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STEM IN ACTION: REAL-WORLD APPLICATIONS OF SCIENCE, TECHNOLOGY, ENGINEERING, AND MATH

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Abstract

Science, Technology, Engineering, and Mathematics (STEM) is an interdisciplinary educational approach that focuses on the practical application of knowledge and skills in these four areas. STEM education aims to develop critical thinking, problem-solving, and analytical skills essential for success in the 21st century. STEM education has become increasingly important in recent years as technology has transformed nearly every aspect of our lives. This research aims to: (1) What are the benefits of STEM in-action projects? (2) how can STEM in-action projects be effectively implemented in educational and professional settings? (3) what are the real-world applications of STEM, and how are they impacting society? and (4) what is the future of STEM in action, and what trends and developments are shaping its direction? This research is a literature review involving 17 journals published in 2019-2023. The results of this study found that: (1) STEM can help the student to develop critical thinking skills, problem-solving skills, and creativity; (2) provide students with opportunities to work on authentic problems, promoting collaboration and teamwork, and provide professional development for educators; (3) healthcare, energy, and the environment, (4) data science and artificial intelligence; (4) the growing demand for STEM professionals, and the need for greater diversity and inclusivity in STEM fields. STEM in-action: Real-world applications of STEM is a concept that seeks to bridge the gap between theory and practice in STEM education. It is an approach that emphasizes applying STEM principles in real-world scenarios, allowing students to see how the concepts they learn in class are relevant to the world around them. STEM in action is a fundamental approach to STEM education that helps students develop practical skills and knowledge while preparing them for the challenges of the 21st century.

Keywords: STEM education, real-world applications, problem-solving, hands-on learning, 21st-century workforce

Abstrak

Sains, Teknologi, Teknik, dan Matematika (STEM) adalah pendekatan pendidikan interdisipliner yang berfokus pada penerapan praktis pengetahuan dan keterampilan di keempat bidang ini. Pendidikan STEM bertujuan untuk mengembangkan pemikiran kritis, pemecahan masalah, dan keterampilan analitis yang penting untuk sukses di abad ke-21. Pendidikan STEM menjadi semakin penting dalam beberapa tahun terakhir karena teknologi telah mengubah hampir setiap aspek kehidupan kita. Penelitian ini bertujuan untuk: (1) Apa manfaat dari proyek in-action STEM? (2) bagaimana proyek STEM dapat diimplementasikan secara efektif dalam pengaturan pendidikan dan profesional? (3) apa aplikasi STEM di dunia nyata, dan bagaimana dampaknya terhadap masyarakat? dan (4) bagaimana masa depan STEM dalam tindakan, dan tren dan perkembangan apa yang membentuk arahnya? Penelitian ini merupakan kajian pustaka yang melibatkan 17 jurnal yang diterbitkan pada tahun 2019-2023. Hasil penelitian ini menemukan bahwa: (1) STEM dapat membantu siswa untuk mengembangkan keterampilan berpikir kritis, keterampilan memecahkan masalah, dan kreativitas; (2) memberikan siswa kesempatan untuk bekerja pada masalah otentik, mempromosikan kolaborasi dan kerja tim, dan memberikan pengembangan profesional bagi pendidik; (3) kesehatan, energi, dan lingkungan, (4) ilmu data dan kecerdasan buatan; (4) meningkatnya permintaan akan profesional STEM, dan kebutuhan akan keragaman dan inklusivitas yang lebih besar di bidang STEM. STEM in-action: Aplikasi STEM di dunia nyata adalah konsep yang berupaya menjembatani kesenjangan antara teori dan praktik dalam pendidikan STEM. Ini adalah pendekatan yang menekankan penerapan prinsip-prinsip STEM dalam skenario dunia nyata, memungkinkan

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siswa untuk melihat bagaimana konsep yang mereka pelajari di kelas relevan dengan dunia di sekitar mereka. STEM dalam tindakan adalah pendekatan mendasar untuk pendidikan STEM yang membantu siswa mengembangkan keterampilan dan pengetahuan praktis sambil mempersiapkan mereka menghadapi tantangan abad ke-21.

Kata kunci: pendidikan STEM, aplikasi dunia nyata, pemecahan masalah, pembelajaran langsung, tenaga kerja abad ke-21

INTRODUCTION

STEM education has become increasingly important in recent years as technology has transformed nearly every aspect of our lives. STEM education is an interdisciplinary approach that practically applies knowledge and skills in these four areas (Siregar & Anggrayni, 2023). STEM education aims to develop critical thinking, problem-solving, and analytical skills essential for success in the 21st century (Siregar et al., 2019). One approach to STEM education that has gained popularity is STEM in action: Real-world applications of science, technology, engineering, and math. This concept seeks to bridge the gap between theory and practice in STEM education by emphasizing applying STEM principles in real-world scenarios.

STEM in action involves hands-on learning experiences that enable students to develop practical skills and knowledge through experimentation, problem-solving, and collaboration (Rosli et al., 2019). By engaging in projects that apply STEM principles, students gain a deeper understanding of how science, technology, engineering, and math can solve real-world problems (Rosli & Siregar, 2022). The benefits of STEM in action are numerous. It helps to develop critical thinking skills, problem-solving skills, and creativity. It also prepares students for the 21st-century workforce, where STEM skills are in high demand. Additionally, it encourages students to pursue careers in STEM fields, which are critical for driving innovation and economic growth (Siregar & Rosli, 2021; Siregar et al., 2023).

STEM in action is not just about learning science, technology, engineering, and math; it is about applying that knowledge to real-world problems. This education approach helps break down the traditional barriers between subjects and encourages students to think beyond the confines of a particular discipline (Siregar & Anggrayni, 2023). It also helps to develop skills such as communication, teamwork, and leadership, which are essential for success in any field.

STEM in action projects can take many forms, from designing and building a robot to creating a sustainable energy system for a community. What is important is that students are engaged in applying STEM principles to solve real-world problems. This project-based learning

allows students to take ownership of their learning and develop a deeper understanding of the subject matter. One of the critical advantages of STEM in action is that it allows students to see the relevance of STEM subjects to their everyday lives. Students can see how STEM principles are used in healthcare, transportation, and energy production by engaging in real-world projects. It can increase their interest in these subjects and encourage them to pursue careers in STEM fields.

Another advantage of STEM in action is that it allows students to develop practical skills in high demand in the workforce. For example, the ability to program a computer or design and build a robot are skills employers highly value in many industries. Students can develop these skills by engaging in STEM action projects and making themselves more marketable to employers. STEM in action is also an effective way to address the gender and diversity gap in STEM fields. By engaging in hands-on projects relevant to their lives, girls and underrepresented minorities are more likely to become interested in STEM subjects and pursue careers in these fields (Rosli et al., 2020). It can help to increase diversity in STEM fields, which is critical for driving innovation and addressing the challenges of the 21st century.

Overall, STEM in action: Real-world applications of science, technology, engineering, and math is a fundamental approach to STEM education that helps students develop practical skills and knowledge while preparing them for the challenges of the 21st century. Students gain a deeper understanding of these subjects' importance and relevance to the world around them by engaging in real-world applications of science, technology, engineering, and math. This approach to education is critical for driving innovation and economic growth and addressing the challenges of the 21st century.

Benefits of STEM in Action Projects

STEM in action projects offers numerous benefits to students, teachers, and the community. These projects engage students in hands-on, project-based learning that applies STEM principles to real-world problems (Bybee & Landes, 2019; Prajoko et al., 2023; Prince, 2020). The following are some of the critical benefits of STEM in action projects.

First, STEM in action projects requires students to think critically and solve complex problems. Students learn how to identify problems, analyze data, and develop solutions through these projects. These skills are essential for success in any career path. Second, STEM

in-action projects can help students develop a deeper understanding and appreciation for STEM subjects. By engaging students in project-based learning that applies STEM principles to real-world problems, teachers can help students see the relevance of these subjects to their lives and future careers. It can increase interest in STEM and inspire students to pursue careers in it.

Third, STEM in action projects often requires students to work in teams, which promotes collaboration and communication skills. Students learn to work effectively with others, listen to different perspectives, and communicate their ideas clearly and effectively. Fourth, STEM in-action projects encourage students to be creative and innovative. Students learn how to think outside the box and develop new and innovative ideas by designing and building solutions to real-world problems. Fifth, STEM in-action projects can help students build confidence in their abilities and develop a sense of self-efficacy. By completing these projects, students can see the tangible results of their efforts, which can be a powerful motivator and help build a sense of accomplishment.

Sixth, STEM in action projects can help prepare students for tomorrow's workforce by developing skills essential for success in any career path. These skills include critical thinking, problem-solving, collaboration, communication, and creativity. By engaging in project-based learning that applies STEM principles to real-world problems, students gain valuable experience that can help prepare them for future careers in STEM fields and future.

Implementing STEM in Action Projects

Implementing STEM in action projects in the classroom requires careful planning and consideration. STEM in action projects should design to align with the curriculum and learning objectives of the course. Teachers should consider students' knowledge and skills and how the project will support their learning. When selecting a project, teachers should consider the interests and abilities of their students, as well as the resources and support available (Siregar, 2020). Projects should be engaging and challenging but achievable with the available resources and time. Teachers should develop clear and objective criteria for assessing student learning and progress throughout the project (Kolmos et al., 2019; Sadler, 2019; Weston & Bain, 2019).

Assessment should align with the course's learning objectives and the project's goals. Teachers may need additional resources and support to implement STEM in action projects

effectively. It may include access to materials and equipment, professional development opportunities, and support from colleagues and community partners (Siregar & Anggrayni, 2023). STEM in action projects can be messy and chaotic, and teachers should prepare to manage the classroom environment effectively. It may include setting clear expectations and guidelines for behavior, assigning roles and responsibilities, and providing guidance and support as needed.

STEM in action projects should be an iterative process, with opportunities for reflection and revision throughout the project. Teachers should encourage students to reflect on their learning and experiences and to identify areas for improvement and further exploration. Teachers can also use student feedback to refine and improve their approach to implementing STEM in action projects in the future.

Real-World Applications of STEM

Real-world applications of STEM involve using science, technology, engineering, and math principles to solve real-world problems (Panch et al., 2019; Raghupathi & Raghupathi, 2019; Topol, 2019). STEM is essential for addressing some of the world's most pressing challenges, such as climate change, healthcare, and energy sustainability. Researchers and practitioners can develop innovative solutions that benefit society by applying STEM principles to these challenges. STEM plays a crucial role in economic development, as it drives innovation and supports the growth of new industries (Siregar et al., 2019). By investing in STEM education and research, communities can attract new businesses and industries, creating jobs and economic opportunities.

STEM is essential for advancing healthcare and improving health outcomes. By developing new medical technologies, treatments, and therapies, STEM can improve the quality of life for individuals and communities. STEM is essential for addressing environmental challenges like climate change and resource depletion. By developing new technologies and systems for renewable energy, waste reduction, and sustainable agriculture, STEM can help ensure a sustainable future for generations to come.

STEM is critical for advancing our knowledge and understanding of the natural world. STEM can help us better understand complex systems and phenomena by researching and developing new theories and models. STEM is a driving force behind innovation and creativity, as it encourages individuals to think critically and develop new solutions to complex problems.

By fostering a culture of innovation and creativity, STEM can inspire individuals to pursue new ideas and contribute significantly to society.

Real-world applications of STEM can be found in various industries and fields, including healthcare, energy, transportation, agriculture, and environmental management (Panch et al., 2019; Raghupathi & Raghupathi, 2019; Topol, 2019). From designing new medical devices to developing renewable energy technologies, STEM has the potential to impact our world significantly. Investing in STEM education and research ensures that future generations have the knowledge and skills to continue making meaningful contributions to society.

Future of STEM in Action

The future of STEM in action is bright and promising. As we continue developing new technologies and innovations, the demand for individuals with strong STEM skills will only grow. The following are some key trends and developments shaping the future of STEM in action (Chrysafiadi & Virvou, 2019; Gadanidis & Borba, 2020; Kay & Greenhill, 2020): (1) Digital Transformation: Digital transformation is changing the way we live, work, and learn, and it is also shaping the future of STEM in action. Digital technologies, such as artificial intelligence, machine learning, and robotics, drive innovation and create new opportunities for STEM professionals (Rahman et al., 2022).

(2) Focus on Sustainability: The focus on sustainability is increasing, and STEM in action will play a crucial role in addressing environmental challenges and supporting a sustainable future. It will require a focus on developing new technologies and systems for renewable energy, waste reduction, and sustainable agriculture. (3) Diversity and inclusion: The need for diversity and inclusion in STEM is becoming increasingly recognized, and efforts are underway to promote greater diversity and inclusion in STEM fields. It will require addressing barriers to entry and providing support and resources for underrepresented groups.

(4) Collaboration and interdisciplinary approaches: Collaboration and interdisciplinary approaches are becoming increasingly crucial in STEM in action. As problems become more complex, bringing together individuals from different backgrounds and disciplines will be essential to develop comprehensive solutions. (5) Lifelong Learning: Learning is becoming increasingly crucial in STEM action as new technologies and innovations emerge. Professionals must adapt to new challenges and opportunities and continue learning.

(6) Ethical Considerations: Ethical considerations are becoming increasingly crucial in STEM action as new technologies and innovations raise complex ethical questions. It will be essential for STEM professionals to consider the ethical implications of their work and to work collaboratively to develop ethical frameworks and guidelines (Siregar & Nasiah, 2022). Overall, the future of STEM in action is exciting and full of opportunities. As we continue developing new technologies and innovations, the demand for individuals with strong STEM skills will only grow. By investing in STEM education and research, promoting diversity and inclusion, and fostering collaboration and interdisciplinary approaches, we can ensure that STEM in action continues to make a meaningful impact on society in the years to come.

METHODS

This study examines the benefits, implementation, and future of STEM in action: Real-world applications of science, technology, engineering, and math. The methodology for this research will involve a systematic literature review. The following sections outline the research methodology in more detail.

Research Questions

(1) What are the benefits of STEM in action projects?

(2) How can STEM in action projects be effectively implemented in educational and professional settings?

(3) What are the real-world applications of STEM, and how are they impacting society?

(4) What is the future of STEM in action, and what trends and developments are shaping its direction?

Data Collection

Data collection will involve a systematic review of existing literature on the topic. The search will use various academic databases, including Google Scholar, JSTOR, and ScienceDirect. The search terms used will include "STEM in Action," "real-world applications of STEM," "STEM education," "STEM implementation strategies," and "STEM trends and developments." The search will be limited to articles published within the last ten years. Inclusion Criteria: Articles that (1) have been published in the last five years, (2) the article must be written in English, (3) the article must be a primary research article, and (4) focused on STEM in action: Real-world applications of science, technology, engineering, and math

included, and (5) articles published in 2023-2019. Exclusion Criteria: (1) articles that needed publishing in English, (2) those that needed to focus more on STEM in action: Real-world applications of science, technology, engineering, and math excluded.

Data Analysis

Data analysis will involve a systematic review of the literature collected during the search. The literature will be analyzed using a qualitative approach to identify common themes and patterns. The analysis will focus on the benefits, implementation strategies, real-world applications, and future trends and developments of STEM in action. The author obtained 54,200 journals from the search results, using the inclusion and exclusion criteria; the articles analyzed in this article were 17.

Validity and Reliability

Validity and reliability confirm this study; multiple data sources, including scholarly articles, books, and reports, will be used. The search terms will be carefully selected to ensure that relevant literature includes in the review. A team of researchers will also conduct the study to ensure the analysis is unbiased and comprehensive.

Limitations

One limitation of this study is that it is limited to a review of existing literature. It means that the study depends on the quality and relevance of the available literature. Another limitation is that the search will be limited to articles published within the last ten years, which may exclude relevant literature published before this period.

RESULTS AND DISCUSSION

Benefits of STEM in Action Projects

The literature review on the benefits of STEM in action projects identified several key benefits, including increased student engagement and motivation, improved critical thinking and problem-solving skills, and increased interest in STEM careers (Zeegers et al., 2021). Various educational settings demonstrate these benefits, including K-12 classrooms, informal education programs, and higher education institutions. STEM in action projects can increase student engagement and motivation by allowing students to apply their knowledge to real-world problems. This approach to learning is more effective than traditional lecture-based approaches, as it encourages students to take an active role in their learning (Bybee & Landes, 2019; Lee & Kim, 2020; Prajoko et al., 2023; Prince, 2020).

Another study by Johnson and Laubach (2018) found that STEM in action projects can improve critical thinking and problem-solving skills. Working on real-world problems forces students to think critically and develop creative solutions to complex problems. This type of learning is essential for preparing students for future careers in STEM fields. Finally, several studies have found that STEM in action projects can increase interest in STEM careers among students. By providing students with opportunities to work on real-world problems and interact with STEM professionals, students can see the relevance of STEM subjects to their future careers. It can help to address the growing need for skilled workers in STEM fields.

Implementation Strategies for STEM in Action Projects

The review of existing literature on the implementation of STEM in action projects identified several key strategies for success. These include providing students with opportunities to work on authentic problems, promoting collaboration and teamwork, and providing professional development for educators. Providing students with opportunities to work on authentic problems is essential for the success of STEM in action projects. Authentic problems are relevant to real-world situations and require students to use STEM skills to solve them. This approach to learning is more effective than traditional lecture-based approaches because it helps students to see the relevance of STEM subjects to their daily lives (Dare et al., 2021; Kolmos et al.,2019; Sadler, 2019).

Another study by Banks and Sokolowski (2010) found that promoting collaboration and teamwork is essential for the success of STEM in action projects. By working in teams, students can share their ideas and learn from one another. This approach to learning is more effective than individual learning because it encourages students to take an active role in their learning. Finally, several studies have found that providing professional development for educators is essential for the success of STEM in action projects. Educators must train in implementing STEM in action projects, including selecting authentic problems, promoting collaboration and teamwork, and providing student feedback.

Real-World Applications of STEM

The review of existing literature on the real-world applications of STEM identified several key areas where STEM has a significant impact, including healthcare, energy, and the

environment. These areas are critical areas where STEM professionals must address society's complex problems. STEM significantly impacts healthcare by developing new technologies and treatments that improve patient outcomes. Examples include the development of personalized medicine, which uses genetic information to tailor treatments to individual patients, and telemedicine, which allows healthcare professionals to monitor and diagnose patients remotely (Dobrin, 2020; Panch et al., 2019; Raghupathi & Raghupathi, 2019; Topol, 2019).

Another study by Bryan et al. (2020) found that STEM significantly impacts energy by developing new technologies that increase energy efficiency and reduce carbon emissions. Examples include the development of renewable energy sources, such as solar and wind power, and using smart grids, which allow for more efficient energy distribution. Finally, several studies have identified the environment as a critical area where STEM professionals are needed to address complex problems. STEM is critical in addressing climate change by developing new technologies that reduce greenhouse gas emissions and promote sustainable development. Examples include the development of carbon capture and storage technologies, which capture carbon dioxide emissions from power plants and store them underground, and the development of sustainable agriculture practices, which reduce the environmental impact of farming.

Future of STEM in Action

The review of existing literature on the future of STEM in action identified several key trends that are likely to shape the future of STEM education, including the increasing importance of data science and artificial intelligence, the growing demand for STEM professionals, and the need for greater diversity and inclusivity in STEM fields. Data science and artificial intelligence will likely be increasingly important in STEM education. These technologies use in various fields, including healthcare, finance, and marketing, and expecting to become more prevalent in the coming years. This trend highlights the need for STEM educators to incorporate these technologies into their curricula (Gadanidis & Borba, 2020; Wang et al., 2020).

Another study by Pease et al. (2020) found a growing demand for STEM professionals, particularly in computer science, data science, and engineering. This demand is driven by the increasing importance of technology in various fields and demographic changes resulting in

an aging workforce. Finally, several studies have identified the need for greater diversity and inclusivity in STEM fields. Women, racial and ethnic minorities, and individuals with disabilities underrepresent in STEM fields; efforts must increase their participation. One study by Ang and Lim (2019) found that providing mentorship and support for underrepresented groups can help to increase their participation in STEM fields.

CONCLUSION

STEM in action projects is a promising STEM education approach that allows students to apply their knowledge to real-world problems. The review of existing literature identified several vital benefits of STEM in action projects, including increased student engagement and motivation, improved critical thinking and problem-solving skills, and increased interest in STEM careers. The review also identified several key implementation strategies for STEM in action projects, including providing students with opportunities to work on authentic problems, promoting collaboration and teamwork, and providing professional development for educators. Finally, the review identified several key areas where STEM significantly impacts healthcare, energy, and the environment.

Future research is needed to explore the benefits and implementation strategies of STEM in action projects and investigate emerging technologies and their potential for real-world applications. It is essential to continue to invest in STEM education and promote collaboration between educators, industry leaders, and policymakers to ensure that STEM education is responsive to the changing needs of society and the economy. Moreover, STEM in action projects is also driving innovation and entrepreneurship.

Many successful startups have emerged from STEM projects, and employers highly value the skills gained through these projects. Students who participate in STEM in action projects are more likely to pursue STEM careers and are better prepared for the challenges of the workforce. In addition to the impact of STEM in action projects on the workforce, there is also a significant impact on the broader community.

Many STEM in-action projects focused on solving real-world problems and improving the quality of life for individuals and communities. For example, projects focused on developing clean energy technologies, improving healthcare access in underserved communities, and reducing environmental pollution can profoundly impact the well-being of

individuals and society. STEM in action projects are also helping to bridge the gap between research and practice. By engaging with industry and community partners, STEM students and educators can better understand the needs and challenges of real-world applications and develop practical and effective solutions.

This collaboration also facilitates the dissemination of knowledge and best practices across disciplines and sectors, leading to further innovation and progress. However, there are also challenges associated with implementing STEM in action projects. For example, many schools and educators need more training to implement STEM education, such as limited resources, lack of training, and competing priorities. Additionally, there is a need for greater diversity and inclusion in STEM education and careers to ensure all individuals have equal access to opportunities and can contribute to the field.

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