

# STEM Education in Sustainability: A Brief Literature Review (2019 - 2023)

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**Abstract:** During the half past of a decade, STEM education has been adapted worldwide as an effective way to promote leaners and teachers' application of knowledge regarding the interdisciplinary on their own filed. Meanwhile, the learning about sustainability concept has been increasing focus within educational activities in schools. This study aims to provide an overview of implementation of STEM education with sustainability concept in school level during 2019 to 2023. Based on a systematic process to retrieved from SCOPUS database, 44 research articles were analyzed. The coding scheme to examine the papers including learning strategies, research issues, and research method. The findings of this study could shed the light on the provision for educators and future research on STEM education in sustainability studies.

**Keywords:** Research trend, STEM, sustainable development, school, systematic review

## 1. Introduction

In the 21<sup>st</sup> century, STEM education has been recognized by teacher and educator around the world. For education, it became the central focus of many countries' national curriculums in order to fulfill the goal of building and preserving success through the development of their human capital into productive workers. Meanwhile, there are diverse perspectives about the disciplinarity of STEM and STEM education (Erduran, 2020; Tytler, 2020). Despite being at its early stages, the area of STEM education has shown significant expansion in the last decade. Focusing on the development of STEM education, it has been supported by various factors. For example, Li et al. (2022) report that research funding and the growth of research publications are the keys to develop STEM education research. As STEM education evolves and gains significance across the world, its integration with sustainable practices becomes essential. Incorporating sustainability into STEM education not only corresponds with worldwide educational reforms, but it also educates the next generation to tackle and enhance critical environmental concerns.

There is an increasing focus on addressing sustainability concerns within educational activities in schools, with the aim of promoting Education for Sustainable Development (ESD) (Leicht et al., 2018). This recognition has led to calls for educational reforms that consideration of the challenges in science education, particularly in terms of preparing students for the future society (Schulz, 2009; Van Laar et al., 2017). The incorporation of STEM Education with sustainable development has become a significant educational framework within the context of science teaching in schools (Pitt, 2009). As a result, educators can put more of their focus on helping students develop a broad understanding of STEM so that they can effectively contribute as well scientific knowledge citizens in the society (Christenson, Chang Rundgren, & Zeidler, 2014). There are a variety of article categories among high-impact research publications, including empirical studies, research review, and theoretical discussion papers. Review articles and conceptual/theoretical discussion papers are viewed as an assistance

and valuable because they synthesis of the existing studies on a particular topic and/or provide new perspectives and directions.

Typically, Review articles provide the purpose of offering a comprehensive summary of the existing research within a specific field or on a particular topic. They play a crucial role in enabling readers to obtain a broad understanding of a subject matter, including its important aspects and relevant publications (Palmatier, Houston, & Hulland, 2018). Therefore, this study aims to gain insight about research development in STEM education in sustainability, we thus decided to focus on empirical research regarding to the field. Moreover, systematic examining and reviewing those studies were utilized which provide a better comprehension to the emerging trend in terms of research issues, methods, and learning strategies.

## 2. Research Methodology

### 2.1 Data Collection

This research examined papers from the SCOPUS database from 2019 to 2023 on 12 July 2023. The searching was for the publications whose article title, abstract, or keywords met the logical condition. There were 146 papers were found by using ("STEM" or "STEAM" or "science, technology, engineering, and mathematics" or "Science Learning") AND ("Sustainability" or "circular economy" or "green economy" or "bio economy") AND ("school" or "k-12") (n = 146). By limiting the search to social science and article and journal and english, there were 77 papers. By remove papers which were not research article and not school level, a total of 44 papers met the condition (see Figure 1).

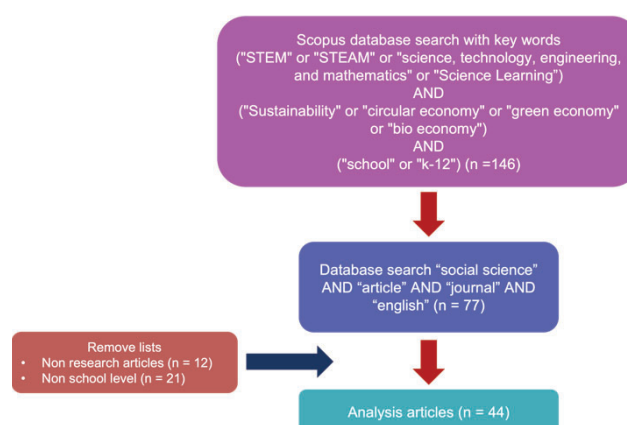


Figure 1. Data Collection Procedure.

After gathering data, two experienced researchers then read and divided the papers based on the coding scheme, if any incompatibility between the coding process was found, the researchers need to discuss until agreement was reached.

### 2.2 Data Distribution

Figure 2 demonstrates the situation of STEM education in the field of sustainability context papers from 2019 to 2023. It was found that the research issues have paid more attention in this field since 2019. There were 2, 12, 10, 10, and 10 papers published in each year, indicating that the researchers started to focus on this research issue increasingly. Moreover, since 2021 to 2023, it indicated that there is remaining focus to this research context.

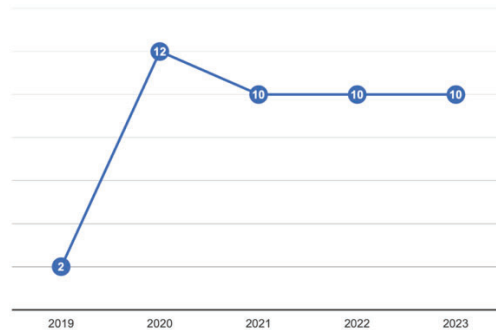


Figure 2. STEM Education in Sustainability Published in 2019 to 2023

### 2.3 Coding Scheme

This study used a coding scheme to analyze information from the published papers which obtained from SCOPUS database, including basic information from the paper (i.e., nationalities, journals, and authors), learning strategies, research methodology, and research issue. The following items describe the coding schemes:

- Nationalities, authors, and journals: The standard information of those published papers is discussed, including nationalities, and journals. The purposes to comprehend which countries have more frequently published papers about STEM Education in the field of sustainability.
- Learning strategies: This study classified the learning strategies into 16 categories that is, learning program, training workshop, case study, project-based learning, citizen science, place-based learning, combination of approaches, exhibition, experiential learning, game interaction, guided learning, inquiry-based engineering learning, online learning, science camp, and thinking-based STEM learning.
- Research methods: The classified research methodology based on the 3 common research design presented by (Creswell, 2014), including mixed method, quantitative methods, qualitative method, and others (i.e., system development).
- Research issue: The research issues were investigated among the 44 papers related to STEM education in sustainability, including cognitive domain, affective domain, and psychomotor domain.

## 3. Results

### 3.1 Journals

This study examined the distribution of the published journals, as presented in Figure 4. It was found that many studies were published in Sustainability (65%), followed by the International Journal of Technology and Design Education (18%), Frontiers in Education (12%), and the others various journal (4%). The sustainability is an open access which welcomes research papers that discuss the challenge related to sustainability. Apart from Sustainability, the other journals also focus on the application of STEM Education in learning environments, and investigate meaningful educational settings.

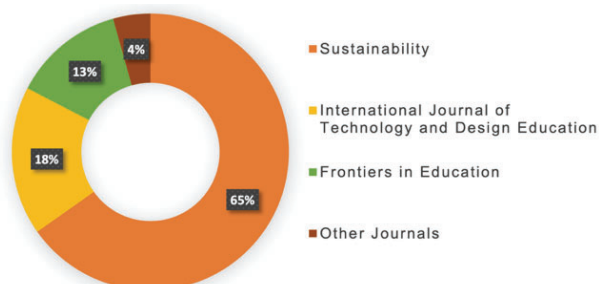


Figure 4. Distribution of Published Journals

### 3.2 Learning Strategies

The learning strategies among the 44 papers which applied in STEM education from 2019 to 2023 were analyzed as shown in Figure 6. The results illustrated that there are 12 papers not mentioned about learning strategy. However, the second greatest is learning program (n = 7), followed by training workshop (n = 5). It can be found that the most explicitly learning strategy which the research designed to emphasize participant's learning on sustainability within STEM education context are learning program and training workshop. For example, Schultz and Delaney (2021) developed chemistry outreach activities related to the periodic table and sustainability in order to increase learner's perception toward chemistry with circular economy.

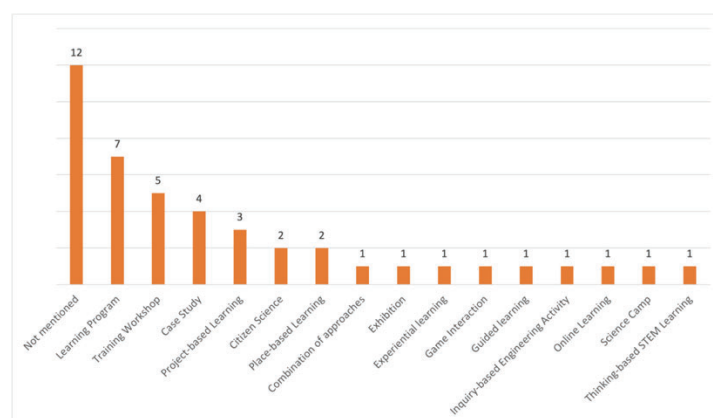


Figure 6. Distribution of Learning Strategy Mentioned Among the Published Papers

### 3.3 Research Issues

Among the selected papers, the research issues in terms of cognitive, affect, and psychomotor domain of each publication were analyzed as shown in Figure 7 and Figure 8. According to the participants who were recruited in the 44 selected papers are students and teachers, this study divided into 2 group of research issues based on the participants. Figure 7 was presented the result of frequency of the issue for student as the participant. It revealed that the most popular issue regarding affective domain including, interest (n = 4) and attitude (n = 4), followed by perception (n = 3), motivation (n = 3), and environmental awareness (n = 3) as shown in Figure 7 (A). Moreover, Figure 7 (B) represented the research issues on cognitive domain including science knowledge (n = 5), learning performance (n = 2), and the understanding of nature of science (n = 1), respectively. Meanwhile in psychomotor domain, the result illustrated that learning behavior (n = 3) was the greatest number of research issues in this domain, following by creativity (n = 2).

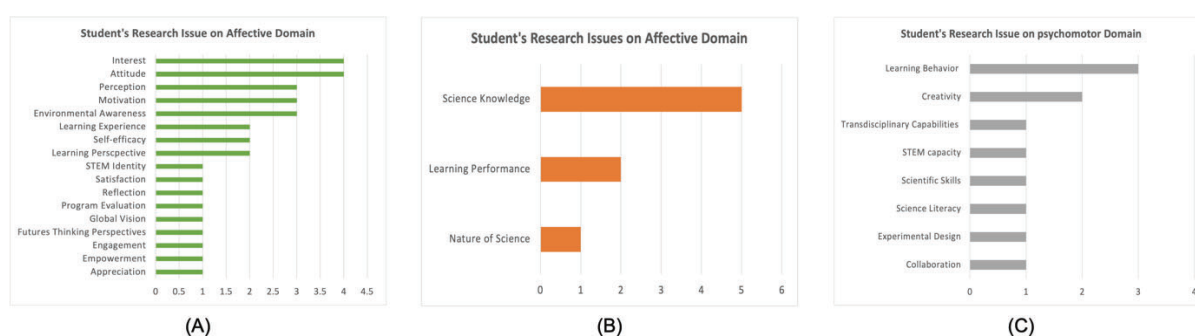


Figure 7. Distribution of Student's Research Issues within STEM Education in Sustainability

In addition, the analysis results shown that the most frequency research issue on teacher in terms of STEM education in sustainability is attitude (n = 4). Moreover, figure 8 illustrated that the following issues including Interest (n = 3), Perspective (n = 3), Motivation (n = 2), teaching confidence (n = 2), and teaching experience (n = 2).

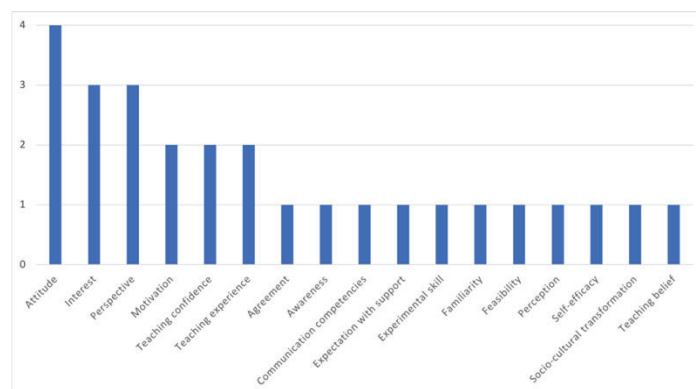


Figure 8. Distribution of Teacher's Research Issues within STEM Education in Sustainability

### 3.4 Research Methodology

Figure 9 shows the most often utilized research methodologies among the 44 publications selected. In STEM education in sustainability, qualitative research (n=20, 48%) was the most commonly employed research, with interviews or discussions used to obtain data for analysis. A quarter of the research (n=11, 26%) employed mixed methods, which combined quantitative and qualitative methodologies. Similarly, the quantitative method (n=10, 24%) obtained data mostly through questionnaires. A relatively small number of the studies (2%) studied the design and development of the system on STEM education in sustainability.

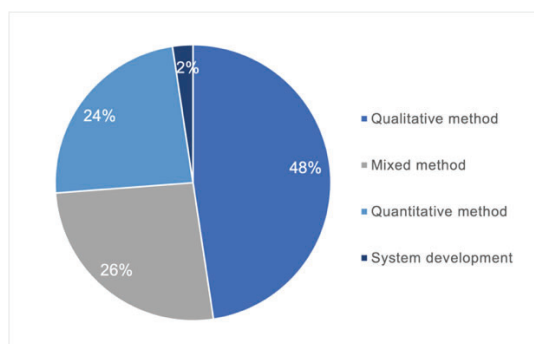


Figure 9. Distribution of Research Methodology

## 4. Conclusion and Discussion

This study analyzed the publications of STEM education in sustainability in the SCOPUS database to determine the most important or influential keywords, authors, countries, hot topics, learning strategies, and research methodology. The results showed that the number of papers was constantly increasing since 2019, indicating that more research on the field was published with the focusing of sustainability. In addition, the findings also revealed that the most published journal among the samples was Sustainability (65%). This might be due to the aims and scopes of the journal related to the aims or subject area in the articles. In addition, learning strategies' result shown that learning program is the most strategies to conduct research among the published articles. This suggested that the researchers concentrated on learning programs when STEM education in sustainability concept was implemented, using qualitative method (48%) which illustrated the shifting of research method reported by Li et al. (2022), that quantitative methods were used as the dominant approach from 2005 to 2019 among the high impact empirical studies in STEM education. In terms of research issues, it was categorized into two types based on the participant among the publications. The research issues on students revealed that science knowledge, interest, and learning behavior were the most study issue regarding to cognitive, affective, and psychomotor domain respectively. For

teachers, the most focusing issues was attitude, interest, perspective, motivation, teaching confidence, and teaching experience. This implied that investigating and enhancing teacher's teaching competency in STEM education in sustainability remain a challenging and important issue. Nevertheless, it is crucial to acknowledge several limitations when interpreting the aforementioned conclusions. The search terms employed, the journals chosen, and the publication dates utilized in this study may have unintentionally ignored other relevant literature and may not fully capture the entirety of research trends.

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