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STEM Education in Secondary Schools: Teachers' Perspective towards Sustainable Development

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Abstract: Young people are the future of society and agents for social change, and so it is crucial to provide education that not only equips them with knowledge and skills but also changes their attitudes and behavior towards sustainable development. This study provides a review on how pedagogical approaches in science, technology, engineering, and mathematics (STEM) education can be deployed to teach concepts of sustainability. It also shows how secondary school teachers perceived STEM education and how they applied integrated STEM disciplines in designing projects to address development issues in Vietnam. Seventy-seven STEM teaching projects of teachers across the country were analysed, and interviews were conducted with 635 teachers who participated in the STEM program. Teachers valued STEM education and were willing to apply constructivist pedagogical methods to help solve the real-world problems. It is hoped that an integrated STEM approach can transform education into an innovative and inclusive education for social equity and sustainable development.

Keywords: real-world contexts; constructivist pedagogical methods; STEM teaching projects; sustainability; SDGs; Vietnam

1. Introduction

Humans are the key actors of most contemporary global and regional environmental changes. The changes, such as technological innovation, environmental disasters, climate change, and pandemics, have enormous impacts on present and future human well-being and socioeconomic stability. Human–environment interaction and the connection between elements in bio-physical, technical, and human systems are complex and dynamic, which creates challenges for humans to navigate a safe operating space for development. This opens a space for education—a key sector for preparing the young generation with the knowledge and skills to address present and future socio-economic and environmental challenges, such as global climate change, digitalization and globalization. As the world is connected, dynamic and complex, with global challenges, young people should experience a school education that reflects the reality of these challenges. As education can enhance people's lives and contribute to sustainable development, the need for education that supports a more sustainable world has become more evident [1]. Sustainable development is defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" [2] (p. 43). The goal of sustainable development is to integrate economic development with environmental concerns and social integrity, sharing fairly the costs and benefits to contribute to the well-being of the current generation without compromising the needs of the next generation [3].

Society expects the young generation to deal with these development challenges. In this context, education is the engine behind the development of the young generation. There has been growing international attention and recognition of the role of education in sustainable development. Innovative education empowers people to change their ways of thinking and work towards a sustainable society. The United Nations (UN) has launched several initiatives to promote the role of education in sustainable development, such as the UNESCO Global Action Programme on Education for Sustainable Development and the UN Decade for Education for Sustainable Development (2005–2014). The UN's 4th Sustainable Development Goal (SDG) was set with a specific focus on education for sustainable development [4]. Education is an important means of achieving the SDGs. Educational policies play a key role in the effective implementation of education for sustainable development and influence the development of curricula, teacher training, learning materials, and learning environments [1]. Every SDG requires education to empower people with the knowledge, abilities, skills and values to develop themselves and contribute to society. In this context, STEM (science, technology, engineering, and mathematics) education appears to be essential in preparing the young generation to address the challenges facing society.

STEM education is an innovative approach to education [5,6] and features extensively within the global landscape of educational policy and reforms. STEM education represents a multidisciplinary approach that combines the four disciplines of science, technology, engineering and mathematics [7]. This approach not only addresses the aims of policy reforms, such as ensuring competency in mathematics and science, but it also emphasises that it is no longer sufficient for modern citizens to understand science and mathematics; their knowledge must be integrated with technology and engineering [7]. STEM education uses a "learner-centred" approach to develop learners' self-direction, problem solving, collaboration and project management [8]. It also drives innovation through creating, designing and producing solutions to real-world problems [9] and uses real-world challenges as entry points for the integration of STEM disciplines [10].

Through literature review and a case study of STEM education in Vietnam, this study examined how sustainable development concepts and practices can be integrated into the pedagogical principles of STEM education and to discuss how an integrated STEM approach in secondary education could promote the role of education in sustainable development. This paper begins with a literature review on pedagogical approaches in STEM education and their relevance to "sustainable development" education. It is followed by a case study of the STEM education program in Vietnam in which we illustrate what the secondary school teachers perceive STEM education and how they use integrated STEM disciplines in designing projects to address development challenges.

2. Literature Review

The literature review focused on giving a summary of the knowledge base of STEM education principles and discussion on how these teaching approaches are relevant to teaching the concept of sustainability in the secondary schools. The integrative or critical review approach was applied to critique and synthesize the literature [11] on STEM teaching methods and their relevance to real-world contexts of sustainable development. Since this integrative or critical review approach does not require researchers to follow a specific standard of data analysis [12], we performed the review and interpretation through our conceptual thinking [13] to critically review the STEM education, its pedagogical approaches and their relevance to "sustainable development" education.

2.1. STEM Education Principles and "Sustainable Development" Education

STEM Education

STEM education is defined as an interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering and mathematics in contexts that make connections between school, community, work and the global

enterprise enabling the development of STEM literacy and with it the ability to compete in the new economy [14]. Although many definitions of STEM education have been proposed [15], it is commonly agreed in both theory and practice that STEM education refers to the integration of the four disciplines (science, technology, engineering and mathematics) in various ways and levels [16]. STEM education emphasises the importance of making connections between academic knowledge and real-world problems as a foundation for integrating S-T-E-M subjects in teaching [10]. With the integration of S-T-E-M disciplines, STEM education can offer high-quality science and technology education and the relevant knowledge to understand scientific, technical and cultural interrelations [15]. It also provides students with important digital competences [17] and soft skills, such as problem solving, creativeness and critical thinking, that are essential for the workforce to sustain a country's economic growth [18].

There have been increasing demands for future citizens to be literate in STEM subjects and to have knowledge of socio–scientific–technical interrelations and their application in addressing real-world problems. Modern citizens must be able to employ the science and technology knowledge that they learn in school to deal with development challenges, including environmental pollution, unpredictable climate phenomena, the exhaustion of natural resources such as water and energy, and social and political conflict. As well as preparing students with STEM competencies, STEM education improves students' abilities to innovate—an increasingly important skill for openly embracing change and responsibly shaping the future. With these soft skills, modern citizens are able to follow sustainable lifestyles; promote human rights, gender equality and a culture of peace and non-violence; appreciate cultural diversity; and trigger culture's contribution to sustainable development.

Due to its interdisciplinary nature, STEM education is seen as both a curricular and a pedagogical approach [10]. In terms of curriculum, STEM education refers to the interdisciplinary framework, whereas pedagogical approaches centre around instructional practices such as enquiry through representations, problem solving and reasoning, challenge-based learning, design-based approaches and digital technologies. Many studies have shown that the following key principles are necessary for integrated STEM education in secondary schools to address sustainability: the integration of STEM content; enquiry based on the real world; and problem-centred, design-based, and cooperative learning approaches [19,20]. Hence, the interdisciplinary and real-world problem-based works are engaged in STEM pedagogical practices and curriculum and material designing [21–23].

Many instructional practices in STEM education are congruent with the underlying real-world problems and concepts of sustainability. It is widely agreed that the SDGs are a global responsibility, but their achievement requires local action. Due to their complexity, most of the SDGs require a multidisciplinary and interdisciplinary approach, and so the UN has been promoting education projects involving STEM education to achieve the SDGs (sustainabledevelopment.un.org). An integrated STEM approach is a promising framework for sustainable development education.

2.2. STEM Pedagogical Principles and "Sustainable Development" Education

2.2.1. Integration of STEM Disciplines

A principle of STEM education is the application of knowledge and practices from multiple STEM disciplines to learn about or solve problems in the real world. STEM education was first introduced in the US to "raise mathematics and science achievement, improve economic competitiveness, increase job prospects for future generation workers, and support greater opportunities for low-income and minority students" [24]. STEM literacy and skills are essential to address sustainability. An important question is how education's contribution to sustainability will shape our future. The local and global challenges today cannot be solved within a single discipline. With comprehensive knowledge of STEM disciplines, however, schools will produce a young generation with the multidisciplinary expertise and, with the support of technology, the skills to examine the complexity of real-world challenges and to determine integrated solutions.

Through the integration of STEM disciplines with the support of technology and mathematics, all science disciplines can teach and discuss sustainable development in their fields, which enhances students' awareness of their roles in the achievement of the SDGs. For example, by exploring agro-ecological systems, biology education, combined with other science disciplines such as chemistry and physics, can contribute to achieving the 1st, 2nd, 14th and 15th SDGs. Similarly, chemistry education can contribute to achieving the 3rd, 6th, 12th, 14th and 15th SDGs by improving students' knowledge of physio-chemical properties and their impact on the environment and human health.

Furthermore, while there is much demand in the global jobs market for people with the multidisciplinary expertise to address the problems of a complex, connected and dynamic world. Global youth unemployment and living in poverty is because the current labour markets need people with new skills. Basic skills are not adequate. Soft skills, analytical skills as well as knowledge of science, technology, engineering and mathematics are required for more dynamic and complex jobs. If school education can prepare young people with multidisciplinary expertise, this could facilitate the employment pathway of youth in the future. Improving the skills of young people can improve their employment prospects and improve the quality of their lives and well-being [25]. The UN states that STEM education "can remove poverty and reduce inequality in developing countries". Science and technology is a key element in economic and social development. STEM education will also encourage and recognise women who are making strides in the STEM arena and help to balance the employment rate of men and women.

2.2.2. Real-World Context-Based Inquiry

Educational approaches based on real-world contexts help students see the relevance of science to their daily lives and enhance their interest and enjoyment in addressing the real-life situations around them [26–28]. Real-world context-based teaching and learning assumes that everyday situations that are familiar to learners can be enquired into and that STEM concepts relevant to these problems can be explored and deployed to explain the situations [27,29]. Some studies, such as George and Lubben [27], Gutwill-Wise [30] and King and Henderson [31], have shown that students' interest in science increases through teaching approaches that are based on real-world situations. Students can make connections between the real-life context and the concepts they are taught, and they are more interested in learning if they see how what they are taught in schools relates to what they do in their daily lives. This kind of learning and reasoning will change students' behaviour towards their environment.

It is well known that human activities have an enormous negative impact on our planet [32,33]. There has been increasing international concern about people's ecological behaviour towards protecting and preventing from global environmental degradation threats [34,35]. STEM education is an indispensable tool in addressing environmental problems [36,37]. Through teaching approaches based on the real world, STEM education can influence students' internal representations and understanding of the real world, and ultimately transform students' attitudes towards environmental protection.

2.2.3. Problem-Based Learning Approach

The problem-based learning approach is another essential instructional practice in integrated STEM education [19]. Problem-based learning is a constructivist pedagogical approach in which students learn about science and develop their skills in critical thinking, problem solving and collaboration by solving real-world problems [38]. The core principles of problem-based learning emerged from cognitivist constructivism [39] and social constructivism [40]. This approach is premised on the theory that students' abilities are developed through social learning [41]. Through working together in a small group and being coached by teachers, students identify problems, formulate hypotheses, collect data, perform experiments, develop solutions and choose the solutions that best "fit" the problems. The problem-based learning approach encourages students to use and

build on their knowledge and to work collaboratively in self-organizing small groups to make sense of new information, to solve complex problems, and to produce a solution [42].

The global socio-environment is becoming more complex and uncertain and is continuously evolving because of climate and environmental changes and global volatility. Furthermore, the development and increasing use of digital technology are transforming people's daily lives and societies. It is challenging to identify the kinds of jobs that will exist in the future and the expertise they will require. Thus, education must be adjusted to accommodate and equip students with the necessary skills, qualifications and flexibility to fill future jobs.

The problem-based learning approach enhances students' capacity for thinking and reasoning about problems and integrating previously assimilated knowledge and experience into a life-long learning process. This approach refers to instructional "scaffolding" which plans learning steps. Learning built on prior knowledge and skills and developed through the pathway for new knowledge to be acquired and applied to practice has proved to be effective in STEM education [43]. Through the problem-based learning approach, students' skills including reasoning, critical thinking, application of theory to practice, communication, reflection and teamwork are developed.

2.2.4. Design-Based Learning Approach

An important part of STEM education is the engineering design process, in which scientific enquiry, artistic design, construction engineering, mathematical reasoning, and technology are used to solve real-world problems [44]. Design-based learning, in which problems are solved using design assignments, is a form of problem-based learning in which students are given hands-on experience of real-world problems [45,46]. It is an inductive teaching approach built and grounded in the enquiry and reasoning processes leading to the generation of innovative artefacts, systems and solutions [47]. This approach is centred on students' experience of designing a product or object, through which they develop their scientific understanding and problem-solving skills [48]. Design-based learning is considered a promising instructional method to enhance students' learning of and interest in science [49], and it is commonly applied in teaching science and design skills [45,48] and to engage secondary school students in engineering design tasks [47,50].

In terms of sustainability, the key competencies of a modern citizen include systems thinking, interpersonal competence, interdisciplinary study, the embracing of diversity, strategic action and management competence [51]. Design-based learning, as a form of project-based learning, offers students with creativity and innovative mind-set for sustainability practices. Many studies have shown the relationship between sustainability education and transformative learning [52,53]. A multidisciplinary approach is a core element in design thinking, and, due to the complexity of the SDGs, design thinking is essential in addressing and achieving them. A design-based learning approach begins by defining a problem from a real-world context and involves developing optimal solutions for social challenges, contributing to the achievement of the SDGs [54].

2.2.5. Cooperative-Learning Approach

The cooperative-learning approach is another constructivist pedagogical method that involves students working in small groups to help one another learn. The aim of STEM education is to equip students with a broad mix of skills and interdisciplinary knowledge. Cooperative learning plays an essential role in helping to develop, spread and sustain the role of education in society. It has been shown to be an effective instructional method that provides a wide variety of outcomes and academic achievements of students [55].

The positive effects of cooperative learning include motivational aspects, such as the motivation to self-learn and to encourage and help groupmates to learn; social cohesion, as the goal of group leaning is to ensure that all the members of the group learn; and cognitive development, as the students' interaction with one another to complete specific tasks results in their mastery of critical concepts [56,57]. Cooperative learning builds students' collaborative skills and teamwork—important skills in

the 21st century, as they are essential for addressing the complexity of present and future socio-economic challenges [58]. By building collaborative skills in school, students will develop positive attitudes and behaviour outside school to work together for the sustainable development of their community and their country. The collaborative attitudes and behaviour of citizens will greatly contribute to the achievement of SDGs such as poverty reduction, peace and equity, conservation, sustainable consumption and production, social responsibility for development and democracy.

3. The Case Study

The Second Secondary Education Sector Development Program II (SESDPII) (sesdp2.edu.vn) in Vietnam was selected as a case study to give insights on how secondary school teachers perceive STEM education and how they develop their STEM teaching projects in practice. Within the case study, we collected and analysed data on what secondary school teachers perceived STEM education and how they applied integrated STEM disciplines in designing projects to address development issues.

3.1. Vietnam and National STEM Education Program in Vietnam

Vietnam is a lower-middle-income country. It is experiencing rapid demographic and social change, including rural out-migration and an ageing rural population. Industrialization, rapid economic growth, and a population boom have not been friendly to the environment and natural resources, causing challenges for the management of waste and pollution. Moreover, according to the Intergovernmental Panel on Climate Change, Vietnam is among the most vulnerable nations to climate change. The country suffers from sea level rises, typhoons, landslides, flooding and droughts, and other weather events.

Vietnam ranked highly in the Program for International Student Assessment (PISA) in 2012 and 2015, in which the performance of the Vietnamese students exceeded that of many OECD countries. Although Vietnam performs good on general education in terms of both education coverage and the level of learning, the teacher-centred approach and teachers' absolute rely on text books are common in most public and private schools. This approach prevents students from gaining the maximum benefit from contextualised lessons. Thus, the questions arise, however: how can the educational system in Vietnam develop students' academic and professional competences and ultimately contribute to the achievement of quality education for sustainable development?

Through the Second Secondary Education Sector Development Program II (SESDPII) funded by the Asian Development Bank, the Ministry of Education and Training has integrated STEM education into secondary schools. The objectives of the STEM education established by the SESDPII are (i) to enhance students' comprehensive education; (ii) to improve students' STEM literacy; (iii) to develop students' soft and academic skills, such as problem solving, creativity, critical thinking, argumentation, intellectual curiosity and collaboration; (iv) to connect schools to communities; (v) to guide students' career development; and (vi) to prepare for Industry 4.0.

The ultimate goal of the program is to promote the teaching of science integrated with math, engineering and technology. The program established an STEM research team at the national level whose members are from pedagogical universities in both northern and southern Vietnam. The results of the team's experiments on interdisciplinary teamwork, collaborative ideas and innovative approaches to teaching integrated STEM are available for all high school teachers in the country. The program provides school managers, educational policy-makers and implementers with professional training in STEM concepts, integration frameworks, pedagogical approaches for both lower and upper secondary schools and STEM education's role in development. Members of the STEM research team provide the training, and lecturers from several pedagogical universities in different regions of the country are invited as observers. The program encourages teachers to collaborate with their colleagues to develop their STEM teaching projects/topics and start experimenting with STEM teaching in their schools.

3.2. Data Collection and Analysis

Using SESDPII as the case study, we examined which teaching topics and pedagogical methods the teachers who participated in the STEM program of SESDPII have used to develop their STEM teaching lessons or projects and assessed their understanding of STEM education and their perception of STEM education's role in addressing development challenges. Two steps of investigation have been made:

(i) Step 1: Face-to-face interviews with secondary school teachers

Face-to-face interviews were conducted with 635 teachers who participated in the four professional training sessions organised by the SESDPII in 2019 in the Highlands, Central and Northern regions of Vietnam. The interview was conducted in Vietnamese.

The interview was composed of two parts:

(1) Interviewers' understanding and perception of STEM education.
(2) Interviewers' perspectives of STEM education towards sustainable development.

In order to avoid influencing of an interviewee's response to another's as the interviews were conducted during the breaktime of the professional trainings, interviewed teachers were asked to write on a piece of paper how they defined STEM education and list the development challenges in Vietnam that they wanted to address through their STEM teaching projects/topics.

Content analysis was used as the main research tool to the interview transcripts. We firstly determined concepts about STEM education and real-world development topics, teachers wished to integrated into STEM teaching, expressed in written by teachers during the interviews. Thus, the presences of these themes and concepts were quantified.

(ii) Step 2: Analysis of STEM teaching projects of secondary school teachers

Before selecting participants for professional trainings of the SESDPII, secondary school teachers across Vietnam were called to submit their STEM teaching project proposals. They were encouraged to collaborate with their colleagues to develop their project ideas and start experimenting with STEM teaching in their schools. Seventy-seven STEM teaching projects across the country (15 provinces) were submitted to the SESDPII.

We fully accessed the database of these seventy-seven STEM teaching projects. Using content analysis, seventy-seven documents were read several times to get sense of the projects' contents and structures. We then divided these project documents into several sections: premises, objectives, class procedure/steps and learning outcomes. The main focus of the analysis was to see within each project (i) what was the entry argument of the project, (ii) what was the main teaching topic, (iii) which subjects and how many were integrated to design the lecture, and (iv) which pedagogical methods were used. Existing terms in the literature of STEM education and sustainable development were used to label information according to their significance in our research objective.

3.3. Findings

3.3.1. Sociodemographics of Interviewed Teachers

Overall, 211 teachers participated in the SESDPII professional trainings in the North, 244 in the Central region and 180 in the Highlands were interviewed, providing a total interview number of 635 (Table 1). There was a significant difference in the number of male and female teachers that participated in the interviews among the three locations ($\chi 2 = 10.41$, df = 2, $p < 0.01$): more female teachers in the North (53.08%) and the Highlands (58.33%) participated in the interviews than in the Central region (43.03%).

Table 1. Sample demographics and comparisons among interviewees of three locations (North, Central and Highlands).

	Total	Nothern		Central		Highland		Statistic	df	*p*-Value
No. of interviews (n)	635	211		244		180				
Gender (n,%)										
Male		99	46.92%	139	56.97%	75	41.67%	χ^2 = 10.41	2	0.005
Female		112	53.08%	105	43.03%	105	58.33%			
Teachers' degree (n,%)										
Bachelor		141	66.82%	151	61.89%	124	68.89%	χ^2 = 0.49	2	0.78
Master		70	33.18%	68	27.87%	53	29.44%			
School level (n,%)										
Lower secondary		85	40.28%	101	41.39%	59	32.78%	χ^2 = 10.90	4	0.028
Upper secondary		120	56.87%	128	52.46%	103	57.22%			
Combined		6	2.84%	15	6.15%	18	10.00%			
School type (n,%)										
Regular		190	90.05%	222	90.98%	71	39.44%	χ^2 = 242.55	4	<0.001
Gifted		14	6.64%	10	4.10%	4	2.22%			
Boarding		7	3.32%	12	4.92%	105	58.33%			
Teaching subject (n,%)										
Math		41	19.43%	47	19.26%	30	16.67%	χ^2 = 31.85	12	0.001
Physics		35	16.59%	47	19.26%	44	24.44%			
Chemistry		37	17.54%	33	13.52%	28	15.56%			
Biology		34	16.11%	40	16.39%	26	14.44%			
Technical Design		23	10.90%	16	6.56%	5	2.78%			
Informatics		30	14.22%	33	13.52%	15	8.33%			
More than 1 subject		11	5.21%	25	10.25%	32	17.78%			

There was no difference in the number of interviewed teachers holding a bachelor's and master's degree among three locations ($\chi2 = 0.49$, df = 4, $p = 0.78$). However, the significant difference was found in the numbers of interviewed teachers from different school types ($\chi2 = 242.55$, df = 4, $p < 0.01$). The majority interviewed teachers were more likely to come from regular schools in the North (90.05%) and the Central (90.98%) region, while a large number of interviewed teachers in the Highlands were from boarding schools (58.33%). This can be explained by the fact that many boarding schools in the highlands have been established in the last decade under the Vietnamese policy on strengthening education development in ethnic minority communities and mountainous regions. There was also a difference in the proportion of interviewed teachers from different teaching subjects ($\chi2 = 31.85$, df = 12, $p < 0.01$). Math and science (i.e., physics, biology and chemistry) teachers participated more than technical design and informatics teachers, as math and science are the core subjects in the secondary schools.

3.3.2. Teacher's Perceptions of STEM Education

Through the interviews, we explored how the teachers perceived STEM education and what development challenges in Vietnam they wanted to use in their STEM projects. They were asked to write on a piece of paper how they defined STEM education and list the development challenges in Vietnam that they wanted to address through their STEM teaching projects.

Table 2 presents the teachers' perceptions of STEM education. The results reveal that the teachers hold positive perceptions of STEM education. Most considered STEM education to be an integrated learning approach that uses real-world problems to enhance students' competency in science and their soft skills.

Table 2. Teachers' definitions of science, technology, engineering, and mathematics (STEM) education, coded and grouped (N = 635).

No.	Teachers' Perceptions of STEM Education	% Respondent
1	STEM education is an interdisciplinary learning approach in which students learn and apply STEM knowledge to solve real-world problems and through which their interest in learning science is enhanced	36.9% (234/635)
2	STEM education encourages students to apply STEM knowledge in problem-solving, thus helping them develop the competency in science and soft skills to solve real-world problems.	26.0% (165/635)
3	STEM education encourages students to participate in the enquiry and reasoning processes leading to the generation of a product or object	10.6% (67/635)
4	STEM education is simply an interdisciplinary teaching approach.	7.4% (47/635)
5	STEM education encourages students to use prior knowledge and search for new knowledge	6.3% (40/635)
6	STEM education helps students develop their soft skills and competencies.	5.0% (32/635)
7	STEM education is a new, effective and positive learning and teaching method.	4.7% (30/635)
8	STEM education encourages the application of engineering processes and the scientific method in secondary schools.	3.1% (20/635)

3.3.3. Teacher's Perspective on Development Issues to Be Addressed through STEM Education

Figure 1 shows how the teachers responded when asked to list the development challenges in Vietnam that they wanted to address through their STEM teaching. More than 80% of the teachers preferred to use the topic of environmental pollution in their projects, to enhance students' environmental knowledge, to increase how much they value environmental protection and to improve their knowledge of the tools and methods to monitor and evaluate the environment. The second most common development topic was sustainable consumption and production. The teachers were interested in applying STEM teaching methods such as design-based learning to promote more sustainable daily use objects. The third-ranked issue was recycled materials. Renewable water and energy and sustainable agriculture and food production are also among the teachers' preferred topics. The teachers viewed STEM education as an innovative teaching approach that enhances their roles and the importance of secondary education in addressing the current development challenges of the country, which contributes to the achievement of the SDGs.

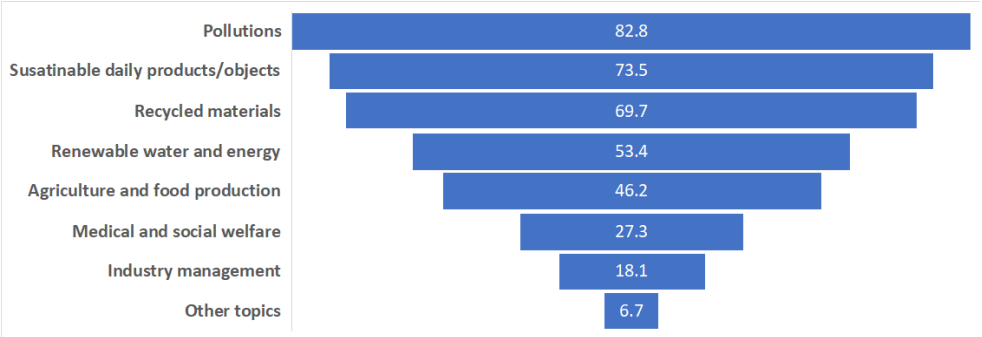

Figure 1. Teachers' preferences for development topics to be used in their STEM education projects (% respondents) (N = 635).

3.3.4. Teachers' STEM Teaching Projects on Socio-Economic and Environmental Challenges

The seventy-seven teaching projects were submitted by both upper (43%) and lower (57%) secondary schools. Most projects came from schools in big cities like Ho Chi Minh (16 projects), Hanoi (11 projects), Kien Giang and Can Tho (11 and 7 projects). However, there were few projects from remote and minority ethnic schools in the mountainous north such as Lai Chau, Tuyen Quang and central highlands in Lam Dong and Daklak provinces. These STEM teaching projects were led by 56% female and 44% male teachers in collaboration with her/his interdisciplinary teams for emerging collaborative ideas and methods to enhance students' science knowledge and application of theories to solve the problems around them. 45% projects were designed by full integration of four STEM disciplines: the combination of Physics—Informatics—Technical Design—Math (41%) and Physics—Biology—Informatics—Technical Design—Math (4%). Other 44% were the combination of three STEM disciplines, Biology, or Chemistry, or Geography with Informatics and Math (a few with Technical Design). The only 10% were the integration of two STEM disciplines.

Most of the projects used the combined inquiry and design-based learning (49%), combined problem and collaborative-based learning (22%), combined inquiry and experiment-based learning (20%) and real-world inquiry-based learning (9%) approaches. These constructivist and solution-based approaches help students in building their creativity and innovative mind-sets, which is essential for addressing current and future development challenges. Details of STEM teaching projects are found in Table S1 in the Supplementary Material.

In addition, Figure 2 shows the development themes were used by the teachers to develop their STEM teaching projects. Although no suggestions were given to the teachers about the types of topics for their projects, most of the projects were related to the SDGs that have a local impact as well as global relevance, such as sustainable consumption and production, water availability and quality, sustainability of energy, and sustainable agriculture and food production. For instance, 31% projects were designed to teach students to create simple sustainable daily life use objects or products, recycling materials and waste management. In total, 30% of projects focused on food safety and food security, water treatment and saving and renewable energy. These projects were also designed to teach health protection and education (10%) and flood prediction, drought mitigation and agri-environmental protection (8%). In short, the majority of projects (83%) were used real-world issues and phenomena such as the premise of the lecture objective, whereas only 17% of projects were purely scientific experiment and inquiry.

Figure 2. Distribution of STEM teaching topics of examined secondary school teachers to Secondary Education Sector Development Program II (SESDPII) (N = 77).

4. Discussion

4.1. Connecting Teaching to Real-World Context

The teachers who participated in the case study showed their interest and willingness to connect their teaching with real-world context through STEM projects. They seemed to believe that STEM education can be deployed to solve development issues. This finding is in accord with Steiner and Posch [59] that STEM education can be used to teach sustainable development concepts and practices in secondary schools by breaking out of the existing conventional teaching structures and processes that mainly rely on textbooks. Sustainable development is a complex concept that is not easy to teach in secondary schools, as different subjects and contents must be integrated into a class, and the class should be connected to real-world context and communities.

The above results also demonstrated that teachers were sensitive to the development issues surrounding them. Sustainable water, food and energy, as well as sustainable consumption and production are among the most common topics the teachers integrated into their STEM projects and/or they wished to teach within their STEM lectures. Indeed, in the last decades, Vietnam has experienced threats to its energy security [60], vulnerability of its water resources [61], and ground water contamination. It is a country that is particularly vulnerable to climate change, given its extensive coastline and river deltas and its vulnerability to typhoons and floods [62].

A challenge facing many secondary schools is the disconnection between the school and the community. The teachers in this study seemed to want to connect the teaching of science with real-world context through STEM education. Through the problem-based learning approach, teachers can bridge community-based knowledge and school-based knowledge, providing intellectual and meaningful science learning through practical experience. Bouillion and Gomez [63] conducted a case study of teachers who adopted an interdisciplinary approach to teaching science, mathematics, language, arts, and civics by having their students identify pollution problems in a river. Their study confirmed that such contextual scaffolding to connect science with the community can create bridging opportunities between community-based and school-based knowledge.

4.2. Nurturing Secondary School Students as Agents of Social Change

Our findings also show that interviewed teachers positively perceived and understood STEM education. Most of the examined STEM teaching projects are the integration of three or four S-T-E-M subjects and the application of constructivist teaching methods and the topics were around the development issues. The integrated STEM thinking facilitated teachers to design their STEM projects aiming at challenges of development with the sense of enthusiasm, viewing the development problems through the eyes of someone actually facing it. Teachers applied systems thinking in designing their projects. They used a problem identified from the local context and developed the optimal solution by applying the STEM pedagogical principles.

With this STEM approach, teachers seemed to break up the traditional didactic triangle—teacher, student, content—in which teachers indoctrinate passive students. The teacher-centered and textbook-based approach is common in most public and private schools in Vietnam, but it prevents students from gaining the maximum benefit from contextualised lessons [29].

These STEM contemporary constructivist pedagogical methods might help to reform education in secondary schools, encouraging students to take part in science and technology competitions, assume agentive positions in reconfiguring their own individual and collective futures and contributing to sustainable development [64]. These approaches promote "learning by doing" through lessons based on real life that allow experimentation, enabling students to make mistakes and learn from them. The integrated STEM approach also improves students' motivation to address real-world problems as they learn, "touch" and experiment with the real-world problems through the learning process.

According to Hoff and Hickling-Hudson [65], many international non-governmental organisations have promoted the teaching of sustainable development in adult education (e.g., environmental education and social justice education). The challenge of sustainable development, however, is complex and systemic and requires different ways of thinking, receptivity to new ideas, and the ability to navigate direction for innovation and transformation. Achieving sustainable development through education is a long-term process that requires the transformation of the young generation's thinking and actions. Motivated teachers with STEM teaching skills and digital competences [17,66] can enable students to meet the challenges of tomorrow. Teachers communicate important knowledge to students so that they not only understand the problems but also think about possible solutions as foundations for social change.

Since STEM education helps enhance students' knowledge and skills and change their attitudes towards real-world problems, teaching integrated STEM in secondary schools provides a great opportunity to promote more transformative social change through equal access to STEM education. However, although teachers from 15 provinces across the country were interested in developing STEM teaching projects, the number of teachers from rural and minority ethnic schools in remote provinces that participated is still low. This can be explained by the fact that the existing thinking around STEM education is that it involves a large investment in technology and is thus often only for wealthy private schools, gifted public schools, and students who are naturally oriented towards science. Thus, STEM education has become commercialised and dominated by private high-tech companies and schools in the large cities of Vietnam. The partnership between expensive private education and foreign high-tech companies and organisations has created inequality between the urban and the rural, the rich and the poor, and the ethnic majority and ethnic minorities.

STEM education should be inclusive and available to every student. This appeals more investment and expansion of STEM education in these less developing provinces. By integrating the STEM disciplines, using constructivist pedagogical methods, connecting to a real-world context and making use of technology, teachers and students in these disadvantaged areas are able to catch up with their peers in the big cities.

5. Conclusions

This study provides meaningful insights into how pedagogical approaches in STEM education can be deployed to teach science in the context of sustainable development. Interviewed teachers were interested in using STEM teaching to address the real-world development issues, such as pollution, sustainable consumption and production, and energy and water conservation. Most STEM teaching projects developed by the teachers integrated from three to four S-T-E-M subjects and applied contemporary constructivist pedagogical methods, such as problem-based learning, design-based learning and cooperative-based learning, which emphasise a student-centered teaching approach. To engage students in the STEM learning environment, this approach focuses on various principles, such as students' independent enquiry, lesson plans, material searching, lesson processes, communitive interactions among students, group working, and student–teacher relationships. This implies that training should be provided to secondary school teachers to enhance their knowledge and application of contemporary constructivist pedagogical approaches to promote students' self-direction, collaboration and problem-solving ability. Teachers must be qualified and skilled, however, so that, through their lessons, students develop their critical and creative thinking and STEM literacy. Importantly, teachers must be capable of driving students to apply and contextualise their learning and to innovate through designing, creating and producing solutions to real-world problems.

In conclusion, inclusive STEM education could contribute to the achievement of SDG4—equitable and quality education for sustainable development and sustainable lifestyles and social equity. It should have received more attention, however, within sustainable development agendas at national and international levels. The implementation of inclusive STEM education requires innovation and change in pedagogical approach, curriculum development, methods of student assessment, school management structure and teacher-support initiatives. It also requires more investment facilities, infrastructure and technology for schools in remote areas, for ethnic minorities, for poor students and for areas of social conflict. It is hoped that, in this way, education in Vietnam can be positively transformed and contribute to the achievement of SDG4. Inclusive, equitable and quality secondary education is for the development of global citizenship and cultural diversity and culture's contribution to sustainable development.

Supplementary Materials: The following are available online at http://www.mdpi.com/2071-1050/12/21/8865/s1, Table S1: List of 77 STEM teaching projects.

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