New Challenges of Teaching Materials in STEM-related ESD/SDG Activities in Taiwan

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Author Note

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Abstract

Taiwan has actively taken actions to support the aim of UNESCO's ESD (Education for Sustainable Development) for 2030 as well as SDGs (Sustainable Development Goals), and has to face and solve some emerging challenges that come with progress. This paper firstly introduces the status of STEM-related ESD/SDG Activities, and identifies the following five new challenges in teaching materials for STEM-related ESD/SDG activities: (1) Teachers are not familiar enough with teaching materials in non-specialized fields in cross-field STEM-related ESD/SDG activities; (2) Teachers need to spend too much time transforming ready-made social resources; (3) The ability of primary and secondary school teachers and students to use international teaching materials is often limited due to their language skills; (4) Lack of a comprehensive platform for exchange and sharing of teaching materials; and (5) The COVID-19 pandemic caused emergency remote teaching which suffered from limited quality online teaching materials.

Keywords: Education for Sustainable Development (ESD), Sustainable Development Goals (SDGs), teaching materials, STEM education

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Introduction

The United Nations Educational, Scientific and Cultural Organization (UNESCO) promotes Education for Sustainable Development (ESD) to equip learners of all ages with the knowledge, skills, values and agency to address interconnected global challenges including climate change, biodiversity loss, unsustainable use of resources and inequality (UNESCO, 2022). The ESD global implementation framework integrates ESD into UNESCO's 17 Sustainable Development Goals (SDGs), and encourages countries to support ESD in the following five priority action areas: advancing policy, transforming learning environments, building capacities of educators, empowering and mobilizing youth, and accelerating local level actions (UNESCO, 2022). Although aspiring to participate, Taiwan is not a member of the United Nations (UN) or its sub-organizations such as UNESCO. Even so, Taiwan has actively taken actions to support the aim of ESD for 2030--"to build a more just and sustainable world through strengthening ESD and contributing to the achievement of all 17 Sustainable Development Goals" (UNESCO, 2020).

Given that ESD is a lifelong learning process and needs an implementation of glocalization, the adaptation of global avocations and strategies to local situations and cultures, this paper aims to introduce the status of STEM-related ESD/SDG Activities, and to state the teaching materials and their new challenges in STEM-related ESD/SDG activities. STEM in this paper refers to STEM education, which is a field of study or teaching approach that combines science (S), technology (T), engineering (E), and mathematics (M).

Status of STEM-related ESD/SDG Activities

Taiwan's current school system mainly consists of six-year elementary schools, three-year junior high schools and three-year senior high schools, followed by two-year junior colleges or four-year colleges. Compulsory education lasts for 9 years through elementary and junior high school. Built on the nine-year compulsory education, the 12-year basic education was introduced in the 2014 school year to offer students more education opportunities. Senior high schools are divided into the following four types: general, vocational, comprehensive, and specialized.

Primary and Secondary Education

1. **STEM-related ESD/SDG activities have been conducted in MOE-mandated and STEM-related courses**

In Taiwan, the curriculum development of elementary and secondary schools must follow the Curriculum Guidelines of 12-Year Basic Education to cultivate students' core competencies in the following three broad dimensions: spontaneity, communication and interaction, and social participation. The 12-Year Basic Education Curriculum is classified into two types: MOE-mandated curriculum and school-developed curriculum (Ministry of Education [MOE], 2014). In elementary schools and junior high schools, the MOE-mandated curriculum includes the following eight domains/learning areas: Language Arts, Mathematics, Social Studies, Natural Sciences, Arts, Integrative Activities, Technology, and Health and Physical Education. The courses in Mathematics, Natural Sciences, and Technology, such as Living Technology courses in the Technology domain, are seen as STEM-related courses.

For example, a junior high school in Kaohsiung City designed two STEM-related projects entitled "Earthquake-resistant Structure Design and Fabrication," and a "Solar

Aquaponics System," in its Living Technology course, and embraced ESD/SDG activities. In those projects, teaching materials mainly included textbooks and internet resources.

MOE-mandated courses in the aforementioned four-type senior high schools include "general subjects" for students to achieve basic learning in various domains as well as "technical subjects" and "practice subjects" for students to gain career development. In addition to the STEM-related ESD/SDG activities conducted in MOE-mandated and STEM-related general courses, vocational senior high school programs play a vital role as a natural delivery system for STEM education, and often embrace ESD/SDG activities. Teaching materials used in those ESD/SDG activities at this stage of education also mainly include textbooks and internet resources, such as the Climate Change Education Information Platform (MOE, n.d.).

2. **Trans- or inter-disciplinary STEM-related ESD/SDG activities have mainly been conducted in school-developed curricula**

   The school-developed curriculum mentioned above is designed and offered by each school to highlight the school's vision of education and to facilitate students' development according to their aptitudes. Under the umbrella of a school-developed curriculum, alternative curricula are offered for elementary- and junior-high-school students, while school-developed required courses, elective courses, group activity sessions, and alternative learning periods are offered for senior-high-school students. Thus, trans- or inter-disciplinary STEM-related or STEAM-related ESD/SDG activities have mainly been seen in school-developed curricula. For example, focusing on the issue of climate change, an elementary school in Kaohsiung City designed a 160-minute cross-curricula unit entitled "Green Energy and Energy Conservation." In this unit, the theme is "green building" and its spin-off concepts include energy conservation design, renewable energy, environmental protection building materials,

friendly environment, and ecological sustainability. Teaching materials in the unit include readings, PPTs, videos, and worksheets.

In addition to the above formal learning channels, students may participate in STEM-related ESD/SDG activities through non-formal learning modes. There are a variety of on- and off-campus fairs, competitions, and workshops involving STEM-related ESD/SDG activities (Ku, & Lin, 2022). Teaching materials used in those activities are varied.

Post-secondary and Higher Education

1. **STEM-related ESD/SDG activities have been infused in STEM-related programs**

It is observed that the number of students in STEM fields accounted for 32.5% of all college students in the 2021 school year (MOE, 2022a). Thus, STEM-related ESD/SDG activities have been infused in various STEM-related programs. Normally, colleges/universities treat SDGs as an interpretation framework that can be scattered throughout each course and can become a guiding principle. In addition, SDG Indicators 4.7.1, as well as 12.8.1 and 13.3.1 have been employed to monitor progress in some programs.

2. **The SPROUT Project and world university rankings have successfully promoted STEM-related ESD/SDG activities**

The MOE of Taiwan launched the Higher Education SPROUT (i.e., Sustained Progress and Rise of Universities in Taiwan) Project (HESP) to spur the enhancement of higher education. The project has promoted STEM-related ESD/SDG activities. For example, in the second phase of HESP (2023-2027), “Fulfilling University Social Responsibility (USR)” and “Social Responsibility Contribution” are required in fund applications. In terms of the “Social Responsibility Contribution,” the universities applying corresponding project funds have to implement the concepts of SDGs through international cooperation, combine sustainable

environment, health, safety and other issues with academic research, serve the society by means of academics, give back to the domestic society and contribute to the world, and help Taiwan and the world face major global challenges (MOE, 2022b). Additionally, world university rankings, such as Times Higher Education (THE) Impact Rankings, assess university commitment to sustainability; its progress is normally measured for each of the individual 17 SDGs, as well as across the goals as a whole.

Mainly influenced by the SPROUT Project and world university rankings measurement, all universities/colleges pay attention to the implementation of ESD/SDGs. For example, National Cheng Kung University (NCKU) in Tainan City published its SDGs annual reports and highlighted its main performance in 2022 as shown in Figure 1. Figure 1 indicates that until 2022, NCKU had 1,864 SD-related researchers, offered more than 1,500 SD-related courses, completed more than 370 SD-related dissertations and theses, made more than 1,615 SD-related international presentations, conducted more than 1,328 SD-related research projects, and hosted more than 5 SDG workshops.

Figure 1 National Cheng Kung University's main SD-related performance in 2022

Note: Extracted from NCKU, 2023.

Helping elementary and secondary schools sustainably develop is in the realm of USR. Thus, it is observed that universities' experiences and even resources in the implementation of ESD/SDGs have been transferred to elementary and secondary schools.

Teaching Materials and Their New Challenges in STEM-related ESD/SDG Activities

Teaching materials (TMs) are also known as teaching-learning materials (TLMs) or instructional materials (IMs) to emphasize student-centered learning. The various teaching materials commonly used by school teachers are listed in Table 1. A combination of those materials is often used for gaining synergy. In addition, teaching materials often need to be supported by teaching aids. For example, PPTs are normally supported by computers, projectors, and screens.

Table 1 Types of various teaching materials

Classification Basis	Material Types	Examples
Receiving Senses	Visual	blackboard/whiteboard writings/drawings, flashcards, graphs, infographics, posters, printed textbooks
	Audio	CDs, lecture talking, radio, tape recordings
	Audiovisual	documentaries, films, videos, virtual classrooms
	Computer-assisted	blogs, CDs, e-books, podcasts, quizzes, smart classes
User Subject	Teaching (T)	blackboard/whiteboard writings/drawings, charts, cutouts, films, ICTs, masks, models, objects, pictures, posters, PPTs, printed materials, puppets, videos
	Learning (L)	activity sheets, classroom displays, games, self-study units, reference materials, supplementary materials, workbooks
	T-L overlapped	CDs, community resources, labs, library, textbooks, workbooks

Note: Revised from Team Leverage Edu, 2022 and Vallika, 2021.

A variety of teaching materials have been used in the aforementioned STEM-related ESD/SDG activities, and at least the following five new challenges have emerged:

1. **Teachers are not familiar enough with teaching materials in non-specialized fields in cross-field STEM-related ESD/SDG activities**

   STEM-related ESD/SDG activities are often trans- or inter-disciplinary and need several cross-field teachers to work together. It is found that participating teachers are not familiar enough with teaching materials in non-specialized fields. More trans- or inter-disciplinary pre-service teacher education and in-service professional development are anticipated.

2. Teachers need to spend too much time transforming ready-made social resources

There are more and more ready-made social resources, such as internet resources, for ESD/SDG activities but few of them are tailor-made for specific learner groups. Thus, teachers need to spend plenty of time transforming them. More user-friendly social resources should be encouraged to be made for use as teaching materials.

3. **The ability of primary and secondary school teachers and students to use international teaching materials is often limited due to their language skills**

There are valuable international teaching materials for ESD/SDG activities, but many primary and secondary school teachers' and students' language skills are not good enough to access them. Hopefully, the Bilingual 2030 Policy could improve the bilingual (English-Mandarin Chinese) abilities of primary and secondary school teachers.

4. **Lack of a platform for exchange and sharing of teaching materials**

More and more ESD/SDG activities and teacher-made or teacher–identified teaching materials are emerging, and the lack of a comprehensive platform for exchange and sharing of teaching

materials is becoming a new challenge. Establishing a web-based platform is urgently needed, especially for the stages of primary and secondary education.

5. **The COVID-19 pandemic caused emergency remote teaching to suffer from limited quality online teaching materials**

In Taiwan and other countries, the COVID-19 pandemic caused emergency remote teaching/learning in recent years. During the difficult period, STEM-related ESD/SDG activities suffered from limited quality online teaching materials. Hybrid teaching and learning has become a new normal and teachers' abilities of developing and managing online teaching materials for STEM-related ESD/SDG activities should continue to be enhanced.

Conclusions

Based on the above status description and new challenges identification, it can be concluded that Taiwan highly values STEM-related ESD/SDG activities. Not only post-secondary and higher education but also primary and secondary education policies and practices make efforts to promote the activities. However, there are at least the preceding five new challenges of teaching materials in STEM-related ESD/SDG activities which should be solved as soon as possible.

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