SUSTAINABLE DEVELOPMENT EDUCATION: A PROPOSED MODEL OF ENERGY EFFICIENCY EDUCATION FOR INFORMATION TECHNOLOGY UNDERGRADUATES OF UNIVERSITI PENDIDIKAN SULTAN IDRIS

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SULTAN IDRIS EDUCATION UNIVERSITY
2022

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ABSTRACT

This study aims to design, develop, and evaluate a model on energy efficiency education for Information Technology (IT) undergraduates. This research utilized a Model Research (MR) method, which is a sub-category of the Design and Development Research (DDR) method. The use of this method helped the researcher to focus on the design and development of the proposed model and the conditions which facilitate its use. The STAUNCH©Criteria instrument was used to quantitatively assess the contribution of IT curriculum to the Sustainable Development (SD) integration. The findings showed that there was a lack of SD visibility aspect in the learning modules of the IT course of Universiti Pendidikan Sultan Idris (UPSI). Furthermore, the findings showed that the five components of the design of the concept of SD, namely stakeholders, tool, integration approach, pedagogy, and organizational change, were important principles of energy efficiency education. Finally, the findings showed that the respondents acknowledged that there was a need for Education for Sustainable Development (ESD) and energy efficiency (EE) education in the current IT curriculum. In conclusion, the findings suggest that EE education should be included in the current IT curriculum to help IT undergraduates learn the aspects of ESD and SD. Given that the proposed model was examined formatively, more studies are therefore entailed to evaluate such a model in a summative manner.

PENDIDIKAN PEMBANGUNAN KELESTARIAN: SATU MODEL CADANGAN PENDIDIKAN KECEKAPAN TENAGA UNTUK SISWA TEKNOLOGI MAKLUMAT UNIVERSITI PENDIDIKAN SULTAN IDRIS

ASBTRAK

Kajian ini bertujuan untuk mereka bentuk, membangun dan menilai satu model untuk penyelidikan kecekapan tenaga bagi siswa teknologi maklumat (IT). Kajian ini menggunakan kaedah Penyelidikan Model yang merupakan sub-kategori kaedah Penyelidikan Reka Bentuk dan Pembangunan. Penggunaan kaedah ini membantu penyelidik memfokuskan kepada reka bentuk dan pembangunan model yang dicadangkan dan syarat-syarat yang memudah cara penggunaannya. Instrument STAUNCH©Criteria digunakan untuk menilai secara kuantitatif sumbangan kurikulum IT kepada pengintegrasian pembangunan lestari. Dapatan menunjukkan terdapat kekurangan dari aspek kebolehlihatan dalam modul-modul pembelajaran yang digunakan dalam kursus IT di Universiti Pendidikan Sultan Idris (UPSI). Tambahan pula, dapatan menunjukkan bahawa lima komponen yang digunakan dalam reka bentuk konsep, iaitu pihak berkepentingan, alatan, pendekatan pengintegrasian, pedagogi dan perubahan organisasi, merupakan prinsip-prinsip pendidikan kecekapan tenaga yang penting. Akhir sekali, dapatan mendapati para responden mengakui betapa pentingnya pendidikan pembangunan lestari dan pendidikan kecekapan tenaga dalam kurikulum IT. Kesimpulannya, dapatan menyarankan agar pendidikan kecekapan tenaga perlu dimasukkan ke dalam kurikulum IT yang sedia ada untuk membantu golongan pendidik belajar aspek-aspek berkaitan dengan pendidikan pembangunan lestari dan pendidikan kecekapan tenaga. Oleh kerana model yang dicadangkan ini hanya dinilai secar formatif, maka kajian seterusnya perlu dijalankan untuk menilainya secara sumatif.

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LIST OF ABBREVIATIONS

DDR	Design and Development Research
ESD	Education for Sustainable Development
HE	Higher Education
HEIs	Higher Education Institution/s
HEMS	Home Energy Management System
HESD	Higher Education Sustainable Development
ICT	Information and Communication Technology
IT	Information Technology
MR	Model Research
PBL	Problem Based Learning
SD	Sustainable Development
SDGs	Sustainable Development Goals
STAUNCH©	Sustainability Tool for Assessing Universities' Curricula Holistically
TMFAs	Tools, Methods, Frameworks and Approaches

APPENDIX LIST

A1	Concept Questionnaire
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CHAPTER 1

INTRODUCTION

1.1 Overview

This chapter presents a brief background of Education for Sustainable Development (ESD), moreover it furnishes the research questions and objectives for the study. This chapter further presents the problem statement in accordance with the objectives of the study and furnishes the scope of the research. This chapter finally presents the limitations and importance of the study, before giving an outline for the rest of the dissertation.

1.2 Background of the Study

With the world population currently at 7.7 billion people, and growing exponentially every day, coupled with the finite number of natural resources found on earth, the human race needs to learn to live more sustainably. We as human beings need to understand that our actions today can have major future implications on the lives of the people and the planet. To assure a sustainable future the human race should have a full understanding, and appreciation, of the strong interplay and overlaps among the three pillars, which are the basis of sustainable development (De Andrade Guerra et al., 2018; Khalili et al., 2015).

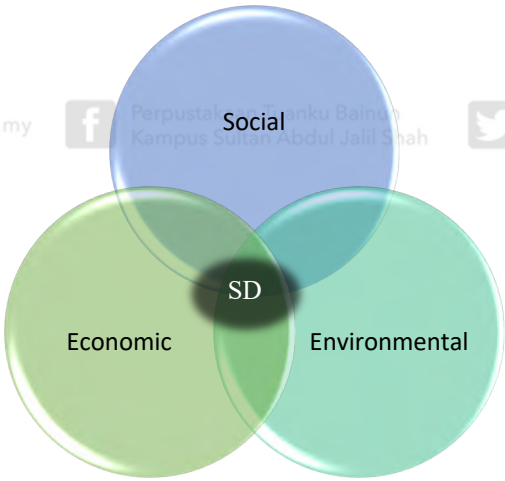

Figure 1.1. Three Pillars of Sustainable Development (SD)

Figure 1.1 shows the three pillars of sustainable development, namely, the economic, social and environmental pillars and their strong interplay and overlaps. Purvis et al. (2018) stated that there is no single point of origin of this three-pillar conception, but more accurately that it emerged steadily from various early analysis of the academic literature on the economic status quo from both social and ecological

perspectives. Purvis et al. (2018) stated that the pillars concept also originated, on the other hand, from the quest to reconcile economic growth as a solution to social and ecological problems on the part of the United Nations.

Sustainable development is the overarching paradigm of the United Nations. We can imagine Sustainable Development (SD) as an individual and social search, learning and design process in which all members of society participate. The concept of sustainable development was described by the 1987 Bruntland Commission Report as development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

Education for Sustainable Development (ESD) empowers learners of all ages with the knowledge, skills, values and attitudes to address the interconnected global challenges we are facing, including climate change, environmental degradation, loss of biodiversity, poverty and inequality. ESD is the umbrella term that refers to the various forms of learning and teaching associated with SD in societies. Such a participatory process requires that all actors have the appropriate knowledge and skills to participate in it (Trechsel et al., 2018). Thus, ESD is a key enabler for SD and vital component of the educational mandate (Dlouhá & Pospíšilová, 2018).

United Nations Educational, Scientific and Cultural Organization (UNESCO) stated that ESD can empower people to change their perspectives and work together towards a sustainable future. UNESCO also stated that there is growing international

recognition of ESD as an integral element of quality education and a key enabler for SD. Their commitment towards ESD was solidified by the institutions decision to include it in its Sustainable Development Goals (SDGs).

Figure 1.2 shows the seventeen UN SDGs that make up the 2030 Agenda for Sustainable Development. This 2030 Agenda is a plan of action for people, planet and prosperity. It also seeks to strengthen universal peace in larger freedom. According to the United Nations Development Programme (UNDP) the SDGs are first introduced at the United Nations Conference on Sustainable Development in Rio de Janeiro in 2012. As stated in Dlouhá & Pospíšilová (2018) they are developed as a follow-up to the Millennium Development Goals (MDGs) and adopted by the United Nations (UN) General Assembly in September 2015. The MDGs have played an important role in shaping both development and development discourse. However, the MDGs have been widely critiqued. The MDGs were led by a set of goals, targets, and indicators, this indicator-led development agenda has been critiqued for allowing these indicators to drive development agendas, rather than being used to measure progress towards broader development aims. Informed by their origin in the Rio+20 process and the critiques of the MDGs, the objective was to produce a set of universal goals that meet the urgent environmental, political and economic challenges facing our world. In short the SDGs are a universal call to action to shift the world onto a more sustainable path.

Figure 1.2. The UN Sustainable Development Goals (SDGs)

There are seventeen interconnected SDGs as seen in Figure 1.2. and one hundred and sixty-nine targets, but for the purpose of this study goal number four which is quality education is the focus. As shown in Figure 1.3, which shows goal number four of UNESCO's SDGs, goal number four is to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all. According to UNESCO achieving inclusive and quality education for all reaffirms the belief that education is one of the most powerful and proven vehicles for sustainable development.

There are ten different targets under the fourth sustainable development goal which is seen in Figure 1.3 but for the purpose of this study target 4.7 is the focus. According to UNESCO's Sustainable Development Goals (SDGs) target 4.7 states that:

> "By 2030 ensure all learners acquire knowledge and skills needed to promote sustainable development, including among others through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship, and appreciation of cultural diversity and of cultures contribution to sustainable development." (UN, 2021)

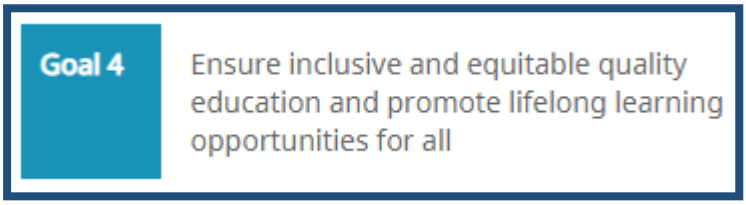

Figure 1.3. Goal 4 of the UN Sustainable Development Goals (SDGs)

More importantly target 4.7 of the SDGs stated, in part, that by 2030 we should ensure that all learners acquire the knowledge and skills needed to promote sustainable development. To achieve SD, the world needs reflective, innovative, forward looking and responsible women and men. The indicators for target 4.7 under the SDGs are amongst others the extent to which ESD is mainstreamed at all levels in national education policies, curricula, teacher education and student assessment.

According to Aktas et al. (2015) it is an important requirement for Higher Education Institutions (HEIs) to integrate SD as an effective way to share and promote ideas with future generations. During the last two decades, many higher education institutions have become involved in embedding SD into their academic systems (Lozano et al., 2015). HEIs play a vital role in shaping the earth's future generations whom after their studies will assume key roles in society and can actively and decisively

help to shape SD. Faham et al. (2017) and Leal Fihlo et al. (2018) stated that higher education institutes have the potential to prepare and increase student information and knowledge with the use teaching and learning, research, community engagement and general campus operations as tools in a move towards a sustainable future, for the reason that they are the future leaders and inheritors of technology. Moreover, students generally regarded sustainability competences as important to the future labor market (Grinsted, 2015). Furthermore, Klimova et al. (2016) and Porras et al. (2016) stated that greening by ICT is a new opportunity in terms of employment for smarting buildings and the grid.

There are seventeen interconnected SDGs as seen in Figure 1.2. and one hundred and sixty-nine targets, but for the purpose of this study goal number four which is quality education is the focus. As shown in Figure 1.3, which shows goal number four of UNESCO's SDGs, goal number four is to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all. According to UNESCO achieving inclusive and quality education for all reaffirms the belief that education is one of the most powerful and proven vehicles for sustainable development.

The Information and Communication Technologies (ICT) sector is viewed as important in ensuring SD (Klimova et al., 2016). Gouvea (2018) stated that it is important to note that ICT presently interpenetrates and is vital to the economic, social, and environmental dimensions of many nations around the globe. Furthermore, the pervasive diffusion of ICT also aides in addressing societal and sustainability challenges in the area of energy (Gouvea, 2018). ICT contributes immensely on the

design of smart grids, moreover it has a vital role in energy efficiency and low carbon energy strategies in areas such as behavioral modifications towards energy conservation (Gouvea, 2018).

Klimova & Rondeau (2017) stated that there was a lack of qualified specialists with high expertise in ICT who are able to design, develop, deploy, and maintain both pervasive computing systems and communication architectures for sustainable development. This has led to the necessity of incorporating SD principles into Higher Education (HE). There is evidence that pointed to the need for more emphasis on energy efficiency (Torre, 2017; Armstrong, 2016) and renewable energy concepts and technologies within HE (Kandpal & Broman, 2014). Goal seven of the SDGs deals with 'affordable and clean energy' and target 7A states in part that.

> "By 2030 enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency."
>
> (UN, 2021)

According to Labodová et al. (2014), all advancements of energy efficiency are consequential for the reason that any small step towards higher energy efficiency steers the world towards a more sustainable future. Furthermore, it is important to remember that sustainability is a journey of continuous improvement, not a target place (Labodová et al., 2014).

1.3 Problem Statement

It is evident from the background that energy efficiency education is integral for future Information Technology (IT) students to aid them to garner the competencies required to strive for a more sustainable future, therefore the ultimate aim of this study is to design, develop and evaluate a model for the energy efficiency education of undergraduate IT students.

a) The lack of investigation on SD and ESD implementation and integration strategies:

Although there is a plethora of literature on ESD, a closer look at the literature revealed that there are still major areas of concern, such as better integration of ESD into curricula, research, and most importantly holistically into HEI systems (Ramos et al. 2015). HEIs are making advancements in SD implementation but creating a process in the local and global context to incorporate ESD in their institutions is a challenge that is being faced by many (Wals, 2014). Future research should take into account the core activities of HEIs (Aleixo et al., 2018). Furthermore, Dlouhá et al. (2017) stated that research activities are important at all stages of transition to reflect on ESD innovations. Alonso-Almeida et al. (2015) stated that SD practices in HEIs and their impact on HEIs and society should be the focus of future research, whilst Blanco-Portela et al. (2017) and Kankovskaya (2016) further stated that the drivers of and barriers to sustainability change should be empirically explored and assessed. Cicmil et al., (2017) stated that to better understand the organizational context for implementation of ESD from an HE perspective more research needs to be conducted.

b) The lack of exploration and the need to report on the SD and ESD TMFAs:

According to Kapitulčinová et al. (2018) more exploration of the sustainability tools, methods, frameworks and approaches (TMFAs) used in HEIs is required, for the reason that this exploration captures the TMFAs that might not have been recorded in the academic literature.

c) Scarcity of energy efficiency education models for undergraduate IT students:

According to Wals (2014) there is a need for more ESD centered models that foster sustainability and the development of alternative values for the reason that they are still scarce around the globe. There is a huge gap in the literature on the topic of energy efficiency education, furthermore there are very few examples of models for energy efficiency education of undergraduate IT students. There are suggestions to teach energy efficiency (Torre et al. 2017). Casarejos et al. (2017) further stated that an expressive demand for energy exists in HEIs, and for this reason it is important to educate students on energy efficiency. Moreover, Ciriminna et al., (2016) stated that education requires the merging of updated technology with energy education.

Vargas & Heyes (2016) noted the importance of a project designed to link different parts of the institution together in such a way that the campus becomes a living laboratory in which innovation and ESD principles may be implemented and tested together. According to Desha et al. (2015) energy efficiency education is of great

importance for the reason that there is a need for long-term planning for energy efficiency education within HE, government and industry, as this is an evolving topic where there will continue to be new knowledge and skills to be integrated.

d) The importance of evaluating the model:

Evaluation is always an integral part of any program and as such De Andrade Guerra et al., (2018) stated that it is important to monitor the effectiveness and efficiency of sustainability programs that are integrated and/or implemented into HEI systems.

1.4 Research Aim

The main aim of this study had been to develop a model on energy efficiency education for undergraduate students in UPSI. However, this study does not aim to promote energy efficiency education, instead it attempts to provide a view on the enhancement of academic program pertaining to the energy efficiency education in UPSI.

1.5 Research Objectives

The following had been the research objectives for the study:

1. To investigate holistically how HEIs are implementing and/or integrating ESD and/or SD into their institutions.

2. To explore the ESD and/or SD tools, methods, frameworks and approaches (TMFAs) used in HEIs.

3. To design and develop a model for energy efficiency education of undergraduate IT students.

4. To evaluate the proposed model and provide best practices on how to improve it.

1.6 Research Questions

The study examined four research questions, as follows:

1. How do HEIs implement and/or integrate ESD and/or SD into their institutions?

2. What ESD and/or SD tools, methods, frameworks and approaches (TMFAs) are used in HEIs?

3. How to design and develop a model for energy efficiency education of undergraduate IT students?

4. How to amend the proposed model for energy efficiency education of undergraduate IT students?

1.7 Research Contribution

The contributions of this research are as follows:

- **This research produces a comprehensive review of ESD literature.** The holistic nature of the investigation of SD and ESD produce a comprehensive review of the literature available in the top academic databases.

- **This research reports on the TMFAs explored in ESD literature.** All TMFAs reported in the available literature have been documented within the literature review.

- **This research develops a conceptual model for energy efficiency education.** Defining the requirements to design, develop, evaluate and amend a new conceptual model for implementing and/or integrating energy efficiency education for undergraduate IT students with focus on the different processes and the required elements of each.

- **This research recommends ways in which amend the model for energy efficiency education.** Providing the limitations of the model for implementing and/or integrating energy efficiency education for undergraduate IT students and detailed future recommendations on how to improve it.

1.8 Importance of the Study

First, this research adds to the available literature and moreover it can also aid in stakeholder comprehension of ESD and/or SD implementation and/or integration into HEIs. Secondly, this research can capture the TMFAs in the literature to date and furthermore give insight on how successful the use of these TMFAs has been. Third, this research can aid in the design, development and evaluation of future models for educating IT students on energy efficiency. Last but not least, this research can give stakeholders a conceptual model to educate IT students on energy efficiency.

1.9 Limitation of the Study

The study is limited to a single HEI and a pre-determined number of courses. This study covers part of the undergraduate IT curriculum at Sultan Idris Education University in Perak, Malaysia. The coverage of this study is limited to courses that deal with computer programming and computer networking. This research aims to integrate sustainability into the curriculum using the aforementioned courses (programming and networking). There is lack of literature on the topic of energy efficiency education for IT students as most of the literature available pertains mostly to other fields of study i.e. engineering. Moreover, model design and development examples that dealt with the topic of energy efficiency education for IT students are few and far apart for the reason that it is still an emerging field.

This research focuses on educating the undergraduate IT students on energy efficiency by utilizing a conceptual model centered on the use of a living laboratory as a tool for the development of the students' sustainability competencies. The laboratory consists of a smart green building setup which assists students to gain the appropriate knowledge, skills and attitudes in regards to energy efficiency and renewable energy resources. Furthermore, the use of the smart green building also allows students to gain knowledge, skills and attitudes in regards to smart buildings, smart grids and home energy management systems (HEMS). However, there are a lack of facilities to evaluate summatively a working model using the case study method. For this reason, the research aims to evaluate the model using questionnaires aimed at firstly, ESD experts from the Centre for Global Sustainability Studies (CGSS) at Universiti Sains Malaysia and secondly, networking and programming lecturers from the Faculty of Art, Computing and Creative Industry at Universiti Pendidikan Sultan Idris (UPSI). Finally, the collected data is qualitatively analyzed and comprehensively reported and discussed.

1.10 Operational Definition

In this section of the operational definition of the study is defined. All definitions have been modified for the purpose of this study as well as within the context of this study.

a) Sustainable Development:

Sustainable development in this study refers to the many processes and pathways to obtaining a more sustainable world such as research and technology transfer, education and training, and other, involves in the context of the curriculum Bachelor of Education in Information Technology offered in UPSI.

b) Education for Sustainable Development:

The learning must prepare students to find solutions for the challenges of today and the future. The education is transformative and allows students to make informed decisions and take individual and collective action to change our societies and care for the planet.

c) Energy Efficiency Education:

The teaching and learning on energy consumption and the environment. In this study, the energy efficiency education is related to the curriculum of Bachelor of Education in Information Technology offered in UPSI.

d) Model Research (MR):

A sub-category of the Design Development Research (DDR) method. The MR method is suitable for this study as it pertains to research that deals with the development, validation and use of design and development models.

e) Tools, Methods, Frameworks and Approaches (TMFAs):

TMFAs is currently used at HEIs as the change agent's aspiration in promoting SD integration at HEIs. In this study, TMFAs is relatively used to the application

context of the curriculum Bachelor of Education in Information Technology offered in UPSI.

f) Curriculum Evaluation:

An evaluation and analysis of the level of SD contribution. The higher the contribution's value, the better the balance amongst economic, environmental, social, and crosscutting dimensions. In this study, the STAUNCH© Assessment Criteria is used for curriculum evaluation in all the selected modules descriptors.

g) Concept Evaluation:

An evaluation and analysis of the effectiveness and efficiency of the concept designed. In this study, in order to evaluate the effectiveness and efficiency of the concept designed for the proposed model on energy efficiency education of undergraduate IT students, a questionnaire has been developed to collect quantitative data from a number of respondents.

h) Model Evaluation:

An evaluation and analysis of the effectiveness and efficiency of the model designed. In this study, in order to evaluate the effectiveness and efficiency of the model designed on energy efficiency education of undergraduate IT students, a questionnaire has been developed to collect quantitative data from a number of respondents. This section deals with the quantitative analysis of the collected data from the aforementioned questionnaire.

i) Living Laboratory:

For the purpose of this research a living lab is a interdisciplinary teaching and learning facility that incorporates both characteristics of smart buildings and green buildings. Furthermore, it utilizes new technologies to efficiently use and measure energy consumption and production and research new alternative renewable energy sources.

1.11 Outline of Dissertation

The rest of the dissertation is organized as follows:

- **Chapter 2 – Literature Review:** This chapter presents a systematic literature review of the available literature on ESD and/or SD implementation practices amongst HEIs, relevant stakeholder perceptions, assessment and reporting of ESD and/or SD, organizational change management, curricular orientation and campus operations of HEIs.
- **Chapter 3 – Methodology:** This chapter presents the four-phases methodology detailing the analysis, design, development, and evaluation phases of the model. The four-phases methodology guided how the research was to be conducted in order to achieve the objectives and answer the research questions. In the case of this research, a four-phases methodology.

- **Chapter 4 – Curriculum Evaluation and Integration**: This chapter provides a comprehensive explanation of how SD is integrated into the selected networking and programming modules of the undergraduate IT curriculum of the Faculty of Art, Computing and Creative Industry (FSKIK) at the Sultan Idris Education University (UPSI).
- **Chapter 5 – Evaluation and Discussion**: This chapter offers a comprehensive analysis of the data collected from the respondents through the concept and competence questionnaires. Furthermore, this chapter also describes the results of the STAUNCH© analysis carried out on the selected programming and networking modules from the undergraduate IT course at UPSI. Finally, this chapter ends with a discussion of the evaluation results.
- **Chapter 6 – Conclusion and Future Recommendations:** This chapter summarizes and concludes the research. This chapter also provides future recommendations on any alterations that may need to be done to the model and how to improve the proposed model.

1.12 Summary

This section of the study highlighted the background of the research, statement of problems, the research aim, research objectives, research questions, research contributions, importance of the study, limitation of the study and finally, the operational definition of terms had been discussed.