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The Level of Awareness of Science, Mathematics & RBT Teachers in the Planning and Implementation of STEM Programs in Primary Schools

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Abstract

This study emphasises how crucial it is to include STEM education in schools as a means of developing students' 21st-century competencies and equipping them for the difficulties posed by the coming 4.0 industrial revolution. The study focuses on the importance to solve the difficulties instructors encounter when implementing STEM. The study synthesises findings from research by Shahali, Ihsan Ismail, Lilia Halim, McGowen, Goh, Pauline, Matthews, Bobbie, and others using a thorough literature review methodology. This approach incorporates a variety of viewpoints and identifies potential solutions to provide a nuanced knowledge of the difficulties facing STEM education. The study's main findings highlight the variety of difficulties teachers confront, such as students' waning enthusiasm in STEM subjects, a lack of preparatory knowledge, few opportunities for training, a lack of facilities and equipment, and a widespread phenomenon known as the "End of Syllabus Syndrome." These difficulties are made worse by the administrators' lack of assistance. The report does, however, offer realistic answers to these problems, highlighting the necessity of increased awareness, thorough teacher preparation, assuring proper infrastructure, and encouraging cooperation between administrators and teachers. The results highlight STEM's beneficial effects on students' learning and highlight how it may help students reach their full potential and produce information that is useful and long-lasting. The study lays the groundwork for subsequent inquiries by highlighting the need for more research on the long-term impacts of adopted solutions on STEM education. It also emphasises how crucial it is to look at the efficacy of programmes for training teachers and how administrative assistance affects the use of STEM. Future studies should also examine how STEM is changing to reflect societal shifts and technological breakthroughs, and comparative analyses of various educational systems can reveal best practices for STEM education around the world.

Keywords: Awareness, Science, Mathematics, RBT, Planning, STEM Programs.

Introduction

The learning approach is constantly changing with specific innovations, including in the teaching and learning of science, mathematics, and Design and Technology (RBT). One

approach in current learning is the STEM approach. STEM, which stands for Science, Technology, Engineering, and Mathematics, integrates these four disciplines and was introduced in the United States through education policies by the National Science Foundation in the 1990s. In addition to the four scientific disciplines, STEM can also be combined with Medicine, referred to as STEMM, or diversified with Arts, abbreviated as STEAM. The presence of Arts in STEAM can enhance creativity and reasoning, making the learning experience more meaningful and memorable in the long term. The use of STEM as a form of integration of these four disciplines is considered a suitable solution at present because fragmented learning of Science, Technology, Engineering, and Mathematics makes learning meaningless and boring (Kelley & Knowles, 2016). Students learning under the STEM approach can also create interactions and form experiences in conducting authentic investigations (Tofel-Grehl & Callahan, 2014).

21st-century skills encompassing communication, cooperation, critical thinking, and creativity, collectively known as the 4C skills, are crucial skills to be developed today. Teachers are required to facilitate education that equips students with 4C skills to help them face the challenges of globalization (Teo, 2019). STEM has a positive relationship with 21st-century skills (Kan & Murat, 2018). These skills are enhanced through inquiry-based learning (Kembara et al., 2019), with STEM being one of them (Tofel-Grehl & Callahan, 2014). The relationship between STEM and 21st-century skills indicates that they are inseparable and mutually related.

The introduction of Science, Technology, Engineering, and Mathematics (STEM) curricula into elementary schools is a significant advancement in the ever-changing field of education, as it has a profound impact on students' engagement with core subjects. It is essential that research be conducted on the knowledge, readiness, and proactive participation of science, math, and design and technology (RBT) educators in the development and implementation of STEM programmes. This study is extremely important because it aims to clarify the crucial connection between teacher involvement and the effective application of STEM education, illuminating the potentially transformative effects on both teachers and students.

It is imperative that this field be studied because there is a growing need in the workforce for 21st-century skills, or 4C skills—communication, cooperation, critical thinking, and creativity—that go beyond traditional academic knowledge. It is crucial to equip the next generation with a strong foundation in STEM subjects as well as the practical application of their knowledge in an era driven by globalisation and technological advancements. Therefore, understanding how educators view and use STEM programmes is essential to developing educational policies that work and creating an atmosphere that supports the development of holistic skill sets.

Furthermore, the significance of this study goes beyond the classroom setting. The advancement of society, economic expansion, and innovation are all accelerated by STEM education. This study intends to provide insights that can guide curriculum development, teacher training initiatives, and educational practices by investigating the role of teachers in STEM implementation. In the end, having an in-depth knowledge of how educators interact with STEM education will help teachers improve their methods of instruction while also preparing students to be skilled problem solvers, critical thinkers, and cooperative members of a world that is changing quickly.

There are several advantages to this research. It provides educators with a chance to consider how they teach and gain insights that can improve professional development programmes

that are specifically designed to meet the needs of STEM schooling. The results can be used to inform and encourage the integration of STEM education into primary school curricula by policymakers. A well-designed STEM curriculum not only imparts knowledge but also cultivates a mindset that is necessary for success in an increasingly complex and interconnected global landscape. Students stand to benefit most from this.

In conclusion, research on the awareness, readiness, and participation of science, math, and RBT teachers in STEM programmes is not just an academic endeavour; rather, it is a critical analysis of the major participants in the educational revolution. By looking into this field, we set the stage for a time when STEM education is more than just a curriculum; rather, it will act as a catalyst to develop the abilities and perspective required to take advantage of the opportunities and challenges presented by the twenty-first century.

Challenges in STEM Implementation

The integration of science, technology, engineering, and mathematics (STEM) in the STEM Education teaching approach brings many benefits but also involves several issues and challenges that need to be addressed. Meanwhile, the fourth industrial revolution (4.0) has caused changes in educational innovation, such as the development of artificial intelligence and digital physical frameworks, making humans interact with technology routinely (Shahroom & Hussin, 2018). Another challenge is the internet of things, big data, and cyber-physical systems (Jeon & Suh, 2017). These challenges require teachers to prepare students to have the knowledge and skills to address these issues (Nordin & Norman, 2018). This is because the fourth industrial revolution encourages everyone to develop new knowledge and competencies so that the education system can respond quickly to the developments and changes that exist (Lee et al., 2018).

The implementation of STEM as one approach to learning is highly suitable in the era of the fourth industrial revolution (Hafni et al., 2020). Since STEM Education integrates several subject areas to creatively solve problems for future innovation (Roberts, 2012). Based on the study by Ni'mah et al (2019), the motivation and experiences of students to shape and create something increase through STEM-based learning.

The pressure to implement STEM is strengthened by the existence of several advantages obtained through STEM approach learning, including (1) improving students' correlational mathematical abilities, (2) enhancing students' critical thinking skills, (3) enhancing creative thinking skills, (4) improving students' systematic and logical thinking according to the demands of 21st-century skills, and (5) enhancing students' problem-solving abilities. These findings confirm that STEM is a potentially applicable approach in the 21st century and the era of the fourth industrial revolution.

Implementation Limitations

The Teaching Approach of STEM Education is an area of study that is gaining increasing attention among education researchers. Despite the many benefits that can be gained through research in this field, there are several limitations that need to be considered. While it holds great potential for addressing current challenges, the implementation of STEM learning faces numerous obstacles (Wahono & Chang, 2019). Therefore, this study was conducted to explore the difficulties faced by mathematics and science teachers during the implementation of STEM in the last five years to find appropriate solutions to minimize their challenges in the future. Active student involvement in STEM learning requires various

support programs such as a clear curriculum, guidance and assessment instruments, the integration of Engineering and Technology knowledge into the Science and Mathematics curriculum, and the enhancement of scientific inquiry skills (Kennedy & Odell, 2014).

Currently, the STEM approach in Malaysia is not explicitly stated in the national curriculum but is implied in the curriculum goals, demanding students to be faithful, creative, innovative, productive, and able to contribute to the community, nation, and civilization worldwide. Additionally, the knowledge patterns that can be developed in the curriculum consist of both single (monodisciplinary) and multiple disciplines (multidisciplinary). It can be assumed that the implementation of STEM in Malaysian education is an extension of the concept of the 2013 curriculum. However, the development of a STEM-supportive curriculum framework is time-consuming (Nugroho et al., 2019) and can be anticipated by implementing STEM that supports the 2013 curriculum by incorporating existing local wisdom in Malaysia (Suhery, 2017).

The implementation of STEM in education is greatly influenced by teacher competencies, including their perceptions. Furthermore, teachers are required to possess sufficient knowledge to guide students to acquire skills suitable for the demands of the 21st century. Other findings indicate that teachers' readiness to implement STEM based on behavioral and affective and cognitive aspects is high but not yet optimal in providing STEM-based learning. Teachers' understanding of STEM is also very low, and students lack motivation to participate in STEM learning (Susilo & Sudrajat, 2020). Based on the identified obstacles, it is necessary to explore other difficulties faced by teachers in implementing STEM to make the STEM learning process more effective (Thibaut et al., 2018).

Teachers' difficultness during implementation of the STEM approach

Referring to the first literature used in this study (Milaturrahmah et al., 2017), the difficulties faced by mathematics teachers based on their experiences in the STEM learning process are (1) finding real-life problems related to mathematical topics and (2) providing learning tools and materials. Regarding the first difficulty, implementing STEM in mathematics is challenging because some mathematical topics are quite abstract, and teachers cannot find suitable contextual examples or applications of these topics in real life. The second difficulty reveals insufficient learning tools and materials, reducing the motivation of teachers to conduct mathematics learning using the STEM approach.

Meanwhile, based on the literature by Becker and Park (2011), the challenges faced by mathematics teachers in implementing STEAM (Science, Technology, Engineering, Arts, and Mathematics) are ineffective despite government support due to the following conditions: (1) limited time provided for teaching mathematics in class to implement STEAM projects, (2) lack of teacher competence to implement STEAM due to insufficient training and support references on STEAM projects, and (3) only a few topics in mathematics can be implemented in STEAM projects.

Referring to Parmin et al (2020), who explicitly mention the difficulties faced by science teachers in implementing STEM, there are nine difficulties identified from the research, including (1) time constraints, (2) barriers to collaborating with other professionals and experts related to STEM, (3) uncontrolled teamwork, (4) lack of support from students' parents, (5) teacher incompetence in providing the necessary tools and materials in STEM, (6) insufficient sponsorship for STEM learning, (7) unsupported school management in providing adequate time and funds, (8) school facility limitations, and (9) teachers' unfamiliarity with

designing STEM-based teaching plans. According to this article, the most significant difficulties faced by teachers are time constraints, especially in planning STEM, support from students' parents, and providing learning with STEM integration.

The fourth literature by Nugroho et al (2019) explores the perspectives of science teachers in implementing STEM. Based on the study, the difficulties faced by teachers in implementing STEM include (1) inadequate understanding of STEM, (2) government-provided teacher training being very general and unrelated to current teaching needs, (3) insufficient school facilities, and (4) some teachers not actively participating in school subject teacher workgroups as forums for discussing specific subjects and transferring information about current teaching approaches, including STEM.

Referring to the fifth literature used in the study by Newton and Tonelli (2020), the implementation of STEM in the classroom presents rational, neutral, and irrational obstacles for science teachers. Rational constraints include limited knowledge of STEM, difficulty combining science topics with mathematics, and not all topics can be taught using the STEM approach. Neutral constraints consist of varying student abilities, low mathematics skills, teacher educational backgrounds, time constraints, and limitations in using technology. Meanwhile, irrational obstacles include schools located far from urban areas, limited facilities and infrastructure, students unfamiliar with STEM learning, low student motivation, lack of application in devices, and frequent power outages.

Furthermore, based on Nessa et al (2017) insights into science teachers, there are several difficulties faced by teachers: (1) teacher confidence due to insufficient information about STEM, (2) science teachers hesitate to teach integrated science because of their lack of expertise, and (3) a lack of teacher confidence that integrated STEM is a suitable approach in teaching science.

Finally, it is known that the difficulties of biology teachers in implementing STEM include: (1) teachers not understanding the meaning of STEM in detail but only knowing the abbreviation, (2) lack of time in the STEM learning process, (3) low student interest in integrated STEM learning, and they still do not understand the essence of STEM learning, and (4) teachers' experience in teaching STEM is still low and requires further training to become more proficient during implementation (Alfika et al., 2019).

STEM implementation issues in schools

There are many factors contributing to the issue of empowering STEM in schools. The arising issues can be internal or external and may affect the performance of teachers in schools. According to Shahali et al (2017), teachers lack prerequisite knowledge about STEM and lack sufficient opportunities to be critical, creative, and innovative. Even though teachers are provided with STEM education, the information and training they receive are inadequate due to the limited time allocated for courses.

On the other hand, according to a study conducted by McGowen (2007), he analyzed that STEM education is also influenced by the lack of facilities and equipment available in schools. This is somewhat true, as highlighted in the Nor et al (2017), where teachers cannot conduct activities due to insufficient time, laboratory supplies, and allocated budgets. Consequently, these obstacles limit students from exploring and discovering more about science and mathematics.

Additionally, the 'End of Syllabus Syndrome' is one of the crucial issues occurring in every implementation of a new approach in education (Goh & Matthews, 2011). Teachers and

students are too bound by the examination-oriented system that requires them to cover the syllabus. As a result, teachers do not have enough time, and worse, they are burdened with heavy task loads.

Furthermore, the decreasing number of students in the Science stream shows a negative impact on the implementation of STEM. As stated by Jayarajah et al (2014), the decline in the number of students in the Science stream is due to fear and lack of confidence to pursue STEM fields. This is because they perceive the Science stream to have a heavier curriculum compared to other streams.

The lack of support from administrators is another issue. According to Schwier, support from school administrators is crucial, where school leaders need to have an open mind to support teachers in implementing new approaches. In this context, school administrators are not actively involved in STEM education. The situation worsens when they are not aware of the problems faced by teachers in schools.

Solutions to overcome teachers' difficulties in implementing STEM

The STEM approach has a positive impact on learning. STEM, which stands for Science, Technology, Engineering, and Mathematics, combines these four disciplines in education to connect with real-life problems. Other reasons for choosing STEM over other learning approaches include: (1) the availability of necessary subject adjustments within STEM, (2) the ease, simplicity, usefulness, and cost-effectiveness of STEM applications without requiring significant expenses and excessive time, (3) the effectiveness of STEM learning processes, maximizing student potential, easy understanding, and creating lifelong or lasting learning, and (4) generating diverse knowledge with added value (Bozkurt & Özyurt, 2019).

Applicable solutions to address teachers' difficulties in implementing STEM include: (1) Educational authorities should raise awareness among teachers about the importance of STEM to motivate them and enable them to guide students actively in STEM-based learning, (2) Providing sufficient training so that teachers have the skills to implement STEM, and (3) providing the necessary facilities during STEM projects. Teachers need assistance by organizing training to develop professionalism, pedagogical support, and curriculum understanding so that they are ready to apply the STEM approach in teaching (Setiawaty et al., 2020).

To overcome teachers' difficulties in dealing with insufficient learning tools and materials, teachers can seek information from various sources, including other countries, to adopt STEM implementation. After finding suitable applications, teachers are encouraged to customize and implement STEM applications based on the current facility conditions in their schools (Milaturrahmah et al., 2017). Efforts to provide STEM training to teachers are crucial and beneficial. Teachers must be given the opportunity to develop their professionalism to be ready to guide students with the STEM approach. The crucial role of teachers in learning influences the implementation of STEM. Teachers are interested in implementing STEM but are unsure whether they can do so without adequate preparation through workshops or training.

The discovery and development of STEM learning tools indicate educators' interest in implementing STEM in education, and there is great potential for further development. Furthermore, increasing teachers' and the government's awareness of STEM education is essential to create opportunities and enhance its implementation. Another solution that would greatly assist teachers in implementing STEM is support from school management and

other teachers besides mathematics and science teachers. This is because STEM is primarily understood by the majority of mathematics and science teachers, and other teachers may not be able to assist them in implementing STEM. Additionally, the success of STEM implementation will be achieved with a clear and supportive curriculum, as teachers will have greater opportunities to implement STEM learning without neglecting the goals of the national curriculum.

Conclusion

The STEM learning approach is a suitable solution for mastering 21st-century skills and responding to changes in educational innovation due to the 4.0 industrial revolution. Because it is relatively new, the implementation of the STEM approach in learning poses specific challenges for teachers. Based on a literature review, the difficulties faced by teachers in implementing STEM or STEAM vary depending on the primary focus on mathematics or science. However, in some studies, both mathematics and science teachers share common difficulties in implementing STEM, such as the following: low understanding of STEM, lack of resources, and limited time in the teaching schedule. Therefore, to address the difficulties mentioned earlier, several solutions are proposed depending on needs, such as improving teachers' understanding of STEM, equipping school facilities, and adjusting curriculum goals under STEM implementation.

In overall, this study provides a deeper understanding of the STEM Education Teaching Approach. Despite issues and challenges in the effective integration of science, technology, engineering, and mathematics, a student-centered learning approach has proven beneficial in increasing students' interest and engagement in STEM subjects. Furthermore, the use of the STEM education teaching approach is closely related to students' academic achievements in STEM subjects. Therefore, this study provides a strong foundation for further research and development in this field, with the hope of enhancing the quality of STEM education and helping prepare students for future challenges that are more complex and technologically driven.

References

Alfika, Z. A., Mayasari, T., & Kurniadi, E. (2019). Modul STEM berbasis pemecahan masalah dengan tema rumah dome. *Jurnal Pendidikan Fisika*, *7*(1), 93-105.

Becker, K. H., & Park, K. (2011). Integrative approaches among science, technology, engineering, and mathematics (STEM) subjects on students' learning: A meta-analysis. *Journal of STEM education: Innovations and research*, *12*(5).

Bozkurt, A., & Özyurt, M. (2019). Investigate the Evaluations of Prospective Teacher on STEM Education, Based on Their Experiences with Planning and Implementing STEM Activities. *Malaysian Online Journal of Educational Technology*, *7*(4), 81-97.

Goh, P. S., & Matthews, B. (2011). Listening To the Concerns of Student Teachers In Malaysia During Teaching Practice. *Australian Journal of Teacher Education*, 36(3). https://doi.org/10.14221/ajte.2011v36n3.2.

Hafni, R. N., Herman, T., Nurlaelah, E., & Mustikasari, L. (2020). The Importance of Science, Technology, Engineering, and Mathematics (STEM) Education To Enhance Students' Critical Thinking Skill in Facing The Industry 4.0. *Journal of Physics: Conference Series* (Vol. 1521, No. 4, p. 042040). IOP Publishing.

Jayarajah, K., Saat, R. M., Rauf, A. & Amnah, R. (2014). A Review of Science, Technology, Engineering & Mathematics (STEM) Education Research from 1999-2013: A Malaysian Perspective. *Eurasia Journal of Mathematics, Science & Technology Education*, 10(3).

Jeon, J., & Suh, Y. (2017). Analyzing the Major Issues of the 4th Industrial Revolution. *Asian Journal of Innovation and Policy*, *6*(3), 262-273.

Kan, A. U., & Murat, A. (2018). Investigation of Prospective Science Teachers' 21st Century Skill Competence Perceptions and Attitudes Toward STEM. *International Online Journal of Educational Sciences*, *10*(4).

Kelley, T. R., & Knowles, J. G. (2016). A Conceptual Framework for Integrated STEM Education. *International Journal of STEM Education*, 3, 1-11.

Kembara, M. D., Rozak, R. W. A., & Hadian, V. A. (2019). Based on Lectures to Improve Students' 4C (Communication, Collaboration, Critical Thinking, and Creativity) Skills. In *International Symposium on Social Sciences, Education, and Humanities (ISSEH 2018)*, 22-26.

Kennedy, T. J., & Odell, M. R. (2014). Engaging Students in STEM Education. *Science Education International*, *25*(3), 246-258.

Lee, M., Yun, J. J., Pyka, A., Won, D., Kodama, F., Schiuma, G., ... & Zhao, X. (2018). How to Respond to The Fourth Industrial Revolution, Or the Second Information Technology Revolution? Dynamic New Combinations Between Technology, Market, And Society Through Open Innovation. *Journal of Open Innovation: Technology, Market, and Complexity*, *4*(3), 21.

McGowen, R. S. (2007). The Impact of School Facilities on Students Achievement, Attendance, Behaviour, Completion Rate and Teacher Turnover Rate in Selected Texas High Schools.

Milaturrahmah, N., Mardiyana, M., & Pramudya, I. (2017). Science, Technology, Engineering, Mathematics (STEM) as Mathematics Learning Approach in 21st Century. In *AIP Conference Proceedings*, 1868(1).

Nor, M. N., Leong, K. E., & Salleh, M. U. K. (2017). Changes in the Malaysian school curriculum from the pre-independence years until the new millennium. *Education in Malaysia: Developments and challenges*, 101-118.

Mohd Shahali, E. H., Halim, L., Rasul, M. S., Osman, K., & Zulkifeli, M. A. (2017). STEM Learning through Engineering Design: Impact on Middle Secondary Students' Interest towards STEM. *Eurasia Journal of Mathematics, Science and Technology Education,* 13(5), 1189-1211. https://doi.org/10.12973/eurasia.2017.00667a.

Nessa, W., Hartono, Y., & Hiltrimartin, C. (2017). Pengembangan Buku Siswa Materi Jarak Pada Ruang Dimensi Tiga Berbasis Science, Technology, Engineering, And Mathematics (STEM) Problem-Based Learning di Kelas X. *Jurnal Elemen*, *3*(1), 1-14.

Newton, X. A., & Tonelli Jr, E. P. (2020). Building Undergraduate STEM Majors' Capacity for Delivering Inquiry-Based Mathematics and Science Lessons: An Exploratory Evaluation Study. *Studies in Educational Evaluation*, 64, 100833.

Ni'mah, A., Mariani, S., & Prabowo, A. (2019). Kemampuan Koneksi Matematis Dan Entrepreneurship Siswa SMK Dalam Model Pembelajaran Project Based Learning Dengan Pendekatan Terintegrasi STEM. In *Prosiding Seminar Nasional MIPA Kolaborasi*, 1(1), 100-113.

Nordin, N., & Norman, H. (2018). Mapping The Fourth Industrial Revolution Global Transformations On 21st Century Education on The Context of Sustainable Development. *Journal of Sustainable Development Education and Research*, *2*(1), 1-7.

Nugroho, O. F., Permanasari, A., & Firman, H. (2019). The Movement of STEM Education in Indonesia: Science Teachers Perspectives. *Jurnal Pendidikan IPA Indonesia*, *8*(3), 417-425.

Parmin, P., Saregar, A., Deta, U. A., & El Islami, R. A. Z. (2020). Indonesian Science Teachers' Views on Attitude, Knowledge, and Application of STEM. *Journal for the Education of Gifted Young Scientists*, *8*(1), 17-31.

Roberts, A. (2012). A Justification for STEM Education. *Technology and Engineering Teacher*, *74*(8), 1-5.

Setiawaty, S., Imanda, R., Fitriani, H., & Sari, R. P. (2020). Pengembangan LKS Sains Berbasis STEM untuk Siswa Sekolah Dasar. In *Seminar Nasional Peningkatan Mutu Pendidikan*, 1(1), 484-489.

Shahroom, A. A., & Hussin, N. (2018). Industrial Revolution 4.0 and Education. *International Journal of Academic Research in Business and Social Sciences*, *8*(9), 314-319.

Suhery, T. (2017). Implementasi STEMI Pada Pembelajaran Kimia Dalam Rangka Menerapkan Kurikulum 2013. In *Seminar Nasional Pendidikan IPA Tahun 2021,* l(1), 8-13.

Susilo, H., & Sudrajat, A. K. (2020). STEM Learning and its Barrier in Schools: The Case of Biology Teachers in Malang City. In *Journal of Physics: Conference Series*, 1563(1).

Teo, P. (2019). Teaching for the 21st Century: A Case for Dialogic Pedagogy Learning, *Culture and Social Interaction.*

Thibaut, L., Ceuppens, S., De Loof, H., De Meester, J., Goovaerts, L., Struyf, A., & Depaepe, F. (2018). Integrated STEM Education: A Systematic Review of Instructional Practices in Secondary Education. *European Journal of STEM Education*, *3*(1), 2.

Tofel-Grehl, C., & Callahan, C. M. (2014). STEM High School Communities: Common and Differing Features. *Journal of Advanced Academics*, *25*(3), 237-271.

Wahono, B., & Chang, C. Y. (2019). Assessing Teacher's Attitude, Knowledge, and Application (AKA) on STEM: An Effort to Foster the Sustainable Development of STEM Education. *Sustainability*, 11(4), 950.