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STEAM Education

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Abstract: The International Society for Technology in Education (ISTE) requires institutional education to adapt to rapid technology and prepare students to compete internationally by using e-learning media in the classroom. The purpose of the study's literature is to strengthen every argument about STEAM education. Support argument required originating data source from secondary data. The method used in this research is the study literature method. Data collection techniques through collecting articles on STEAM, STEAM education, and technology in the learning process. Databases used for journal searches include Elsevier, Emerald, Springer, Research Gate, Academia Edu, Google Scholar, and Publish or Perish. The validity test of the data through several stages. The process starts with data collection, reduction, presentation, and withdrawal conclusion. The result of this study is that STEAM builds human resources who can think critically, logically, and systematically and have global competitiveness. Implementing STEAM education enables students to understand the importance of integrating multiple disciplines. Moreover, learners can improve their logical thinking and provide comprehensive opportunities for students to practice their thinking skills.

Keywords: education, learning, STEAM, technology.

INTRODUCTION

Rapid development in the digital era is a new technology that profoundly impacts teaching students (Glaze, 2018). The International Society for Technology in Education (ISTE) requires institutional education to adapt to rapid technology and prepare students to compete internationally by using e-learning media in the classroom (An, 2020). Educators must collaborate with colleagues to improve practice (Utaminingsih et al., 2023a), discover and share ideas, and make changes (Chung et al., 2022).

Teachers' decisions to use technology in the classroom will affect students' technological abilities (Lu et al., 2022). Teachers must empower connected all students in worldwide (Quigley et al., 2020). The way to empower them is by integrating science, technology, engineering, and mathematics (STEM) in their learning media in the learning process (Tretola et al., 2019). STEM is learning where technology lead students to solve the real problem by creating learning innovation opportunities (Zhan et al., 2022). However, only a few teachers are interested in integrating STEM into the classroom (Lindeman et al., 2014). In contrast, all researchers worldwide have suggested that teachers should support using STEM as a learning tool that helps the learning process (Matsuura & Nakamura, 2021).

The STEAM concept has attracted a lot of attention from various researchers in the field of education worldwide (Chung & Li, 2021). STEAM is an advanced approach to the STEM approach. (Aguilera & Ortiz-Revilla, 2021). STEAM is an educational approach incorporating "art" into existing STEAM, comprising science, technology, engineering, arts, and mathematics (Herro & Quigley, 2016; Milara et al., 2020). STEAM has been proven to have the benefit of being able to make it easier to remember, increase cognitive intelligence, and train time management. (Perignat & Katz-Buonincontro, 2019). Furthermore, not only to help teach science concepts but also to make students think and innovate with art concepts (Lin & Tsai, 2021). In addition, it can inspire them to become creative thinkers in interdisciplinary (How & Hung, 2019).

Multiple experts have about STEAM, implementing STEAM to improve mastery of concepts and accelerate imaginative thinking (Bilgiler et al., 2020). Moreover, improving imagination abilities (Graham, 2020) stimulates learning potential, so students do not feel burdened to learn. Furthermore, deepening students' understanding will increase mental

stimulation and creativity. (Quigley et al., 2020). Since STEAM education exists, it positively influences students' learning process (Bertrand & Namukasa, 2020).

Therefore, it will be necessary to analyze the role of STEAM in education. Thus, the results of this concept study will provide information about the benefits of steam in the education sector. In addition, the study's main conclusion is to help teachers, the principal, administrative, and teacher training institutions to find out the needs of students during learning, and the benefits of involving STEAM in the learning process, then they can develop learning concepts that suit the needs of students.

METHODS

The method used in this research is the study literature method. The purpose of the study's literature is to strengthen every argument about STEAM education. Support argument required originating data source from secondary data. Data collection techniques through collecting articles on STEAM, STEAM education, and technology in the learning process. Databases used for journal searches include Elsevier, Emerald, Springer, Research Gate, Academia Edu, Google Scholar, and Publish or Perish. The validity test of the data through several stages, such as data collection, data reduction, data presentation, and withdrawal conclusion.

FINDINGS AND DISCUSSION

Concept of Science, Technology, Engineering, Art, Mathematics (STEAM)

The current acceleration of technology has ushered in new challenges in the field of education (Ellianawati *et al*., 2020). One of the recent efforts to attract students to technology is STEM education. STEM education leads educators to show students how concepts from science are integrated with product development used in everyday life (Agussuryani *et al*., 2022). Experts then expand STEM by incorporating 'art' into learning (Herro *et al*., 2018). STEM has been the main vehicle to overcome challenges in preparing technologically skilled human resources (Lindeman *et al*., 2014). Responding to the need to be efficient in an increasingly technological world, educational researchers are considering integrating technology into the classroom (Matsuura & Nakamura, 2021). One way to do this is through STEAM (Science, Technology, Engineering, Art, and Mathematics). STEAM, where 'A' stands for arts and humanities. Art elements are proposed to enhance the learning process such as student participation, and interest in STEM which will encourage them to be able to solve problems creatively and innovatively (Quigley *et al*., 2020). In addition, STEAM led to the astonishing innovations that the 21st century demands (Perignat & Katz-Buonincontro, 2019).

STEAM is conceptualized as a transdisciplinary teaching approach (Bertrand & Namukasa, 2020). Transdisciplinary is an approach to researching a problem, using the perspectives of various disciplines, to solve the problem, from the beginning of the discussion to drawing conclusions or solving the problem (Murnawianto *et al*., 2017). The concept of STEAM, according to Tan & Lee (2022) train students to: 1) improve technological abilities; 2) use problem-based learning; 3) conduct investigations to solve problems; 4) consider science, technology, engineering, art, and mathematics and; 5) collaborative problem-solving process. STEAM is also seen as more equitable, incorporating artistic, creative, and design skills that appeal to a diverse student population (Kant *et al*., 2017).

Component of the STEAM education guide consists of two main things including (Khikmiyah *et al*., 2021): 1) a means to interest students in solving real-life problems by designing STEAM problem-solving concepts, and 2) support the improvement of technological capabilities, namely through activities outside of school such as video production, digital drawings/sketch, visual tools, and collaboration. Moreover, STEAM simultaneously develops and shares creative solutions to problems (Herro *et al*., 2018). STEAM offers innovative and collaborative ways to reach problem solutions (Perignat & Katz-Buonincontro, 2019).

Technology in STEAM is a fun way for students to learn learning material (Wu *et al*., 2022). Student-centered teaching approaches are positively correlated with increased technology integration. The 'T' in STEAM is conceptualized as related to programming, engineering, and computer graphics (Quigley *et al*., 2020). Thus, the integration of technology in STEAM supports active and creative solutions in solving problems involving technology (Lu *et al*., 2022).

STEAM Education

Facing challenges in the global era, Indonesia needs to improve Human Resources (HR) skills in having good thinking skills competence (Kusumawati et al., 2022), to improve the quality of the student's technology skills (Parniati et al., 2021). STEAM education needs attention to be implemented in schools (Amelia & Marini, 2022). Increasing superior human resources can be maximized by incorporating STEAM characteristics without changing the curriculum itself into the national curriculum. (Murnawianto et al., 2017). STEAM has become an international concern in education to prepare superior and qualified students (Bertrand & Namukasa, 2020).

STEAM-based education builds human resources who can think critically, logically, and systematically and have global competitiveness (Bilgiler et al., 2020). In addition, STEAM education involves students in metacognitive activities (Graham, 2020). Implementing STEAM education in the classroom allows students to understand the importance of integrating various disciplines and their applications (Tan & Lee, 2022). Moreover, learners can improve their logical thinking (Lin & Tsai, 2021) and provide comprehensive opportunities for students to practice their thinking skills (Matsuura & Nakamura, 2021).

The potential of STEAM can fulfil students' learning experiences by assisting them in their ability to transfer learning (Wu et al., 2022). STEAM education has characteristics that integrate STEAM subjects into collaborative learning (Quigley et al., 2020). Moreover, student-centered inquiry to find solutions to problems (Khikmiyah et al., 2021). Students can solve the problem and make a conclusion (Atiaturrahmaniah et al., 2022) based on the principles they have learned (Azizah *et al*., 2020; Izzania *et al*., 2021). According to Sarwi *et al*. (2021), several meta-analyses show that STEAM is effective in both cognitive and affective learning.

STEAM education programs must include (Ozkan & Topsakal, 2021): 1) integration of technology into science and mathematics curricula; 2) a collaborative approach connecting students and educators with the STEAM field; 3) promoting scientific inquiry and instruction in mathematics and science; 4) provide multi-perspective and global perspective; 5) incorporate technology to improve learning outcomes; 6) incorporate strategies such as project-based learning and provide real learning experiences. STEAM is a bridge between different disciplines (Kant et al., 2017). Moreover, it offers opportunities for students to capture various fields of knowledge by learning through fragments of phenomena incorporated into one scientific discipline (Utaminingsih et al., 2023b).

The Integration of STEAM

The several functions of STEAM integration can make teachers realize that there are many ways to develop STEAM design in classroom (Jesionkowska et al., 2020), which are easily incorporated into the curriculum (Quigley et al., 2020). In addition, they realized that STEAM is a fun way to learn interdisciplinary science at the same time. In addition, it is interesting for students to learn collaboratively, and bring out creativity and critical thinking simultaneously (Chen et al., 2019). Furthermore, they learned more about teamwork, sharing, presenting, and applying (Iskariyana & Ningsih, 2021). STEAM education will enable students to explore, discover, analyze, and draw conclusions related to everyday life problems (Azizah et al., 2020). Furthermore, the interdisciplinary knowledge they have will increase their competence (Wahyuseptiana et al., 2022). Therefore, teachers can design interdisciplinary curricula, providing opportunities for students' competence growth (Yunus, 2022).

STEAM education is integrated into several patterns starting from the simplest, where STEAM is a "silo" and is taught separately, to STEAM as a transdisciplinary subject (Lu et al., 2022). The level of STEAM integration depends on many factors, including education level (Choi & Behm-Morawitz, 2017). There are three approaches that can be used in STEAM education including Silo, Embedded, and Integration (Aguilera & Ortiz-Revilla, 2021).

The Silo approach disciplines are taught separately, keeping domain knowledge within the boundaries of each discipline (Herro & Quigley, 2016). The second one is Embedded approach disciplines, which is domain knowledge from at least one discipline is placed in another context (Lin & Tsai, 2021). In the embedded approach, domain knowledge from at least one discipline is placed within another context, choosing one discipline/subject as the parent of several subjects (referring to STEAM literacy) as a shoot

embedded in the host (Herro et al., 2018). Simply put, one subject label simultaneously includes two or more subjects embedded in it (An, 2020). STEAM integration teaches various disciplines into one subject (Bertrand & Namukasa, 2023). Integration can be achieved by combining at least two disciplines, and many more (Murnawianto et al., 2017). STEAM integration into the trans-discipline subject form requires comprehensive curriculum restructuring (Chung et al., 2022). Therefore, so it is relatively difficult to apply in the conventional curriculum that has been implemented in Indonesia (Khikmiyah et al., 2021). Actually, implementing a fully integrated STEAM curriculum is easiest to achieve at the basic level. This is not because of the reasons, students at the elementary level are still taught by class teachers with a large portion (Perignat & Katz-Buonincontro, 2019).

Effect of Pedagogical STEAM Learning

Through the implementation of strategies in learning, STEAM enhances the integration of interdisciplinary knowledge (Ozkan & Topsakal, 2021) and student's project skills (Atiaturrahmaniah et al., 2022). This was stated in several research results, a questionnaire instrument on student project competence and learning motivation was implemented to assess student learning outcomes, and the results positively increased project-based skills (Amelia & Marini, 2022). In addition, the result is that the integration of STEAM can develop students' project competence and learning motivation (Baek et al., 2022).

The pedagogical STEAM model, directs teachers to design learning activities that suit students' needs (Wahyuseptiana et al., 2022) then innovates by integrating content from various disciplines into the curriculum (Jesionkowska et al., 2020). While provides fun and interesting teaching strategies that can be applied flexibly (Kant et al., 2017). Moreover, STEAM guides educators to implement appropriate teaching strategies in helping students develop problem-solving competencies through inquiry learning. (Putri & Taqiudin, 2021).

The pedagogical STEAM model is a reference for teachers implementing interdisciplinary curricula (Kartini et al., 2023) and making the learning curriculum enjoyable. However, it still follows learning outcomes (Iskariyana & Ningsih, 2021). Students' skills, competencies and learning motivation can be improved through activities such as discussions (Izzania et al., 2021), tutoring, and argumentation by integrating STEAM through digital devices or learning devices (Graham, 2020).

CONCLUSION

STEAM is conceptualized as a transdisciplinary teaching approach. Transdisciplinary is an approach to researching a problem, using the perspectives of various disciplines, to solve the problem, from the beginning of the discussion to drawing conclusions or solving the problem. STEAM led to the astonishing innovations that the 21st century demands. STEAM focuses on solving problems using social practices. STEAM-based education builds human resources who can think critically, logically, and systematically and have global competitiveness. In addition, STEAM education involves students in metacognitive activities. Moreover, learners can improve their logical thinking and provide comprehensive opportunities for students to practice their thinking skills.

There are three approaches that can be used in STEAM education including Silo, Embedded, and Integration. The Silo approach disciplines are taught separately, keeping domain knowledge within the boundaries of each discipline. Embedded approach disciplines, domain knowledge from at least one discipline is placed within another context, choosing one discipline/subject as the parent of several subjects as a shoot embedded in the host. STEAM integration teaches various disciplines into one subject. Integration can be achieved by combining at least two disciplines, even more.

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