on experiments, problem-solving, and critical thinking. However, many teachers in Indonesia are not sufficiently trained to implement this approach.

The root of this issue lies in the teacher training system itself. Many educators graduate from teacher training institutions with limited exposure to modern STEM teaching strategies. As a result, they may struggle to incorporate interactive learning, coding exercises, or engineering projects into their lessons (Aziz et al., 2022; Muna & Aziz, 2021; Nur Aziz & Rohmah, 2022; Nur Aziz & Sabella, 2021). Additionally, many teachers, particularly in rural areas, lack familiarity with digital tools and technology-based learning platforms, making it difficult for them to integrate technology into their classrooms effectively.

To address this issue, the government and educational institutions must prioritize professional development programs for teachers. Providing workshops, online training courses, and hands-on experience with STEM tools can help educators feel more confident in teaching these subjects. Additionally, partnerships with universities, technology companies, and STEM professionals can help bridge the knowledge gap and provide teachers with the necessary support to enhance their STEM instruction.

Even when STEM education is introduced in schools, many students remain disengaged due to a lack of awareness and motivation. One of the reasons for this is the perception that STEM subjects are too difficult or uninteresting. Many students view mathematics and science as abstract, theoretical, and irrelevant to real life. Without engaging and practical applications, students may become discouraged from pursuing STEM fields.

Additionally, Indonesia faces a cultural challenge where careers in STEM are often undervalued compared to more traditional career paths such as law, medicine, or business. Many parents and communities prioritize professions with more immediate job security, leading students to avoid STEM fields due to a fear of uncertain career prospects. The lack of STEM role models in Indonesian society further exacerbates this issue, as students do not see enough real-world examples of successful

professionals in science, engineering, or technology.

To increase student engagement, STEM education needs to be made more interactive and relevant to everyday life. Project-based learning, gamification, and real-world problem-solving activities can make STEM subjects more appealing. Schools can also collaborate with industries to provide students with exposure to real-world applications of STEM through internships, field trips, and guest lectures. Additionally, the government should actively promote STEM role models and success stories to inspire students to consider careers in STEM-related fields.

Another critical challenge in Indonesia's STEM education landscape is the underrepresentation of girls in STEM fields. Despite progress in gender equality, cultural and societal norms still discourage many girls from pursuing studies in science, technology, engineering, and mathematics. Traditional gender roles often lead to the belief that STEM subjects are more suitable for boys, while girls are encouraged to pursue careers in social sciences, humanities, or teaching.

Research shows that girls perform just as well as boys in STEM subjects when given equal opportunities, but they often face subtle discouragement from teachers, peers, and even family members. This results in a lower number of female students enrolling in STEM-related courses and fewer women pursuing careers in STEM industries. The lack of female

representation in STEM professions further reinforces the notion that these fields are not welcoming to women, creating a cycle of underrepresentation.

To address gender disparity in STEM, schools and policymakers need to actively encourage girls to participate in STEM activities from an early age. Initiatives such as mentorship programs, scholarships for women in STEM, and female-led science and technology workshops can help break stereotypes and empower girls to pursue STEM careers. Moreover, integrating female STEM role models into the curriculum can provide young girls with the confidence and inspiration needed to succeed in these fields.

Despite various initiatives to promote STEM education, Indonesia's national curriculum still faces structural challenges in fully integrating STEM into mainstream education. The traditional education system in Indonesia remains highly exam-oriented, with an emphasis on standardized testing rather than practical, skills-based learning. This structure often limits the flexibility needed for STEM programs, as teachers are pressured to focus on preparing students for national exams rather than fostering creativity and innovation.

Moreover, there is still a lack of coordination between different education sectors—government policies, school curriculums, and industry needs are not always aligned. Many STEM graduates struggle to find relevant job opportunities because their skills

do not match industry requirements. Strengthening collaboration between educational institutions, government bodies, and private industries is essential to ensuring that STEM education is both practical and applicable to Indonesia's economic and technological landscape.

A possible solution is the adoption of interdisciplinary STEM learning, where science, technology, engineering, and mathematics are taught in an integrated manner rather than as separate subjects. This approach encourages students to apply their knowledge across different domains, preparing them for real-world problem-solving. Additionally, reforms in curriculum design should focus on incorporating more project-based and hands-on learning experiences rather than purely theoretical instruction.

While Indonesia has made progress in promoting STEM education, significant challenges remain that hinder its effective implementation. The lack of infrastructure, shortage of qualified teachers, low student engagement, gender disparity, and difficulties in integrating STEM into the national curriculum all contribute to the slow adoption of STEM learning across the country. Addressing these challenges requires a multi-faceted approach involving government intervention, teacher training, industry collaboration, and cultural shifts in how STEM education is perceived.

Investing in STEM education is essential for Indonesia's future, as it plays a crucial role in

economic growth, technological innovation, and global competitiveness. By overcoming these challenges and ensuring that all students, regardless of gender or geographical location, have access to quality STEM education, Indonesia can cultivate a new generation of problem-solvers, innovators, and leaders who will drive the country forward in the digital age.

## V. Conclusion

The final words to this paper are that Science, Technology, Engineering, and Mathematics (STEM) is not something new unless students had understood it earlier. It is not easy to comprehend, but educators and students can understand how to become good next time and level. On the other hand, STEM today is an 'indiscipline that tries to share slowly with young natives, starting from toddlers to young, simply from elementary to university.

The recommendation of this study is for further research applying action research that trains young learners practically about STEM-based learning for their future careers. In addition, this STEM could be integrated with teaching and learning strategies. Also, if STEM promotes Islamic-young-learners to Indonesia, it would give a real contribution to Indonesia and Islam.

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