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Original Article

Literature Review of STEM/STEAM Teaching in Vietnam

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Abstract: Vietnam didn't start incorporating STEM into its curriculum until 2012. Definitions have been offered by studies using various techniques, such as STEM/STEAM teaching material, STEM teaching strategies, and STEM/STEAM subject functions. The article examines the research challenges using theoretical research methodologies and the Zakaria & Associates (2021) literature search map. Vietnamese studies that have discussed STEM/STEAM education Research methodologies typically utilized to research "STEM/STEAM education" are: Studies have released particular information relating to STEM/STEAM education and how to utilize these results in practice. Finally, the article identified which themes are infrequently discussed in STEM/STEAM education research in Vietnam, as well as some recommendations for future research.

Keywords: STEM/STEAM education, general education, student ability, teaching & STEM/STEAM).

1. Introduction

STEM (Science, Technology, Engineering, and Mathematics) was first introduced by the US National Science Foundation (NSF) in 1998 and was officially adopted in the education in the following years. But for a period, a new acronym appeared: STEAM (“A” stands for Art) [1]. Since then, industrialized countries such the United Kingdom, the United States, Australia, and the Middle East have begun to use this strategy in teaching. STEM/STEAM is an essential educational area, particularly in today's setting of modernization and globalization. STEM/STEAM research strives to develop critical thinking abilities, problem solving, and creativity, all of which are necessary for dealing with 21st-century difficulties.

According to the National Science Foundation (2019), STEM education not only improves scientific and technical understanding, but it also contributes to long-term economic and social growth [1]. Although STEM has gotten a lot of attention, there are still many questions to be answered, notably about how STEM education is provided and how it affects students at various stages of schooling (Bybee, 2013) [2].

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In his renowned speech on "The Two Cultures", Charles Percy Snow critically addressed the relations between science and the humanities in 1959, with significant and long-lasting consequences. Since then, and especially in today's modern culture, the junction of art and science has represented a realm of endless expressions, interpretations, mediums, and outputs relating to research, technology, museums, media, and so on. STEAM is an example of the interaction of art and science (Xanthoudaki, M. 2017) [3]. In 2012, the United States Department of Education stressed the need to include Art and Design in Federal STEM programs to promote innovation and economic growth in the United States. The "STEM to STEAM" program was one of the first and continues to be one of the programs that emphasizes the necessity of incorporating Art and Design into the STEM equation. The United States Department of Education believes that Art and Design have a critical role in tackling complex and urgent concerns such as health care, urban renewal, and global warming (Shatunova, O., et al., 2019) [4].

STEM is an educational paradigm that has evolved into STEAM (STEM + Arts). Both educational approaches seek to reinvent scientific knowledge for the next generation, and by including arts, students' creativity is defined as a vital talent that requires specific attention (Aguilera & Ortiz, 2021) [5]. Many studies offer the notion of STEM as a foundation for future study in developing STEM-oriented lesson design methods. "STEM education" is defined by studies that extract principles from many ways. However, diverse interpretations of what STEM implies in reality are frequently influenced by the school system's perspective. Many people conceive of STEM as four distinct areas. Others regard STEM as combining at least two, three, or all four subjects. Researchers, on the other hand, agree that expanding the use of interdisciplinary teaching techniques would aid in the removal of obstacles to learning and growth between the four domains of science, technology, engineering, and mathematics. Although each subject has its own history, philosophy, and principles, as well as its own repertoire of knowledge, skills, and functions, many scholars (Asunda, 2014; Kelley, & Knowles, 2016) argue that combining the four disciplines under the umbrella of STEM is theoretically reasonable and valuable, because science and mathematics are frequently regarded as the foundation of applied science, including technology and engineering [6, 7]. The purpose of adopting an integrated or interdisciplinary approach to STEM is to encourage and coordinate efforts to equip students with a sound theoretical basis that allows them to offer new solutions to social and global challenges (Lamberg & Trzynadlowski, 2015) [8].

Perhaps Maeda's (2013) concept of STEAM education is the most open approach since it allows for the integration of STEM areas with other courses in the curriculum (arts, languages, history, etc.) [9]. Several researchers take up this defining line, emphasizing the benefits of incorporating the arts into the STEM acronym (STEAM), including i) Unifying convergent thinking (characteristic of STEM disciplines) and divergent thinking (habits in arts and humanities disciplines) in solving real-world problems; ii) Creating personal meaning; and iii) Self-motivation. However, STEAM education, like its precursor STEM, confronts the same issue: various interpretations for the same symbol, STEAM education. Yakman, G., and Lee, H. (2012) describe STEAM education as the interpretation of science and technology via engineering and the arts (a century of research in the humanities), all of which are mathematically oriented [10]. Miller, J., and Knezek, G. (2013) define STEAM as the interdisciplinary use of science, technology, engineering, arts, and mathematics to solve challenges in students' daily lives [11].

STEM education is being taught at many various levels, from elementary school to university, and from a very young age in developed nations like the US, Japan, South Korea, and Europe (Lin et al., 2020) [12]. These nations' schools frequently offer up-to-date curricula and facilities, and they collaborate

closely with businesses to give students chances to practice and hone their practical abilities. In many industrialized nations, STEM education frequently emphasizes students' active participation in real-world projects, problem-solving in the community, and production of useful goods. The primary teaching approach is project-based learning, where students gain critical thinking, collaboration, and creativity abilities in addition to theoretical knowledge. Otherwise, project-based learning is still not widely used in Vietnam, and STEM education is still primarily theoretical. To encourage students' enthusiasm and practical abilities, some educational institutions are experimenting with novel approaches, such as STEM Clubs, project-based learning, and creative science competitions (Nguyen et al., 2024) [13]. One of the most significant distinctions between STEM/STEAM in Vietnam and the rest of the world is that the former is backed by businesses and the community. Through financing programs, contests, and school-industry collaboration projects, organizations, businesses, and communities all play a significant role in promoting STEM education. Students can take part in scientific research, internship programs, and get guidance from professionals in the field (Nguyen et al., 2024) [14].

In Vietnam, the Prime Minister's Directive No. 16/CT-TTg of May 4, 2017 on enhancing the capacity to access the fourth industrial revolution; to support general schools in effectively implementing Science, Technology, Engineering, and Mathematics (STEM) education, the Ministry of Education and Training (MOET) provides guidance on implementing and managing STEM education activities in secondary schools. The MOET published Instruction No. 3089/BGD DT-GDTrH on integrating STEM education in secondary school, with the following objectives: i) Increasing managers' and teachers' knowledge of the position, role, and relevance of STEM education in secondary schools; ii) harmonizing the content, techniques, and forms of arranging STEM education in schools. Strengthening the use of STEM education in secondary education to help achieve the goals of the 2018 General Education Program; iii). Improving managers' and teachers' capacity to organize, manage, construct, and implement teaching and learning using the STEM education approach (MOET, 2020) [15]. Furthermore, the new general education program, which focuses on integrating disciplines to build students' potential, requires instructors to have integrated teaching capacity, including STEM/STEAM education (Giao, 2023) [16].

To far, the Vietnamese Ministry of Education and Training has sent out 55 Official Dispatches to spread, carry out, and direct the use of STEM and STEAM education in classroom instruction. These policies have a significant impact on the practical implementation of STEM/STEAM (Nguyen et al., 2019) [17]. Many schools have proactively implemented innovative pedagogical models, launched innovation clubs, science and technology competitions, and formed partnerships with organizations and industries to provide students with a rich and practical learning environment. However, numerous problems remain, including regional variations in facility availability, a lack of resources, and specialized teacher training to teach STEM/STEAM subjects. To effectively promote these policies, investment, training, and communication must be synchronized to improve community and societal understanding of the value of STEM/STEAM education in sustainable development.

The following are some examples of how STEM education is actually implemented in Vietnamese general schools: STEM club activities, competitions, creative experience activities, coordinating STEM activities between schools and private organizations, STEM events, and STEM festivals. As a result, preliminary outcomes have been obtained, establishing favorable conditions for the subsequent phase of mass and successful implementation.

Implementing general education innovation is a critical job for the Education and Training sector. Organizing STEM/STEAM educational activities aligned with the 2018 General Education Program's aims improves student ability and attributes. STEM/STEAM is a new teaching paradigm that combines a variety of courses and abilities to assist students develop in a scientific path. As a result, many educational institutions and schools have integrated STEM/STEAM into their teaching programs, providing students with a variety of engaging experiential activities. At the same time, scientists have undertaken several research on STEM/STEAM. This article examines various study findings on STEM/STEAM education to consider and recommend future avenues for relevant research.

2. Literature Review

STEM/STEAM education in Vietnam, which began in January 2016, shortly after Vietnam announced plans for National Curriculum Reform. To that purpose, the research team visited Vietnamese schools to analyze existing scientific teaching and the possibility for integrating STEM/STEAM education. The project includes intense teacher and school leader training, a research travel to the United Kingdom to learn about effective STEM/STEAM models, and extensive follow-up activities to promote the use of STEM/STEAM approaches in education (British Council, 2016) [18].

The importance of STEM and STEAM education is growing in the context of the digital revolution. This is mostly because younger generations need to be trained to adjust to the labor market's and technology's quick changes. Students that participate in STEM/STEAM education programs gain skills like data analysis, programming, and critical thinking-all of which are vital in today's industry. Additionally, using technology in the classroom-such as augmented reality (AR), virtual reality (VR), and simulation software-helps pupils become more creative and comprehend difficult ideas. The need for human resources with STEM/STEAM skills is growing as a result of the digital transformation. Students that receive STEM/STEAM education are better prepared for the jobs of the future.

2.1. STEM/STEAM Education in Vietnamese Studies

STEM education in Vietnam continues to emphasize the integrated teaching of Natural Science topics such as Mathematics, Physics, Biology, Chemistry, Technology, and Engineering. Teachers will study and develop the characteristic components of each topic to connect them with other subjects, a process known as integration, and will produce content in the direction of STEM education. This is the foundation for activities that equip instructors and students to practice and implement integrated teaching and STEM education in high schools through teaching circumstances (Dao & Ngo, 2021) [19].

STEM and STEAM are two modern educational models, both aiming to develop thinking and skills for students in the 21st century. However, they have important differences, especially in their approach and areas of focus. STEM education emphasizes the development of logical thinking, analytical skills, and problem solving through natural science subjects. The goal of STEM is to prepare students with the skills needed to succeed in high-tech fields such as engineering, computer science, and medicine. Meanwhile, STEAM expands the STEM model by adding the letter "A" representing Arts, including areas such as fine arts, music, languages and design. This addition is intended to encourage creative thinking, communication and collaboration in the learning process. STEAM not only helps students gain a deep understanding of scientific concepts but also develops soft skills such as critical thinking and creative problem solving. STEM is suitable for students who love science and engineering subjects, while STEAM expands opportunities for those with artistic inclinations, helping to comprehensively develop both logical and creative thinking. The

choice between STEM and STEAM should be based on each student's interests and learning goals.

STEM teaching studies frequently begin with the use of an active, current teaching technique, such as developing STEM education themes while teaching a specific topic to aid students in problem solving. The studies follow a typical pattern of using theoretical underpinnings of STEM education, such as the definition, features, forms, and functions of STEM, to suggest a particular approach for designing a specific STEM lesson. STEM education is based on cooperative teaching. STEM education is executed in accordance with curriculum integration theory; that is, while teaching in the direction of STEM education, instructors are free to integrate related disciplines without neglecting the core features and substance of the subject's specialized knowledge. As a result, the present research trend frequently focuses on integrating disciplines into the general education curriculum to tackle a specific problem in practice. Prominent studies focus on designing teaching processes for a STEM lesson and illustrating that lesson through Physics topics related to practice such as shipbuilding, battery experiments, wind turbines, and automatic street lights, Chemistry with topics of Chemistry in Fire Prevention and Fighting, Giaven Water Production, Mathematics associated with preserving and promoting national cultural values, and so on (Diana, 2015; LaForce et al., 2017; Savery, 2006) [20-22]. Furthermore, research on the relationship between STEM education and social science topics is scarce. Only a few social science issues are included in STEM classes, but they are nevertheless linked to natural scientific courses. To incorporate STEM instruction into disciplines such as literature, history, and geography, a specialized approach and activities such as museum visits, hands-on work, gamification or simulation, and video creation are required (Pham, Ngoc, 2019) [23]. As a result, new studies merely propose subjects and teaching methods for a single session in Literature, History, or Geography, without integrating.

In addition to integrating various topics, recent studies have directly connected the growth of STEM education to increasing high school students' abilities. The primary goal of the 2018 General Education Program is to enhance students' traits and competences, making this a key topic and purpose of STEM education. STEM competences encompass both "know-what" (subject-specific information, attitudes, and values) and "know-how" (applied knowledge, ethical values, and successful action in specific circumstances) (Tran et al., 2018) [24]. Le (2023) suggests a set of three required talents: cognitive skills, manipulation and technological abilities, and teamwork and communication skills. In addition to developing a system of skills that students must attain through STEM education, numerous research have begun to establish a self-assessment tool for general instructors' STEM competencies [25]. According to Tang, et al., (2022), the STEM competence assessment toolkit consists of four types of capabilities that were developed through testing and verification. There are 13 criteria for understanding and encouraging learners, 10 for knowledge and teaching techniques, 7 for attitudes toward teaching, and 6 for abilities in creating a learning environment [26].

Studies also recommend that teacher training in STEAM education be carried out concurrently with the design and development of teaching programs, assessment forms, and assessment tools, with the most important being teacher training and the opening of STEAM capacity training courses to improve the expertise of the teaching staff (Nguyen et al., 2021) [27]. So, what innovations and improvements does STEAM have in terms of methodologies and efficacy on students' learning outcomes when compared to STEM?

A quick assessment of STEAM research in Vietnam reveals that it is heavily centered in the disciplines of primary and preschool education. When searching for the phrase "STEAM education in Vietnam", 508 results are given

with most of the titles such as "STEAM education in organizing educational activities in preschools", "Difficulties in accessing STEAM for preschool education students", "Proposing a scale to determine factors affecting the readiness to implement STEAM education in teaching Technology of primary school teachers", "Proposing 5E process to design STEAM educational activities for preschool children".

STEAM research examines several areas of producing creative experiential activities for children in preschools and primary schools. STEAM education has been applied in several techniques to achieve the objective of holistic development for children, with a focus on promoting children's creativity through this educational method (La, et al., 2024) [28]. Many scientists have been drawn to research on STEAM education in preschool teaching, and they all feel that STEAM education for preschool children is a vital foundation for children to prepare for STEAM activities at higher levels of education. With an emphasis on STEAM in preschool education, various research have examined the existing status, features, and function of STEAM education in the current preschool education program (La, et al., 2024; Vu, 2022) [28, 29] Based on the existing scenario of implementing STEAM education in some preschools, the following research delved deeper into the method and arrangement of STEAM educational activities for children at this age. The process of using STEAM to organize educational activities in preschools is described as relying on the characteristics of the preschool education program to implement, such as integration, practicality, concentricity, and development and development according to age, according to the content of each age. These qualities are used to develop a system of planned activities that correspond to the preschool education program's contents and subjects. Furthermore, to make STEAM more effective in educating preschool children, teachers can use STEAM educational methods such as the 5E process, the 6E process, the 4C process, the process based on engineering design activities (EDP), and so on. The 5E teaching model is thought to be the best fit for preschool children (Van, 2022; Nguyen et al., 2022; Vu & Chan, 2023) [30-32].

Furthermore, the study path that is now prominent in STEAM education at the preschool level is to focus on enhancing teachers' ability to use STEAM. The findings, first and foremost, highlight the obstacles that preschool instructors have while using this pedagogical strategy. Preschool teachers frequently face challenges when implementing the STEAM method in preschool education, such as: i) Lack of practical access to educational activities in preschools; ii) Inability to participate in the implementation of preschool STEAM education activities; and iii) A lack of sufficient quality materials and facilities to study and research STEAM education. Studies also highlight and examine instructors' ability to teach STEAM at all levels, not only preschool. Tang Thi Thuy et al., (2022) advocated creating a framework to assess the STEAM abilities of general education instructors [26]. This toolkit is regarded highly comprehensive when compared to alternatives that only focus on developing teachers' ability for integrated STEM instruction (Thanh & Hong, 2023) [33]. This STEAM competence assessment toolkit is divided into four areas, each having 37 criteria defined on a scale ranging from understanding and motivating learners to attitudes and skills in creating a STEAM learning environment (Tang, T., et al., 2022) [26]. Huynh et al., (2023) conducted another study that focused on developing a STEAM educational competence framework for students studying preschool education. Based on STEAM competency frameworks for teachers in Southeast Asia and the United States, the study proposed a set of five competency frameworks that ensure professional standards for preschool teachers, such as: i) Competency 1. Competency related to moral qualities and teaching style demonstrated in organizing STEAM educational activities; ii) Competency 2. Competency related to knowledge and skills in

organizing STEAM educational activities for children; iii) Competency 3: Create STEAM educational plans for blocks and classes based on the school year; iv) Competency 4: Evaluate children's progress in participating in STEAM educational activities; and v) Competency 5: Create a safe and welcoming environment for organizing STEAM educational activities [34].

2.2. Research Methods Commonly used in Research on "STEM/STEAM Education"

Many studies are interested in modern STEM/STEAM techniques because they provide a mechanism for students to combine information from many subjects using diverse teaching methods. For example, project-based approaches to STEM/STEAM help improve students' performance in high-level cognitive tasks such as scientific processes; the potential of problem-based learning in enhancing students' attitudes and interests in STEM/STEAM and future STEM/STEAM careers; or designing experiential tasks in engineering processes are effective activities to cultivate knowledge, create intrinsic motivation and student satisfaction, and stimulate students' interest. Modern approaches when designed will help improve each learner's performance through better reflection of knowledge, having the necessary thinking and innovation to solve problems related to careers in the fields of science, engineering and technology (Luong et al., 2023; Nguyen et al., 2019; Pham & Ngoc, 2019; Savery, 2006; Tran et al., 2018) [22-24, 35, 36]. According to Nguyen, B, et al,. (2019), there are 04 common approaches in STEM/STEAM research including [36]:

- Project-based learning approach in organizing STEM/STEAM lessons: Compared with the STEM/STEAM learning process, project-based learning approach helps STEM/STEAM learning more effectively through benefits such as helping students connect thinking between fields, promoting deeper connections, fostering questioning skills and analytical thinking to solve problems.

- Problem-based learning approach in organizing STEM/STEAM lessons: The characteristic of problem-based learning is defined as teachers empowering learners to conduct their own research to develop feasible solutions to a specific problem. Many STEM/STEAM learning activities view problem solving as a way to create opportunities for students to apply knowledge in the real world, related to students' interest in future STEM/STEAM careers.

- Scientific approach in organizing STEM/STEAM lessons: In STEM/STEAM lessons, students carry out the learning process according to the steps of the scientific research process. Choosing an engineering design challenge will motivate students to create models and test them to determine possible solutions to various problems. In this process, using the scientific method will help students explore the concepts in STEM/STEAM.

- Experiential learning approach in organizing STEM/STEAM lessons: Learners perform activities as they are taught to explore the scientific knowledge framework that is made such as designing, coming up with ideas for technical processes and created such as building, using processes, tools, and technical materials to create products. Thus, the lesson is guided to develop activities that integrate Science, Technology, Engineering, and Mathematics. Performing experiential tasks requires students to work together to find new ideas, apply scientific and mathematical knowledge, test prototypes, and continuously improve products. Therefore, experiential learning is very useful for implementing STEM/STEAM learning.

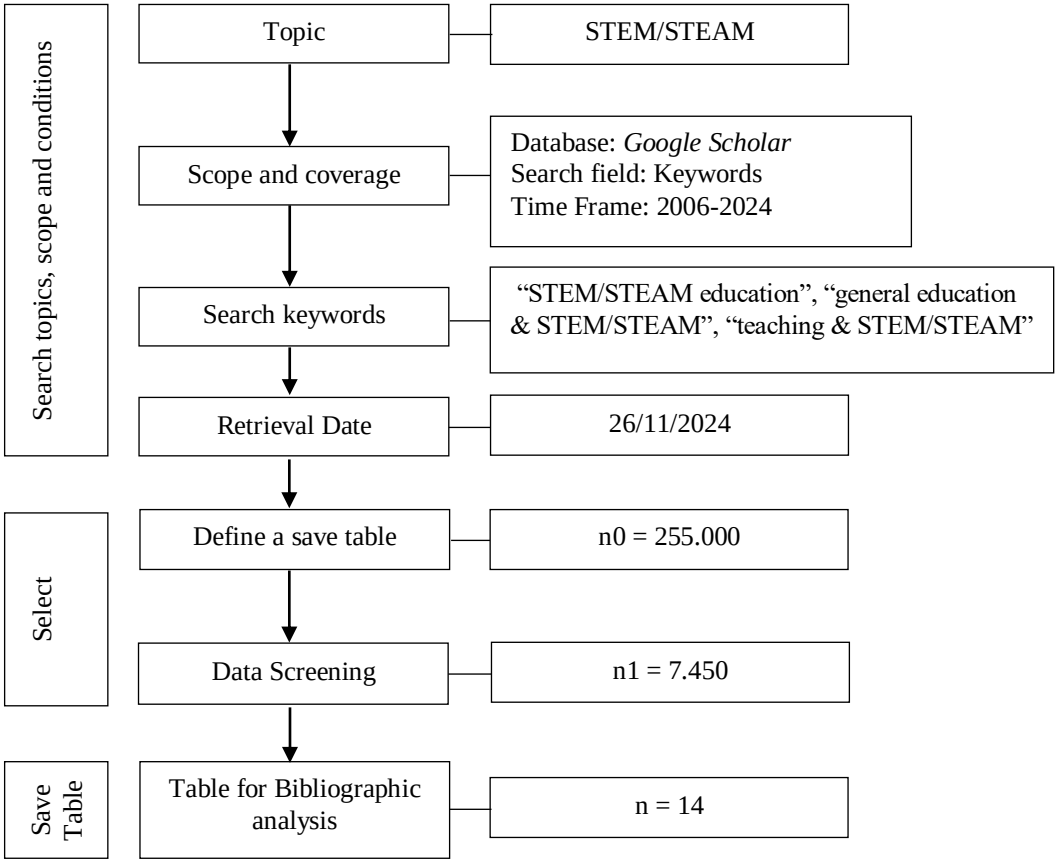
Thus, based on the above research overview, it can be seen that STEM/STEAM are being utilized effectively in Vietnam. STEM/STEAM education, according to objective research, are bringing a "wave" of continuous integrated teaching and learning, in which disciplines are merged not only to develop cognitive capacity but also to arrange activities with greater scientific, technological, and artistic characteristics. STEM or STEAM organization forms demand instructors to be always inventive in order to face the challenges

and quick invention of these two new educational systems.

3. Methods

This study aimed to aggregate a lot of papers on STEM/STEAM education methods in Vietnam from 2013 to 2024. This is the period during which Vietnam is implementing educational innovation in accordance with the Resolution of the 8th Conference of the 11th Central Executive Committee (Resolution No. 29-NQ/TW) on fundamental and comprehensive innovation of Education and Training, meeting the needs of industrialization and modernization in the context of a socialist-oriented market economy and international integration. General education textbook innovation is one of the challenges and solutions specified in Resolution No. 29-NQ/TW.

To achieve the purpose of thi s research, the author primarily uses the method of text analysis from published research works of Vietnamese authors in Vietnamese journals on Google Scholar databases, from scientific journals related to the keywords "STEM education", "STEAM education", "general education & STEM/STEAM", "teaching & STEM/STEAM". As a result, the essay will investigate the following research topics one by one: i) How have Vietnamese studies mentioned STEM/STEAM education? ii) What research methods are commonly used to research "STEM/STEAM education?" iii) What research results have been shown from these studies and how to apply these results in practice? iv) And what topics are rarely mentioned in research - some suggestions for further research?



Source: Zakaria & Associates (2021) [37].

4. Findings

Vietnam did not begin incorporating STEM/STEAM into its school programs until 2012 (MOET, 2020) [15]. Studies have presented classifications based on a variety of techniques, including STEM/STEAM teaching material, STEM/STEAM teaching practices, and the purposes of STEM/STEAM topics.

The British Council, in conjunction with the Ministry of Education and Training, launched Vietnam's first significant STEM/STEAM education study and implementation effort. The purpose of this STEM/STEAM Education Programme Study is to offer a complete overview of the early phases of STEM/STEAM.

Many studies have used these techniques to STEM/STEAM education, indicating efforts to address multiple kinds of STEM lesson organization to improve teaching and learning in general schools. However, the process of approaching STEM/STEAM education still faces many subjective and objective difficulties; therefore, the team of managers and teachers of general schools really need regular support and assistance in terms of expertise as well as diverse forms of training: organizing training classes/courses by experts, officials at all levels of education management from the Ministry, Department, and Sector directly as reporters; linking with local universities.

4.1. Synthesis of Research and Directions for Implementing These Findings in Practice

Review and analysis of 14 studies on STEM/STEAM teaching in Vietnamese schools show that there are some directions for applying research findings on teaching STEM/STEAM in school into practice, such as: i) STEM/STEAM with teacher professional development; ii) STEM/STEAM with student competences development; iii) STEM with career education for students; và iv) STEM/STEAM with creative design thinking in teachers and students.

STEM/STEAM education is studied not only to assist students solve practical issues by using information and skills, but it also helps instructors build their professional and career potential. Studies suggest that STEM/STEAM education is a successful teaching and learning strategy, particularly boosting creativity and interdisciplinary knowledge in teaching. STEM/STEAM learning themes demand teachers to have not only adequate but also substantial professional knowledge and abilities to lead students in solving difficulties within the framework of the lesson. STEM/STEAM learning themes demand teachers to have not only adequate but also substantial professional knowledge and abilities to lead students in solving difficulties within the framework of the lesson. STEM/STEAM encourages instructors to be as creative as possible when teaching. According to studies, teachers' creativity in STEM is evident in the interdisciplinary and practical teaching subjects they develop for students. Professional competence and expertise are progressively increased when teachers teach and organize STEM/STEAM-oriented programs (Table 1).

STEM/STEAM education has been described in studies as a method of assisting students in solving real-world problems through a specific course. STEM/STEAM education emphasizes the establishment and development of learners' problem-solving skills. Each STEM/STEAM-themed course presents students with a setting involving a practical problem that must be solved using scientific knowledge (Le, 2023) [25]. To tackle the problem, students must do research and study knowledge from relevant disciplines (via textbooks, learning materials, laboratory equipment, and technical equipment) and apply it to solve the problem. This information and skills must be integrated, interconnected, and complementary in order for students to not only grasp the ideas but also be able to apply and develop products in everyday life. As can be observed, the subjects covered in the preceding research are mostly concerned with solving practical challenges such as making Giaven bleach and constructing automated street lighting, among others (Table 2).

Table 1. STEM/STEAM with teacher professional development

No	Articles	Findings	Directions for implementing these findings in practice
1	D. Nguyen, H. Le, N. Le, Organizing the teaching of STEM lesson: "Horizontal throwing motion - water fountain" (Physics 10), Journal of Education, Vol. 22, No. 2, 2022, pp. 29-33 [38].	- STEM teaching methods - STEM lesson organization process - Illustration of STEM lesson organization "Horizontal throwing motion - Water fountain" in the "Mechanics" section (Physics 10)	- Manufacturing and testing water jet bridge model.
2	L. Nguyen, Y. Vu, T. Duong, A. Nong, Teacher competencies that need to be fostered to successfully implement STEM-oriented teaching and learning: a case study in Thai Nguyen province, Journal of Education, Vol. 23. No. 6, 2023, pp. 51-57 [39].	- STEM Education - Proposing a teaching competency structure in the direction of STEM education	- 09 competencies needed when teaching in STEM orientation
3	V. Nguyen, H. Bui, Proposing short-term training content for STEM teachers at general education level in Vietnam, Journal of Education, Vol. 22, No. 20, 2023, pp. 36-41 [40].	- Concepts and methods of implementing STEM education. - STEM education policies in some countries around the world. - Some STEM teacher training programs in the world. - Current status of implementing STEM education in Vietnam	Proposed short-term training content for STEM teachers at secondary level in Vietnam: 2-phase curriculum framework with a total of 125 hours.
4	D. Nguyen, A. Doan, Early childhood education students' assessment of learning difficulties to develop STEAM educational awareness, Journal of Science, Vol. 20, No. 1, 2023, pp. 45-52 [33].	- Present the difficulties in approaching STEAM education in their learning process. - Demonstrate the difficulties of students in many aspects from approaching theory to practicing STEAM education at school to directly demonstrating STEAM teaching in kindergarten and training conditions.	- Assess the difficulties in accessing STEAM education of students majoring in Early Childhood Education. - Propose some solutions to solve the difficulties.
5	T. Tang, T. Ha, A. Doan, T. Phung, Developing a self-assessment tool for STEAM competency of general teachers, Vol. 18, No. 3, 2022, pp. 132-144 [26].	- Some tools to assess teacher competence in the world - Assessment tools - Scale verification	- Develop an assessment tool based on an overview of domestic and foreign research.

Table 2. STEM/ STEAM with student competences development

No	Articles	Findings	Directions for implementing these findings in practice
4	N. Quach, A. Nguyen, D. Nguyen, Designing STEM topics in teaching the part "Thermal Science" - Physics 10 towards fostering problem-solving skills for students, Journal of Science, Dong Thap University, Vol. 41, 2019, pp. 19 - 25 [41].	- Problem-solving ability. - Problem-solving ability of students in teaching Physics. - STEM education - The process of designing STEM education topics in teaching Physics to foster students' problem-solving ability. - Designing STEM topics in teaching the "Thermal" section in the direction of fostering problem-solving ability for students. - Applying interdisciplinary knowledge including Science, Technology, Engineering and Mathematics - Developing criteria for assessing students' problem-solving ability in teaching Physics	- Candle production - Project to manufacture a machine to filter dirty water into clean water.
5	M. Nguyen, C. Nguyen, Developing self-study capacity for high school students through teaching the topic "Giaven water production" according to the STEM education model, Vietnam Journal of Educational Sciences, Vol. 18, No. 10, 2022, pp. 27-32 [42].	- STEM education model-Concepts and criteria for assessing self-study capacity - Teaching process of STEM topics in Chemistry teaching - Organizing teaching of STEM topic "Giaven water production" to develop self-study capacity for students	-Javen production
6	T. Luong, A. Nguyen, H. Tran, Building the STEM topic “Automatic street lights” for high school students, Journal of Science and Technology Hoa Binh University, Vol. 9, 2023, pp. 74-79 [35].	- Traffic light topic - Analysis of the knowledge content of the topic corresponding to the general education program	-Design and automatic control of street lights using photoresistors

7	T. Trinh, N. Bui, V. Nguyen, Organizing STEM educational activities in teaching Mathematics in high schools associated with protecting and promoting national cultural values, Journal of Education, Vol. 23, No. 12, 2023, pp. 5-11 [43].	- Some orientations for organizing teaching science subjects according to STEM lessons in the 2018 General Education Program - An example of organizing STEM educational activities in teaching Math in grade 12 high school on the topic "Making models of stilt houses of Vietnamese ethnic groups"	-Design of traditional stilt house model
8	L. Nguyen, Organizing STEM teaching on the topic "Soundproof House" - Natural Science 7, Journal of Science and Technology, Thai Nguyen University, Vol. 227, No. 9, 2022, pp. 482-489 [44].	- STEM education - Natural exploration capacity - Current status of teaching according to STEM education in high schools - Designing a lesson plan on the topic "Soundproof House" in teaching natural science subject 7 - Designing a criteria table to assess students' natural exploration capacity	- House weight ≤ 2 kg, Height ≤ 40 cm; -The house model is creatively designed to facilitate the survey of soundproofing materials; - Select the best soundproofing materials (foam, wood, cardboard,...). Determining good soundproofing materials through software used to measure noise (through measuring sound intensity levels) is available and free on Google Play and App Store
9	T. Van, STEAM education in organizing educational activities in preschools to meet the requirements of educational innovation, Journal of Education, Vol. 22, No. 11, 2022, pp. 1-6 [30].	- The nature of STEM/STEAM education - Organizing educational activities in preschools - The suitability of STEAM education in organizing educational activities in preschools	- Proposing the process of applying STEAM in organizing educational activities in preschools and the process of designing STEAM lessons in organizing educational activities
10	L. Nguyen, H. Dao, Applying the STEAM model in organizing educational activities in preschools, Journal of Education, Vol. 22, No. 13, 2022, pp. 1-6 [31].	- Teaching STEAM in preschool education - Advantages of the STEAM model for preschool children - Process of organizing educational activities according to the STEAM model for preschool children	Present how to apply the STEAM model in organizing educational activities in preschools.

The direction of putting the findings of STEM/STEAM lessons into practice through student-created and produced goods with the goal of enhancing their skills and talents. According to the General Education Program, STEM/STEAM classes are generally focused on natural scientific issues, therefore a wide range of disciplines are integrated. The researchers concentrate on connecting themes and learning assignments for students to real-

world challenges such as creating materials for agriculture and daily living, manufacturing power and water for daily use, and so on. The guidelines for putting STEM/STEAM teachings into practice go beyond manufacturing goods; the main goal is to increase students' skills and talents. The writers aim for a range of skills, with each STEM/STEAM lesson subject focusing on establishing and growing 2-3 distinct talents for students, as well as providing chances and places for students to be exposed to, practice, and complete learning challenges.

Table 3. STEM with career education for students

No	Articles	Findings	Directions for implementing these findings in practice
11	M. Thai, D. Truong, H. Nguyen, N. Nguyen, Designing STEM teaching topics integrating career education for students in teaching the topic "Chemistry in fire prevention and fighting", Journal of Science, Ho Chi Minh City University of Education, Vol. 20, Vol. 8, 2023, pp. 1324-1336 [45].	- STEM education and career education. - Principles and process of building STEM topics integrated with career education. - Process of building STEM topics integrated with career education - Introducing the topic "Gas masks"	- Design of gas mask

STEM/STEAM education research covers ideas, traits, and the process of developing a STEM/STEAM-themed curriculum (LawNet Education, 2023) [46]. These materials serve as the foundation for developing and organizing STEM-oriented lessons. Some studies also highlight the link between STEM/STEAM education and other critical aspects such as student competences, career education, and theme knowledge material in the general education curriculum. Clarifying these linkages with STEM/STEAM education is crucial to improve STEM application in a range of learning and research activities.

Some writers have also created teaching themes based on STEM/STEAM lessons and offered extensive directions for how to execute and deploy a specific lesson. STEM/STEAM classes must focus on real social, economic, and environmental challenges and challenge students to identify effective answers. STEM lesson content is associated with the relatively complete solution of a problem, in which students are organized to participate in learning actively, proactively, and know how to apply the knowledge they have just learned to solve the problem, thereby contributing to the formation of qualities and competencies for students (MOET, 2020) [15].

Table 4. STEM/STEAM with creative design thinking in teachers and students

No	Articles	Findings	Directions for implementing these findings in practice
12	L. Do, Q. Bui, N. Nguyen, D. Bui, Design thinking in environmental protection education through STEM activities, Journal of Vietnam Educational Sciences, Vol. 44, No. 8, 2021, pp.1- 6 [47].	- STEM and environmental education - Some environmental education programs through STEM activities - Concepts and procedures in Design Thinking - Examples of teachers implementing the topic of environmental education through STEM activities according to Design Thinking	- Propose implementation steps in developing environmental protection projects according to the Design Thinking approach.

13	N. Nguyen, T. Ta, STEAM education and the potential of applying design thinking process to implement STEAM education, Journal of Science, Ho Chi Minh City University of Education, Vol. 18, No. 2, 2021, pp. 310-320 [48]	- STEAM education - Forms of expressing liberal arts elements in STEAM education - Teaching process to develop design thinking in STEAM education - Design thinking - Potential to apply teaching process to develop design thinking in STEAM education	- Analyze 4 great potentials in applying design thinking process to implement STEAM education.
14	A. Vu, H. Tran, Proposing a process of designing steam educational activities for pre-school children by 5E model, TNU Journal of Science and Technology, Vol, 228, No. 12, 2023, pp. 38-45 [32].	- The nature of STEAM education - The role of STEAM education for preschool children - The 5E model	- Proposing the process of applying the 5E model to designing STEAM educational activities for preschool children

Some studies have examined the criteria for measuring students' skills during the teaching and learning process using STEM/STEAM themes. The criteria are based on the principles of ensuring teaching objectives, knowledge acquisition, a scientific approach to research methods, pedagogical competence, student relevance, practical topics that are linked to real-world problems, diversity, and ensuring students have experience solving real-world problems. From then, the research suggest that teachers create their own set of criteria before leading and structuring STEM education for students to ensure optimal efficacy in measuring skills and lesson quality.

In summary, contemporary STEM/STEAM education research focuses on how to explain the procedures required to adopt a STEM/STEAM educational subject using existing methods and ideas. The implementation phases end at the description level, with no particular instructions of great generality and a strong emphasis on specialized STEM/STEAM teaching formats. A fundamental step in STEM/STEAM education includes: Problem statement - Solution suggestion - Plan development. - Implementing ideas - Testing and assessment. The writers focus on developing lessons on specific topics using an extended process, moving from description to process.

3.2. Pilot Implementation of STEM Education at the Primary Level

In accordance with Plan No. 526/KH-BGDĐT dated May 17, 2022, on the implementation of STEM education at the primary level, the Ministry of Education and Training (MOET) has initiated a pilot STEM education program in seven provinces. In each province/city, the pilot is implemented in five districts [48]. Within each district/town, two specific primary schools have been selected for the pilot, as detailed in the following Table 5.

The pilot implementation includes the following key activities: i) Raising awareness about STEM education at the primary level; ii) Developing training materials for the pilot implementation of STEM education; iii) Training and professional development for teachers and staff; iv) Enhancing infrastructure and teaching equipment; v) Organizing professional workshops, seminars, and training on STEM education; and vi) Encouraging the involvement of parents and social organizations. With unified direction and guidance from the central to local levels, along with the proactive and enthusiastic participation of school administrators and teachers in the selected primary schools, the pilot STEM education program has been implemented in a structured and effective manner. The program has achieved positive outcomes with significant

impact. STEM education has initially fostered and developed essential competencies and qualities in students, contributing to the effective implementation of the 2018 General Education Program.

Through STEM education at the primary level, students have had the opportunity to showcase and develop their abilities and qualities. The program has enhanced creativity, logical thinking, and problem-solving skills while providing diverse knowledge and improving soft skills such as critical thinking, teamwork, and communication. These improvements have contributed to enhancing teaching quality and successfully realizing the goals of the 2018 General Education Program.

Table 5. Scale of Pilot Implementation in Seven Provinces/Cities Representing Key Socio-Economic Regions Nationwide

No	Provinces/ Cities	Number of primary schools participating in the pilot	Number of students participating in the pilot	Number of teachers participating in the pilot	Number of STEM education teaching hours pilot is deployed	Number of times of professional activities at all levels	Number of teachers trained in STEM education
1	Lao Cai	10	8.637	337	866	90	425
2	Hanoi	10	7.504	264	260	56	590
3	Nam Dinh	10	7.264	289	265	59	482
4	Thua Thien – Hue	10	2.368	300	158	72	300
5	Dak Lak	10	6548	338	204	68	418
6	Can Tho	10	11.210	323	722	129	406
7	Dong Thap	10	9.333	340	631	115	929
	Total	**70**	**52.864**	**2.191**	**3.106**	**589**	**3.550**

However, alongside these advantages, the pilot implementation of STEM education has revealed some challenges and limitations, including: i) STEM education is a relatively new approach, and as the pilot is still in its early stages, opportunities for schools to share experiences and learn from each other remain limited; ii) Infrastructure and teaching resources for STEM education at the primary level are still insufficient, posing significant challenges; (iii)There is a lack of official materials and resources for training and implementing STEM education at the primary level (Moet, 2023) [49].

4. Suggestions for Further Research

According to the summary table above, the primary research direction on STEM/STEAM in Vietnam currently is mostly content-oriented. Authors focus on understanding issues related to subjects in order to tackle real challenges. In addition, a few writers investigate the link between STEM education and the development of student competences. Research on competences has mostly focused on establishing a general competency evaluation framework for students. A review of STEM/STEAM concerns in Vietnam has found that STEM/STEAM plays an essential role in developing competences and attributes in the direction of active teaching, hence enhancing students' autonomy and problem-solving skills. STEM/STEAM concerns are primarily concerned with building teacher competence and student capabilities. Furthermore, STEM/STEAM education in Vietnam often

focuses on other parts of education, such as career education or encouraging creative design thinking in instructors and students.

In comparison to other studies, Vietnamese authors continue to lack in-depth study on how to efficiently and precisely apply and arrange STEM/STEAM instruction. STEM/STEAM encompasses a diverse range of organizational structures, techniques, and associated elements. In poor nations, most instructors are aware of STEM/STEAM but do not know how to incorporate it into the learning process. STEM/STEAM is more than just using subjects to address practical issues; it is also about incorporating practice into studying topics to assist students develop full knowledge and abilities for synthesizing and thoroughly. As a result, teachers' comprehension of STEM/STEAM is critical in its implementation (Li, & Wong, 2020) [50]. One issue that instructors must address in order to have a thorough grasp and know how to construct a STEM-oriented class is the lack of effective STEM teaching regulations in high schools. For example, in the United States, there have been several studies on state regulations to increase teachers' ability to incorporate STEM/STEAM in the classroom. The authors have emphasized that the United States has policies in place to eliminate traditional content-oriented teaching methods; the federal government requires schools to incorporate STEM/STEAM practices or classes that guide students to actively solve their own practical problems based on the day's lesson topics (Johnson, 2012) [51]. Furthermore, research have revealed that previous efforts to establish reform policies in science and mathematics education were directed by STEM/STEAM education. In many situations, instructors have challenges while implementing STEM/STEAM education in the classroom due to a lack of facilities and learning resources. The reform plan, known as Project 2061 of the United States (Shirley, 2009), proposes how to apply STEM/STEAM education within the framework, with the assistance of the American Association for the Advancement of Science [52].

Another emerging issue in the globe that Vietnamese scholars seldom address is the topic of ethics in STEM/STEAM courses. Subject discipline in STEM/STEAM is a relatively new topic in Vietnam, tackled from an entirely new perspective. According to this new study path, STEM/STEAM has a strong connection to discipline and professional ethics (Tekerek et al., 2016) [53]. Nowadays, ethics is a significant topic in a variety of professional and social domains, including business, academia, and healthcare. It influences not just today's society, but also its history and future (Smith et al., 2015) [54]. As a result, individuals' ethical and moral reasoning skills in STEM/STEAM courses must be socially reinforced. Students tackling complicated issues using moral reasoning abilities has recently been identified as an international study area. Applicants' moral reasoning is critical to their performance. According to Dalton and Crosby (2011), persons who desire to further their careers in higher education face comparable difficulties [55]. Individuals' societal duty is enhanced by the moral reasoning abilities required at the university level. At the same time, it will assist them in overcoming ethical issues encountered while carrying out their professional duties. The growing cultural and societal significance of STEM fields complicates ethical issues. This circumstance emphasizes the relevance of individuals' ethical thinking abilities. According to Titus, et al., (2011), while engineers seek to prioritize safety in terms of professional ethics, the amount to which this is achieved is controversial and is dependent on their individual efforts and talents [56].

Furthermore, several studies in Vietnam highlight the usefulness and significance of STEM/STEAM in increasing students' abilities and results. However, research seldom focuses on how to engage and encourage students in STEM/STEAM classes. There are several STEM/STEAM programs in the United States aimed at high school students (14-18 years old). The most noteworthy examples are in Massachusetts, North Carolina, Ohio, and

Texas. The Texas effort focuses on changing schools into communities that involve teachers and students in STEM/STEAM, with the ultimate objective of enhancing high school and college preparedness (Kennedy & Odell, 2014) [57]. Researchers throughout the world have found that the variables that encourage kids to engage in STEM/STEAM lesson activities include: being produced using grade-appropriate materials and including hands-on, reflective, and collaborative learning methodologies; Addressing student outcomes while reflecting the most recent knowledge and understanding of STEM/STEAM sectors; Creating chances to link STEM/STEAM instructors and their students to the larger STEM/STEAM community and workforce; Providing students with multidisciplinary, intercultural, and multidimensional viewpoints to highlight how STEM/STEAM transcends national boundaries and provides them with a global perspective. Using relevant technologies such as modeling, simulation, and remote learning to improve the STEM/STEAM educational learning experience and inquiry; Presented via both formal and informal learning situations.

STEM/STEAM education is expanding to include Social Sciences, History, and Geography. These topics teach students about cultural values and heritage conservation practices. Some studies integrate History and Geography with other subjects such as Civic Education and Political Education, using learning projects to develop a new teaching process known as STEAM, to assist students in solving practical problems related to UNESCO's 17 sustainable development goals. The tendency of incorporating sustainable development challenges into education through STEAM education is one of the emerging, highly successful, and unavoidable developments in educational research.

Based on the foregoing, it is clear that contemporary STEM/STEAM research in Vietnam continues to follow the old path, namely, teaching topics to offer issues that must be answered in reality. As a result, we suggest a more comprehensive and novel strategy to study that will give multidimensional and rich perspectives on STEM/STEAM education. Connecting STEM/STEAM education to new issues and focusing in-depth on its constituent elements such as STEM/STEAM policies for teachers and students, the relationship between STEM/STEAM teaching and issues of professional development and professional ethics, and methods to attract and promote student participation in STEM/STEAM in an enjoyable and effective manner. New research directions that can be developed from the above studies can be derived from the program's science, engineering, and technology subjects, but with new, current trending topics such as AI from an ethical and responsible perspective, space exploration, biotechnology revolutionizing healthcare, climate science and earth observation, and 5G and beyond: Connecting development

5. Conclusion

According to a review of research, the present trend in STEM/STEAM education in Vietnam continues to emphasize the integrated teaching of Natural Science topics such as Mathematics, Physics, Biology, Chemistry, Technology, and Engineering. These studies begin by using an active teaching strategy, such as constructing a lesson on a specific STEM/STEAM topic to help students in problem solving.

STEM/STEAM education has become a prominent focus among researchers as it serves as a method to help students combine knowledge from various scientific disciplines. In Vietnam, there are four prevalent methods in STEM/STEAM research, which are Project-based learning, Problem-based learning, Experiential learning, and Scientific Research Methodology.

The findings of the research indicate several specific related topics, including: professional development for teachers in STEM/STEAM; capacity building for students in STEM/STEAM; career education for students

linked to STEM/STEAM; and the incorporation of creative design thinking in both teachers and students within the context of STEM/STEAM.

Overall, STEM/STEAM education in Vietnam faces certain challenges, including a routine approach to teaching and the use of traditional, uninspiring topics that fail to engage students or highlight their interests. To enhance domestic research, it is essential for authors to adopt a broader perspective on STEM/STEAM, directing their research toward more open-ended questions and connecting STEM/STEAM with other disciplines and professions. As a result, STEM/STEAM education in Vietnam will align with global STEM/STEAM trends, evolving through methods that address real-world issues to stay current with advancements in science, technology, and education specifically.

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