An action research on ESD pedagogy: Enhancing TVET's role in equipping students with generic green skills

by

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Statement of Originality

I, CHEN, Shimin, hereby declare that I am the sole author of the thesis and the material presented in this thesis is my original work except those indicated in the acknowledgement. I further declare that I have followed the University's policies and regulations on Academic Honesty, Copyright and Plagiarism in writing the thesis and no material in this thesis has been submitted for a degree in this or other universities.

Abstract

The study presented in this thesis addresses pedagogical issues regarding the implementation of Education of Sustainable Development (ESD) in Technical and Vocational Education and Training (TVET). The study advances current knowledge and supports the practice of utilizing ESD pedagogy to improve students' generic green skills to support the greening of TVET.

The overall design of this qualitative study utilizes a problem-oriented and project-based learning approach (POPBL) to bring real-world learning opportunities into ESD classrooms. Based on this, a POPBL+ pedagogical model was developed to frame the design of classroom teaching and learning activities to effectively implement a generic green module in TVET through resource development and pedagogical innovation. Drawing on action research, this study was structured into four phases: 1) pilot study; 2) resource development; 3) resource implementation; and 4) impact evaluation. Four TVET teachers and a total of 115 students from a TVET institution in Hong Kong took part in the study.

The proposed POPBL+ model was effective in facilitating pedagogical innovation for improving the implementation of generic green modules for the purposes of developing students' generic green skills. The developed ESD resources, which introduced student-centered learning and real-world examples into the classrooms, enriched teachers' and students' teaching and learning. However, the impacts on some of the students (part-time students) and teachers (with less understanding of ESD) was less significant than on others. Thus, the POPBL+ model applied for this study was subsequently improved, and different approaches were suggested to address the identified challenges and constraints in future. Further research in areas such as validation of the tools that were used to assess generic green

skills, the contribution of generic green skills to the development of specific green skills, and others, are also suggested.

This study contributes to both theoretical and practical developments related to the use of ESD pedagogy in TVET. It enriches current understanding about ESD pedagogy and its role in facilitating the effective development of generic green skills in TVET students and also teachers' professional development. This study fills research gaps related to a lack of empirical studies that examine pedagogical practices for students' generic green skills development in TVET.

Key words: Generic green skills, TVET, ESD pedagogy, ESD resources, POPBL

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List of Abbreviations

ESD	Education for Sustainable Development
TVET	Technical and Vocational Education and Training
POPBL	Problem-Oriented and Project-Based Learning
CBL	Connectivity-Based Learning
WBL	Work-Based Learning
EdUHK	The Education University of Hong Kong

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CHAPTER 1
INTRODUCTION

This chapter sets the background for the study, its importance/significance and relevance. It identifies gaps in the research with respect to the ways Education for Sustainable Development (ESD) can be addressed in Technical and Vocational Education and Training **(**TVET) and, in particular, in terms of generic green skills development. The chapter also specifies research objectives and outlines the structure of the thesis.

1.1 Research Background and Research Gaps

Challenges faced by humanity and the biosphere have led to the formulation of a sustainable development agenda. The United Nations proposed 17 sustainable development goals (SDGs) in 2015 to respond to the identified challenges. These goals call for policies and actions that focus on transitions towards greener economies to support the achievement of sustainability. As a result, governments introduced different measures to ensure the green restructuring of economy. To clarify, for the purposes of this study, "Green restructuring" is the *"pro-active restructuring of the economy in a way that respects planetary boundaries"* (Schmitz and Becker, 2013), by improving the environmental sector (for example, focusing on waste management, green transport, green construction, alternative energy, organic agriculture), closing down highly polluting industries (e.g. coal mining) and greening existing businesses and industries (Pavlova, 2018, pp. 341). Efforts that lead to the development of the "green economy" which *"results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities"* (UNEP, 2011, pp. 2), have been made globally, by both regions and separate countries (Pavlova, 2014; 2016).

As Pavlova (2019) points out, the Government of the Hong Kong Special Administrative Region of the People's Republic of China (PRC) has recognized the importance of transitions towards a greener economy and has introduced measures over the last two decades. Various international agreements, such as the 1992 Convention on Biodiversity, the Copenhagen Accord of 2009, and the Paris Agreement of 2016 – each of which the PRC is a signatory – have been drivers for policies and action plans from both sides of the border. The government of Hong Kong also developed initiative for supporting green restructuring and changing existing industry practices in a shift to a low-carbon, low-waste, sustainable green future (e.g. the CarbonSmart program and the Green Manufacture network) (Pavlova, 2018). The culmination of its response to the global sustainable development agenda was the launch of its Climate Change Action Plan 2030+ that set 2030 as the target for reducing carbon emissions by 65% to 70% from the 2005 levels (Environment Bureau, 2017). To achieve this target, actions were sought to facilitate the following:

> . . .[to] optimise the implementation of renewable energy, make our buildings and infrastructure more energy-efficient, improve public transport and promote walking as a mobility means, strengthen the climate-readiness of the city as a whole, 'cool' the city through landscaping and partner with stakeholders so that our community can be climate resilient now and in the long term. (Wong, 2017,

pp. 5)

Public education is addressed through campaigns related to waste reduction, water conservation and preparation for extreme weather events, as well as field activities and competitions in primary and secondary schools. However, the crucial role of education in terms of equipping the labor force with specific technical and professional skills needed for delivering the plan has not been addressed (Pavlova, 2019).

Furthermore, the greening of the economy is a forward-thinking agenda, despite many challenges and barriers inherent in it, particularly in the area of skills development (Pavlova, 2017), as policies aimed at less energy use, reducing greenhouse gas emissions and increasing the use of renewable energy resources have driven labor market restructuring and the demand for green skills (CEDEFOP, 2013). Changes caused by green restructuring and skills demand are a global challenge. Different levels of government need to strengthen skills training for affected workers as well as human resource development. The International Labour Organization (ILO) (2018) suggests that a "granular assessment" of skills and competencies at the company, community and subprovincial levels is needed to provide useful tools for facilitating structural transformation equitably (e.g. Cadecott et al., 2017). Counties have been called for urgent action to train and retrain workers in skills needed to support the transition. However, as Pavlova (2019) notes, the lack of knowledge about the nexus between environment and skills, the absence of employment projections and financial mechanisms to promote investments in skills development, as well as sluggish participation of social partners, has hindered the achievement of an effective transition in the majority of the 27 countries in Asia and Pacific included in the review.

Since the early 2000s, the contributions of TVET to sustainable development have been widely acknowledged. Publications on this topic highlighted the crucial role TVET plays in contributing to a green economy and a sustainable future through the impacts on the world of work (e.g. Maclean, 2005; Siriwardene & Qureshi, 2009; Mertineit, 2013; Pavlova, 2015; Baryono, 2017). It required TVET to facilitate workforces to consider environmental influences and address sustainability in their professional practice, and to embrace green technology and implement regulatory or monitoring tools to assess and directly deal with the sustainable issues in the forefront. Furthermore, since 2010, the understanding of TVET's contribution to sustainable development has broadened, which in turn drives TVET to begin re-orientating the curriculum to include ESD (Pavlova, 2017). As indicated in the final report for the UN Decade of Education for Sustainable Development (UNESCO, 2014), there have been various initiatives around the world related to ESD inclusion, such as TVET teacher training (China), reforming and innovating the TVET curriculum (Kenya, China, Mauritius, Canada, Poland, Greece), incorporating sustainable development into vocational qualifications (Finland), introducing policy to support green skills development (Australia, Republic of Korea, France) and developing a network to facilitate cooperation between TVET institutions (Peru).

In addition, the United Nations (2015) emphasized TVET as a means to achieving sustainability, since TVET underpins many the Sustainable Development Goals (SDGs) such as goal 4 – quality education, goal 6 – clean water and goal 13 – climate action. The

adoption of SDGs strengthened the emphasis on the role of skills in addressing SD challenges, and included support for green economic restructuring. In relation to the skills required, generic green skills are widely accepted as core competencies for almost any occupation (ILO, 2011; OECD, 2013; Pavlova, 2017; 2018) and have been identified as having a significant impact on facilitating the future workforce's understanding of issues related to green growth, as well as enhancing those skills required for more environmental-friendly performance in the workplace (a more complete discussion about this is in literature review section). In order to address the issue of generic green skills development, generic green modules/environmental modules have been introduced into the TVET curriculum. For example, the Ministry of Education and Training (MOET) in Vietnam introduced a compulsory 30-hour subject on climate change for all TVET institutions under MOET supervision (Pavlova, 2017). Many vocational training providers (VTPs) have included industrial safety units that contain content on environmental awareness, hygiene and safety as a means to address generic green skills (ibid). A limited number of generic green modules that include environmental knowledge and green practices have been introduced in Hong Kong's TVET. Training Providers in Hong Kong, such as the Hong Kong Productivity Council (HKPC) and the Hong Kong Vocational Training Council (VTC) have provided broad opportunities for skills learning through different training programs (Pavlova, 2016). Generic green skills have been included in these training programs to some extent to respond to the development of a green economy and a more sustainable future. One of the approaches for introducing generic green skills in these programs is through developing new learning modules that include green knowledge and reflection on green practices required for greening the economy and society as a whole.

Although the positive processes for greening the TVET curriculum have been observed worldwide, many aspects of its effective implementation remain under-researched (Pavlova, 2017). In particular, the effectiveness of identified modules on students' generic green skills development has not been thoroughly examined. In addition, the pivotal issues related to effective implementation, such as effective pedagogy, appropriate learning resources and teacher capacity building have not been specifically addressed either. The situation in Hong Kong is the same: the effectiveness of implementing these learning modules for the purposes of developing students' generic green skills has not been well examined, and there is a paucity of research that focuses on classroom practices during the delivery of these modules.

Research on education for sustainable development at schools and universities found that traditional methods of instruction, such as content-based lecturing that focuses on knowledge delivery rather than knowledge transformation – that facilitates classroom learning to real world problem solving – have been criticized for inadequately equipping students with sustainability competencies (Steinemann, 2003; Seatter & Ceulemans, 2017). The Global Education Monitoring Report 2016 puts forward a framework for education capable of achieving sustainable development:

> The transformation needed for a cleaner, greener planet requires integrative, innovative, and creative thinking, cultivated jointly by schools, governments, civil society organizations and companies. This collaboration calls for education that

> goes beyond the transfer of knowledge and desirable behaviors by focusing on multiple perspectives – economic, ecological, environmental, and sociocultural – and by developing empowered, critical, mindful, and competent citizens. (p. 11)

As there have not been sufficient studies about effective pedagogy specifically for the inclusion of green elements into TVET, the starting point for designing this study was *the assumption that innovative pedagogy is required to effectively deliver generic green modules in TVET settings*. This assumption was made based on the ESD research that mainly focused on developing key competencies in sustainability in higher education (e.g. Brundiers, Wiek and Redman, 2010). This research posits that such methods as future focused visioning projects (Martin, 2008), case studies (Remington-Doucette, 2012) and issue analysis (UNESCO, 2012) are proven to be effective. Effective curricula that have included sustainability issues (e.g. climate change) and integrate challenges of environment, economy and society, should be implemented through a multi-disciplinary approach and should include learning opportunities from real-world problem solving to facilitate students' attitude and behavior change. However, TVET pedagogy since its inception has been characterized by a relatively uncritical response to skills training for industry demands (e.g. fueling productivity, efficiency and economic growth), which largely ignored the unintended environmental and social consequences (Anderson, 2009; Arenas & Londono, 2013; Bedi & Germein, 2016). Although innovative pedagogies (such as work-based learning, authentic learning and campus-based learning) for facilitating effective teaching and learning in TVET have been suggested in the literature, these studies were not specifically designed to facilitate students' generic green skills development. Therefore, based on the above assumption, it would also fail to prepare students with generic green skills to respond to the challenges and opportunities of a green economy.

Thus, the reorientation of the TVET curriculum for the development of generic green skills requires an innovative pedagogy that provides additional learning opportunities with which to engage students in learning about green practices and developing skills that can contribute to a greener economy and society. This pedagogy should provide interactive, experiential and transformative learning, as well as real-world problem solving opportunities to facilitate students' generic green skills development (this will also be discussed in more detail in the literature review chapter).

Therefore, two preliminary research gaps have been identified:

1. There is a need to develop an innovative pedagogy for TVET that is specifically designed to assist with the implementation of "greener" curricula within TVET.
2. There is a lack of empirical studies that focus on examining the effectiveness of implementing generic green modules for generic green skills development within TVET.

These research gaps will be further examined in the literature review and through the pilot study (presented in the methodology chapter) that was designed to assess the assumption and to observe the ways a generic module has been introduced into the TVET classroom (to examine how students have engaged in learning and to identify challenges teachers have faced in their pedagogical practices).

1.2 Research Aim and Objectives and Research Questions

This section specifies the research aim and objectives for addressing the identified research gaps and formulates the research questions that specifically explain what this study is intended to achieve.

1.2.1 Research Aim and Objectives

In addressing the identified research gaps, this study suggests applying **ESD pedagogy** as a broad framework to re-orientate the curriculum and innovate pedagogical practice to facilitate ESD inclusion through generic green skills development in TVET. The study aims to advance current knowledge and support the practice of utilizing ESD pedagogy to improve the implementation of generic green modules in TVET in order to enhance TVET's role in terms of developing students' generic green skills.

More specifically, this study aims to:

1. Understand how ESD pedagogy might facilitate the teaching and learning of students' generic green skills development in TVET.

2. Develop an ESD pedagogical model to assist with the curriculum reorientation as well as pedagogy innovation for students' generic green skills development in TVET.

2. Evaluate the effectiveness of the ESD pedagogical model on 1) Improving the implementation of generic green modules; and 2) Developing students' generic green skills and teachers' competencies in relation to greening the curriculum.

4. Provide an example of conducting an empirical study that focuses on examining classroom practice to evaluate the implementation of generic green modules for students' generic green skills development in TVET.

1.2.2 Research Questions

Two research questions have been formulated to pinpoint the two specific focuses of the study. The first relates to developing an ESD pedagogical model to respond to the vital need for pedagogical innovation for the generic green modules in TVET. The second relates to an evaluation of the effectiveness of the developed ESD pedagogical model on improving teaching and learning towards generic green skills development. Therefore, two research questions are formulated as:

1. What is an ESD pedagogical model that can specifically support pedagogical innovation for the purposes of improving the implementation of generic green modules in TVET?

2. How effective is the proposed ESD pedagogical model in terms of improving teaching and learning for generic green skills development?

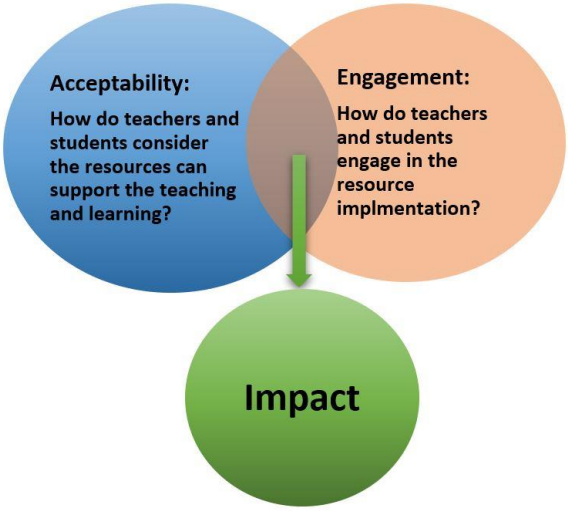
In terms of the second research question, the key to demonstrate the effectiveness of a proposed model is to examine the expected resulting impact based on the model. The expected impact for this study is the students' generic green skills development, as well as the teachers' competency enhancement in relation to greening of curriculum that

contributes to the effective teaching and learning of the generic green module.

Referring to the pilot study, the findings reveal that, the lack of students' and teachers' acceptability of, and engagement with, the implementation of the generic green module (including the insufficient competence of teachers in engaging with the implementation of the module) contributed greatly to the ineffective teaching and learning. Accordingly, an impact assessment framework (see Figure 1) was created to illustrate how the acceptability and engagement influence the expected impact. It illustrates the hypothesis that, if the resources are appropriately designed, and the teachers and students consider these resources helpful in supporting their teaching and learning, and they will be actively engaged in the resource implementation, different level of impact will be produced. This framework also reveals the joint influence of acceptability and engagement on the implementation of the developed resource.

Figure 1

The impact assessment framework



Note. This impact assessment framework demonstrates how the acceptability and engagement influence the expected impact

Therefore, for answering the second question, three sub-questions were further formulated based on the hypothesis:

1. What is the level of teachers' and students' acceptability towards the teaching and learning facilitated by the developed resources?
2. How do teachers and students engage in the resource implementation process?

3. What is the impact of the implementation of the ESD resources on students' generic green skills development as well as the enhancement of teachers' competencies in terms of greening of curriculum?

"Acceptability" in this study specifically refers to how do teachers and students consider the resources as helpful in supporting teaching and learning, while "engagement" refers to how do teachers and students engage in the resource implementation. An examination of teachers' engagement is interpreted as how teachers engage in learning how to implement the resources (co-teaching with the researcher), and the examination of students' engagement is interpreted as their participation in the learning activities designed for the implementation of the resources. "Implementation" here specifically refers to implementing the resources according to the teaching and learning sequences (instructional design) suggested in the teacher guidelines. "Greening of curriculum" refers to inclusion in TVET curriculum modules, topics, activities that aimed at exploring and understanding of sustainability concepts and practices to enable students to understand issues and challenges of greening economies and societies and acquire practical skills to participate in green transitions.

1.3 Significance of the Study

This study has the potential to contribute to both the theoretical and practical developments related to the use of ESD pedagogy for developing generic green skills in TVET. It enriches the current understanding of ESD pedagogy and its role in facilitating the effective implementation of generic green modules and developing students' generic green skills. It also responds to the research gaps by providing empirical evidence related to employing ESD pedagogy in the TVET context.

From a theoretical perspective, the study advances knowledge on conceptualizing ESD pedagogy within the context of TVET by clarifying the concept and learning process of ESD. It also provides a theoretical foundation for integrating real-world learning opportunities into the implementation of generic green modules for the purposes of developing students' generic green skills. In addition, the study has developed an ESD pedagogical model for addressing the gap between pedagogical approaches suggested in literature and practical situations in TVET institutions by reviewing the identified ESD pedagogical approaches and strategies, and generalizing the findings from both the pilot study and main study interventions. It also generalized a connectivity-based learning model that facilitates students to connect learning with their professional contexts, as well as providing a work-based learning model for supporting teachers' different learning needs during professional development.

From a practical perspective, the in-class observations and reflections on teaching and learning helped teachers identify the existing problems and challenges in their classroom practice. In addition, the interventions that were designed, based on facilitating the resource implementation, also had a positive impact in terms of improving the teaching and learning of the generic green module. It enhanced students' engagement and learning experiences and also improved teachers' pedagogical practices. It also evaluated the effectiveness of the developed ESD pedagogical model on students' generic green skills development and teachers' professional competencies in relation to greening the

curriculum. Thus, it contributed to enhancing TVET's role in equipping students with generic green skills.

1.4 Structure of the Thesis

This study is in seven chapters. Chapter 1 (Introduction) explains the background to the research; it identifies the research gaps and formulates the research aims and research questions.

Chapter 2 (Literature Review) conceptualizes the key concepts and defines the terms used in this study. It also reviews the learning theories that help lay the theoretical foundation for the learning models proposed in the discussion chapter. Finally, chapter two examines the resource development models and the relevant issues involved in resource development for ESD inclusion.

Chapter 3 (Methodology) presents the research framework for the study and explains the methodology that informed the research design. It details the methods (tools) and procedures for data collection and data analysis that were formulated based on the methodological approach of action research and the research questions of this study. It also specifies the validity threats and the possible strategies for dealing with the validity threats in this study.

Chapter 4 (Resource Development) explains how the ESD resources were developed, based on a preliminary **POPBL**$^{+}$ model. It outlines the resources development procedures and validates the consistency of the developed resources with the principles underlying the model.

Chapter 5 (Results) reports on the results generated from different data sources and demonstrates how different data sources have comprehensively responded to the research questions.

Chapter 6 (Discussion and Findings) discusses the findings generalized based on the results and how they respond to the research questions. It also discusses the limitations of the study and proposes the necessity of further research.

Chapter 7 (Conclusions) outlines conclusions based on the findings and implications of this study. It also restates the significance of the study and puts forward the direction for future research.

CHAPTER 2
LITERATURE REVIEW

This literature review conceptualizes the key concepts and defines the terms used in this study, including ESD pedagogy and its relevant pedagogical approaches and strategies, as well as the development and classification of generic green skills, based on published works on the topic by accredited scholars and researchers. It also reviews the learning theories that lay the theoretical foundation for the learning models that were developed based on the results in this study and presented in the discussion chapter. Last, it examines the resource development models as well as the relevant issues and challenges involved in resource development for ESD inclusion.

2.1 Conceptualization of ESD Pedagogy

This section outlines the theory and practice related to ESD pedagogy that will be used to establish a theoretical foundation for this study and to design a methodology. First, it conceptualizes the meaning of ESD pedagogy, based on the principles underlying ESD as well as the characteristics of ESD. Following on from this, it outlines the theory and part of the practice relevant to ESD pedagogical approaches and strategies.

2.1.1 Definition of ESD pedagogy

Considering the diverse understanding of ESD and ESD pedagogy in the literature, it is important to conceptualize the meaning of ESD pedagogy and outline some of its related practices. In the main, ESD is regarded as a particular way of linking education and sustainable development, although it is described and conceptualized in different ways according to the various interpretations of sustainable development and educational ideologies (Corney & Reid, 2007). From a teaching and learning perspective, ESD has been understood as an emerging paradigm that enables holistic, systemic, connective and ecological ways of thinking and learning (Sterling, 2002). Although there is no widely accepted definition of ESD pedagogy, many agree about its specific characteristics. The ESD Sourcebook (Learning and Training Tools NO.4 2012) indicates that ESD pedagogies are

> ESD pedagogies are often place-based or problem/issue-based. ESD pedagogies encourage critical thinking, social critique, and analyses of local contexts. They involve discussion, analysis and application of values. ESD pedagogies often draw upon the arts using drama, play, music, design, and drawing to stimulate creativity and imagine alternative futures. Such pedagogies move from teacher-centred to student-centred lessons and from rote memorization to participatory learning. (UNESCO 2012, 15)

Although the majority of the literature on ESD pedagogy has been focused on higher education (e.g. Brundiers, Wiek & Redman, 2010; Blake, Sterling & Goodson, 2013; Remington-Doucette, et al., 2013), the results of studies in the literature can contribute to conceptualizing ESD approaches in the TVET context that can be empirically tested. The identified studies show ESD pedagogy promotes cooperation and collaboration, issues

investigation, multiple perspectives and real-world problem solving (Laurie et al., 2016). For instance, the Burns Model of Sustainability Pedagogy (Burns, 2009; 2013) adopts an integrated approach to examining complex sustainability issues through problem-based learning and collaborative group work that focuses on inquiry, experience and reflection and which have a central focus on ecological design. Although many of the proposed ESD pedagogies, such as inquiry-based learning and case studies, have been in practice in different disciplinary traditions for years, they are now implemented in interdisciplinary contexts and applied to address sustainability issues, which focus more on developing the acquisition of skills, perspective and values required for sustainable societies instead of facilitating learning of knowledge (Laurie et al., 2016).

Therefore, ESD pedagogy can be understood as incorporating diverse teaching and learning methods that facilitate participation and collaboration, develop critical problem-solving abilities, and stimulate innovation through a holistic and interdisciplinary approach, which is in turn value-driven and locally relevant. ESD pedagogy can also contribute to the development of students' generic green skills for the purposes of assisting the future workforce to understand green growth issues and increase their environmental awareness.

2.1.2 ESD Pedagogical Approaches

An increasing number of pedagogical approaches proposed in recent literature adopt traditional approaches such as work-based learning (e.g. Finn, 2017; Wall et al, 2017) and campus-based project learning (e.g. Lindstrom & Middlecamp 2017), or utilize emerging high-tech-based approaches, such as game-based learning (e.g. Madani, Pierce & Mirchi, 2017). Each of these approaches advocate teaching and learning through the process of solving actual, real-world sustainability problems as an effective means of developing sustainability competencies (Rowe, 2007; Brundiers, Wiek & Redman, 2010; Remington-Doucette et al., 2013). Most of the ESD pedagogical frameworks that incorporate real-world problem solving opportunities were developed based on problem-based learning (PBL), project-based learning (PjBL) or the integration of PBL and PjBL (e.g. Brundiers, Wiek & Redman 2010). Therefore, the following discussion concentrates on elaborating the theory and practice related to PBL, PjBL and the integrated models of PBL and PjBL, which form a theoretical foundation for the development of a ESD pedagogical model that facilitates the effective implementation of generic green modules for students' generic green skills.

1. *Problem-based learning*

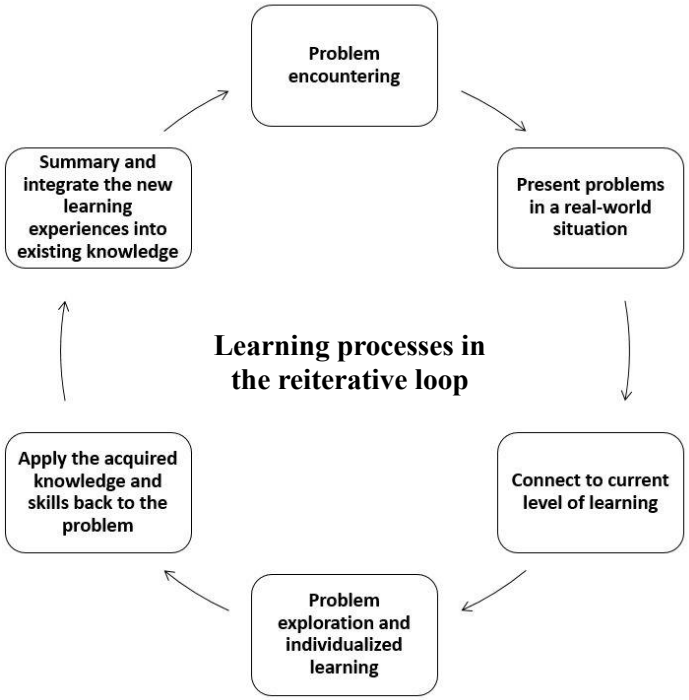
Problem-based learning (PBL) is widely identified as an effective approach for ESD as it focuses on complex interdisciplinary problems, and provides students with the opportunity to gain experience in addressing complex problems they may encounter in their future careers (Steinemann, 2003). PBL encourages students to work in teams and integrate theory with practice to identify solutions to problems, which is the primary aim of the PBL approach to professional education (Savery, 2006).

The foundations of problem-based learning are firmly based on the work of researchers, such as Dewey, Piaget, Bruner and Gagne. Barrows (1986) summarized the important

objectives related to PBL as: developing problem solving and self-directed learning abilities, structuring integrated learning for practice and supporting motivation for learning. He also provided a useful taxonomy to rank the approaches that have the potential to achieve these objectives, and suggested that the use of reiterative methods is more likely to be successful. This study employs the reiterative loop of PBL proposed in Ryan & Quinn (1994) as the foundation for further developing the ESD pedagogical framework. The learning processes in this reiterative loop were:

Figure 2

Learning processes in the reiterative loop of PBL



Note. This figure is based on Ryan & Quinn, 1994.

It is worth noting that these learning processes present challenges for teachers in terms of supporting students' individual learning and designing appropriate learning activities that can facilitate students' knowledge application and transformation.

2. *Project-based learning*

Project-based learning (PjBL) is a form of situated learning, based on constructivism theory. This theory suggests that students gain a deeper understanding of the learning material when they actively construct their understanding by working with, and using, ideas in real-world contexts. (Krajcik & Shin, 2014). PjBL, which combines knowledge application with project practice, can help students consolidate and broaden their

understanding (Tempelman & Pilot 2011), and can also provide opportunities for students to develop the communication, problem-solving and team-working skills which will be needed in their future careers (Elshorbagy & Schönwetter, 2002). Furthermore, when students perceive they are honing professional skills required in their future careers, their learning motivation will be enhanced (Fang, 2012). This kind of motivation can be sustained through meaningful, real-world problem solving and projects (Bell, 2010).

A pan-European study, which compared sustainability subjects in technology universities, found that the most effective pedagogy for students to learn about sustainable development was a community-based project that involved collaboration between multiple learners, as well as the use of a constructive-learning pedagogy (Jollands & Parthasarathy 2013). Another recent study also demonstrated that PjBL can effectively improve students' generic green skills specifically in relation to project management, collaboration and communication proficiency (Ana, Sunarsih & Roheani, 2015).

However, there is no one broadly accepted definition and model of PjBL. The Buck Institute for Education (BIE) is a research and development organization that specialized in research on project-based instruction, and has done significant work on improving the effective application of PjBL. This study suggests using the **'BIE Standards-Focused'** PjBL model (Markham, Larmer & Racitz, 2003) as the foundation for further developing the ESD pedagogical framework, for several reasons.

First, BIE defines standards-focused PjBL as

> a systematic teaching method that engages students in learning knowledge and skills through an extended inquiry process structured around complex, authentic questions and carefully designed products and tasks. (Markham, Larmer & Racitz, 2003, p.4)

It reveals BIE Standards-Focused PjBL, which places an emphasis on student engagement, inquiry learning and authentic context, is consistent with the ESD learning process that stressed "collaboration, whole system, innovation and participation".

Moreover, it also explained that

> This definition encompasses a spectrum ranging from brief projects of one to two weeks based on a single subject in one classroom to yearlong, interdisciplinary projects that involve community participation and adults outside the school. (Markham, Larmer & Racitz, 2003, p.4)

In other words, this model is flexible, which makes it particularly suitable for designing projects that are composed of different topics and based on different disciplines, and involving different stakeholders.

Second, it can address the singular need in the field of PjBL that is required for creating standards-focused projects which fit well with the need for accountability and performance. Markham, Larmer & Racitz (2003) pointed out that

> Project Based Learning is sometimes equated with inquiry-based or experiential

> learning. Though PjBL shares some overlapping characteristics with these two terms, standards-focused PjBL is designed to acknowledge the importance of standards and evaluation of student learning. (p.5)

As a result, Standards-based PjBL that incorporates clear standards, appropriate challenges and valid assessment methods can render the evaluation of students' learning visible and meaningful. However, there is one issue worth noting: the purpose of using driving questions in students' project learning is considered to be a way of creating a need to comprehend the learning material in the standards-based PjBL model. Markham, Larmer & Racitz (2003) stated

> In standards-based PjBL, students are pulled through the curriculum by a driving question or authentic problem that creates a need to know the learning material. The driving question is tied to content standards in the curriculum, and assessment is explicitly designed to evaluate the students' knowledge of the content. (p.5)

Here Markham, Larmer & Racitz (2003) is suggesting teachers use a driving question to help students know the learning material. This could be one feature of driving problem. However, for this study, the purpose of a driving question is not only for knowing the learning material, but more importantly, it should facilitate students to explore a real-world sustainability issue. In addition, learning objectives should not be limited to content knowledge and assessment should also not be explicitly designed to evaluate students' knowledge of content. Instead, a driving question should focus more on both evaluating students' ability to apply knowledge and the process of inquiry learning, as well as encouraging students to devise workable solutions to sustainability issues in the real world.

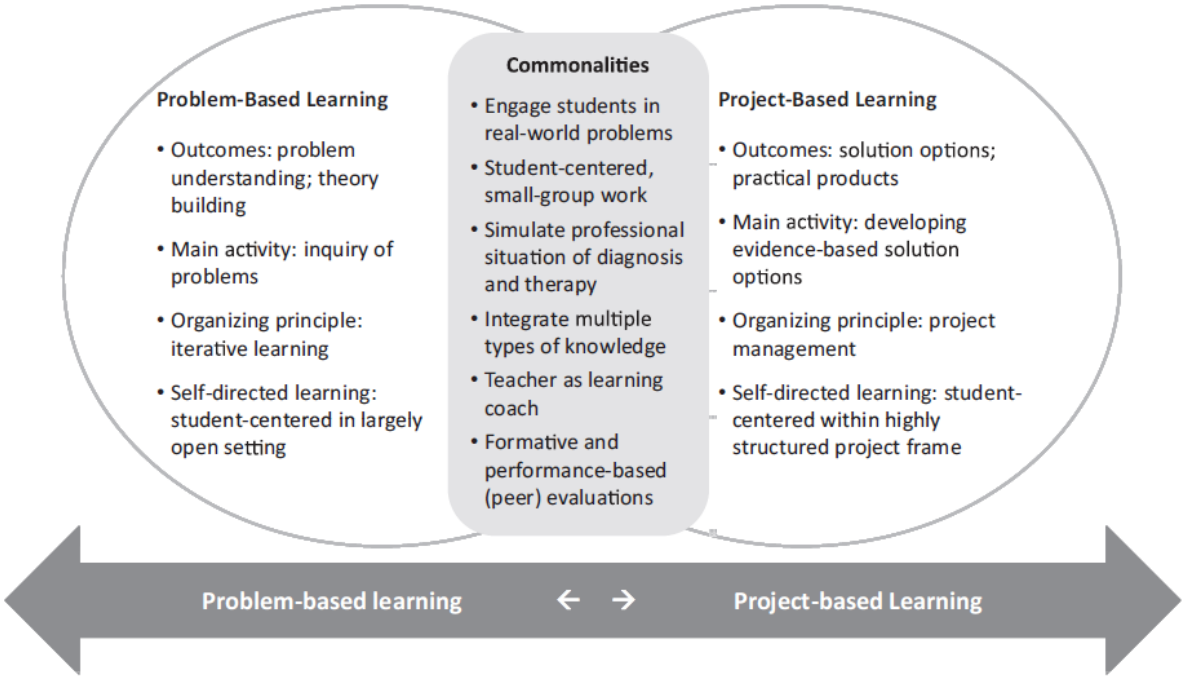
Finally, this standards-based PjBL was accessible and well considered. It clearly specified six steps to help teachers to plan an effective project, which were:

i. Develop a project idea
ii. Decide the scope of the project
iii. Select standards
iv. Incorporate simultaneous outcomes
v. Work from project design criteria
vi. Create the optimal learning environment

Furthermore, PBL and PjBL are considered to have numerous commonalities and are often combined into hybrids (Savery, 2006; Sipos, Battisti & Grimm, 2008; Wiek et al., 2014). Brundiers and Wiek (2013) revealed the commonalities of PBL and PjBL and differences between them in terms of outcomes, main activity, organizing principle and self-directed learning, and presented it in a figure (Figure 3) below. Although the differences presented in this figure distinguish PBL from PjBL, both models has some interrelated aspects. For instance, "inquiry of problem" as the main activity of PBL could be an important part of the main activity "developing evidence-based solution options" in PjBL. In this sense, the outcomes of PBL could be included in PjBl too.

Figure 3

The commonalities and differences between PBL and PjBL



Note. From "Do We Teach What We Preach? An International Comparison of Problem- and Project-Based Learning Courses in Sustainability" by K. Brundiers, and A. Wiek, 2013, *Sustainability, 5(4),*p.1727.

However, the differences reveal that when PBL is centered on problem understanding and knowledge acquisition, it can contribute more to the development of cognitive competence, while PjBL focuses more on problem solving and solution exploration, so it tends to lead to the development of strategies and technological competences. In the final analysis, the two approaches propose student-centered, small-group work, learning in real-world settings and interdisciplinary learning, therefore they are consistent with the identified ESD learning processes.

3. *The integrative models of PBL and PjBL*

ESD has increasingly focused on integrating problem- and project-based approaches to create more real-world learning opportunities for students so they can better understand and address sustainability challenges (Brundiers & Wiek, 2013; Wiek *et al*., 2014; Kricsfalusy, George & Reed, 2018).

Brundiers and Wiek (2013) explained the reasons for combining PjBL and PBL: first, the combination of PBL and PjBL can avoid both the risk of "getting caught in the knowledge-first trap by endlessly analyzing problems", and of "jumping prematurely to solutions without sufficient problem framing and analysis" (p. 1728); second, the combination can expand the engagement structure of PBL by involving stakeholders in a collaborative learning and critical reflection process instead of simply involving stakeholders who act as consultants. There are at least three approaches identified in the literature that have integrated PBL and PjBL.

1) The Problem- and Project-Based Learning (PPBL) approach

The problem- and project-based learning (PPBL) approach is based on constructivist and experiential learning, which specifically integrates the approaches of PBL and PjBL (Wiek et al., 2014). It adopts the learning process of problem inquiry as in PBL to formulate solutions for problem solving through group projects. In these settings, learning shifts from passive to active, whereby students investigate a real-world problem and work on solutions/options by engaging in small-group work (Brundiers & Wiek, 2013). In addition, the PPBL approach features peer- and self-evaluations, reflection on activities, critical thinking as well as quality of outputs. Field experts or project stakeholders might be invited to consult and evaluate students' work from a professional perspective. Compared to lecture-based learning, which mostly focuses on knowledge transmission and cognitive development, the PPBL approach places more emphasis on students' active roles and their sense of self-responsibility for developing knowledge, skills and attitudes.

Since 2007, Arizona State University (ASU)'s School of Sustainability (hereafter SOS) which is the first school in the USA with credible undergraduate and graduate programs in sustainability, has incorporated PPBL opportunities into learning and teaching practice (Brundiers, Wiek & Redman, 2010; Redman & Wiek, 2012; Brundiers & Wiek, 2013). These PPBL activities provide students with unique settings to facilitate their professional capacity building by collaboratively identifying, analyzing and developing solutions/options to sustainability problems at local and international scales (Steinemann, 2003; Thomas, 2009; Wiek, Withycombe & Redman, 2011; Yasin & Rahman, 2011, Wiek et al., 2014). In 2010, a PPBL model (the ASU-SOS "functional and progressive" model) was proposed for building sustainability competence by effectively and structurally integrating real-world learning opportunities into the curriculum (Brundiers, Wiek & Redman, 2010).

2) Problem Oriented Project-Based Learning approach

A similar approach, proposed to address ESD, has been problem oriented project-based learning (POPBL). Yasin and Rahman (2011) indicates "POPBL has to start with the analysis of a research problem followed by the design of the project to solve the problem through the implementation of the activity planned in order to solve the problem under study" (p. 3).

It has been argued that project-based learning in subject-oriented curriculum and problem-oriented project work is crucially different (Kolomos, Fink & Krogh, 2004; Olsen & Pedersen, 2005; Yasin & Rahman, 2011). In a normal subject-oriented project-

based curriculum, students work with questions and themes decided by teachers, and teachers play the role of an expert to demonstrate "how students in a constructive way can relate curriculum and theories to praxis" (Nielsen & Danielsen, 2012, p. 258). In this way students are given, or choose, the topic to "learn", rather than being given the responsibility of identifying the real-world problem they will work on. This kind of "PBL" ignores the notion that formulating a problem is a significant part of the learning process in PBL (Yasin & Rahman, 2011, Nielsen & Danielsen, 2012). The basic principles of POPBL are:

- Student-centered and able to motivate and gain commitment among students
- Problem-oriented not subject-oriented
- Focus is on the learning process and finding solutions rather than knowledge recall
- Project-based, which involves goals and actions for change
- Exemplarity instead of generality
- Promotes group/teamwork, social and communication skills

(Yasin & Rahman, 2011, p.3)

Pavlova (2015) suggests that POPBL helps students to incorporate ethics in the decision-making process and enables reflection on the issues and proposed solutions, and from this perspective it would play a central role in developing pedagogical approaches to ESD. POPBL starts from the identification of an issue/problem and the development of specifications or criteria that the solution should address. This leads to a formulation of several ideas; the selection of the best solution and its subsequent development; experimentation and evaluation; obtaining feedback from different stakeholders; and subsequent improvements to the suggested solution. This process is not linear and requires reflection at each stage throughout the course of the project; it might take students back to the previous stages.

The POPBL approach, for example, has been used in an ESD program – "Life Sciences in Education" – the first ESD course for teacher education at the National University of Malaysia. The positive aspects of adopting POPBL in this program are that the students enjoy and learn a lot through community involvement and real-life situations; they learn and apply generic skills, such as team and interpersonal communication, in group project work (Yasin & Rahman 2011); it also be suggested that the POPBL approach is effective in developing students' generic green skills. The technology teacher-training program at Griffith University (Pavlova, 2009) used this approach for students' final year projects. They needed to pull together all the knowledge and understanding they had developed through the program to identify an issue, formulate a problem (brief) for the project and find a solution within the context of sustainable development.

3) Problem-Based and Project-Organized approach

The problem-based and project-organized approach (Aalborg Model) (Kjærsdam & Enemark, 1994) is another integrative approach targeted at problem solving through project work. It combines the problem-based (meta-concept) and project-organized approaches, and involves problem-orientation, project work, interdisciplinary, participant

directed-learning, exemplary principles and teamwork (Kolmos, Fink & Krogh, 2004). All the learning activities, in different learning processes within this model, are fundamentally centered on problem solving. The Aalborg Model has been used at the Aalborg University across all educational programs, including sustainability programs, such as engineering science and sustainability (Holgaard et al. 2016).

To sum up, the combination of PBL and PjBL provides students with more opportunities to solve real-world problems in order to foster their sustainability competencies. The *project work* offers an opportunity for students to address a real-world problem and create changes in some way, while the *problem-oriented/based learning* process facilitates learning through problem formulation and exploration. All integrative approaches/models emphasize the importance of interdisciplinary learning, self-directed learning, community involvement and real-world problem solving.

However, they each have a slightly different emphasis: the PPBL approach accentuates situations outside classroom settings; the POPBL approach places more emphasis on problem formulation as an essential part of the learning process; and the Aalborg Model highlights the principle of interdisciplinarity, in which all learning activities are centered on problem solving and crosses different programs. Although these models were developed and used mainly in higher education (Bachelor and Master levels) and were not specifically applied to the TVET context, they provide the important theoretical foundation for the development of an ESD pedagogical model for TVET that will be presented in the methodology chapter.

2.1.3 The Identified ESD Pedagogical Strategies

This section reviews ESD pedagogical strategies, which are commonly used, or suggested, in the literature on ESD education. Tilbury (2011) reviewed approximately 200 articles to ascertain the specific processes and learning for ESD and highlighted the more common ESD pedagogical strategies utilized in higher education. These include: Role play and simulations (to gain an in-depth understanding of another person's perspective); Stimulus activities (e.g. watching a video or looking at photos, poems or newspaper articles to initiate reflection or discussion); Debates (to encourage the development of arguments and counter-arguments on a topic); Critical incidents (to consider students' personal perspectives and actions in relation to a moral or ethical stance – what they would do, could do and should do); Case studies (to develop a holistic view on an issue relevant to their context and to devise a solution); Reflexive accounts (to understand the effect of individual action on issues/solutions); Critical reading and writing (to understand possible motivations of the author and how the author might envisage alternative futures as a consequence); Problem-based learning (to identify solutions based on investigation, developing a vision and plan of action); Fieldwork and outdoor learning (to link theory and real-world examples, promote active learning and develop an understanding of the complexity of sustainability); Modeling good practice (to demonstrate action-taking behavior, such as reducing paper use, turning off lights at the end of the class) (Cotton & Winter, 2010; Tilbury, 2011).

In an attempt to further classify pedagogical strategies for ESD in higher education, Lozano *et al*. (2017) selected twelve strategies either from well-cited ESD literature or

strategies that have been broadly adopted. These pedagogical strategies are non-exclusive; there is some overlap in techniques and the clear potential to use two, or more, of the educational strategies synergistically:

- Universal: broadly applicable pedagogies that have been used in many disciplines and contexts (including case studies, interdisciplinary team teaching, lecturing, mind and concept maps, and project and/or problem-based learning);
- Community and social justice: pedagogies developed specifically for use in addressing social justice and community building (including community service learning, jigsaw/interlinked teams, participatory action research); and
- Environmental education: pedagogies emerging from environmental sciences and education practices (including eco-justice and community, place-based environmental education, supply chain/life cycle analysis, and traditional ecological knowledge)

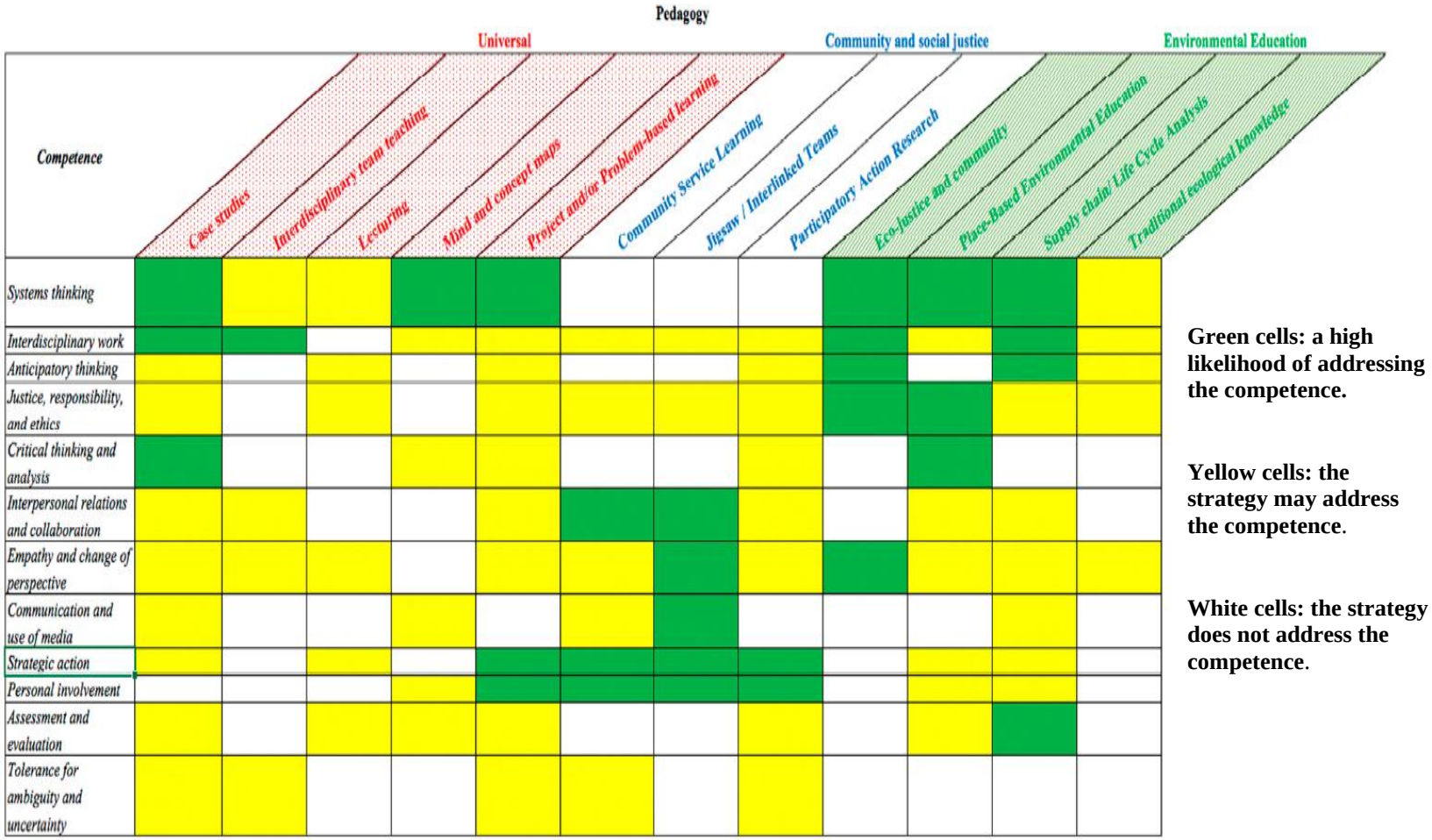
(Lozano et al. 2017, p. 6-7)

In addition, Lozano *et al*. (2017) map the extent to which specific sustainability competencies can be developed through different pedagogical approaches (see Figure 4 below) based on an iterative interpretative approach. The different colors refer to different levels of the effectiveness in addressing identified competencies. The green cells indicate a high likelihood of addressing the competence, the yellow cells indicate that the approach may address it, and the white cells indicate that the approach does not address the competence. For example, systems thinking was indicated that it has a high possibility to be addressed through case studies, mind and concept maps, project and/or problem-based learning, eco-justice and community, place-based environmental education as well as supply chain/life cycle analysis; and it may be addressed by interdisciplinary team teaching, lecturing and traditional ecological knowledge; and it cannot be addressed by community service learning, jigsaw/interlinked teams and participatory action research. It is worth noting that, approaches marked by Lozano *et al*. (2017) as ‘white cells’ can still be used for addressing relevant competencies, such as community service learning, that was found by other scholars to be effective in addressing system thinking (e.g. Lasker, 2019) and critical thinking and analysis (e.g. Sedlak et.al, 2003). Nevertheless, this framework provides a suitable approach for identifying strategies that can contribute towards the most effective development of generic green skills.

In summary, the pedagogy approaches identified in the figure could be used in different ESD learning contexts, based on a comprehensive consideration of students’ characteristics, their previous learning experience about sustainability, the learning objectives for specific lessons, as well as the learning resources and space available for ESD education.

Figure 4

Framework connecting sustainable development pedagogical approaches to competences



Note. From "Connecting Competencies and Pedagogical Approaches for Sustainable Development in Higher Education: A Literature Review and Framework Proposal" by R. Lozano, M. Y. Merrill, K. Sammalisto, K. Ceulemans, and F. J. Lozano, 2017. *Sustainability (Basel, Switzerland)*, *9*(10), p.15 (https://doi.org/10.3390/su9101889)

2.1.4 Justification of the crucial role of ESD pedagogy in effectively implementing generic green modules in TVET

Based on the literature review above, this section considers arguments in support of the study's assumption that ESD pedagogy can effectively facilitate the implementation of generic green modules and develop students' generic green skills within TVET.

The need for translating learning targets and outcomes of ESD into learning activities and teaching strategies has been proposed in the literature (UNESCO, 2005; Pavlova, 2009, 2015). ESD pedagogy was hypothetically proposed in this study as an effective approach to the implementation of generic green modules in TVET for three reasons.

First, most of generic green modules in TVET are transdisciplinary (see an example of one such module in Table 1). These modules include complex sustainability issues and therefore they should require students to develop solution options towards problem solving. Wiek *et al*. (2013) indicated

> Sustainability science is distinct from other disciplines because it develops solution options to specific types of complex societal problems. Developing solution options to these problems requires in-depth exploration, as well as collaboration across different types of expertise. (p.433)

This highlights the importance of learning in an explorative, collaborative and cross-disciplinary setting. In addition, the learning objectives of sustainability programs, and the pedagogical strategies that support students' competency development for sustainability, should

> equip students not only with content knowledge and analytical skills but also with interpersonal competencies and transdisciplinary/transacademic work experience. These skills cannot be developed through lecture-based activities alone, but require hands-on practice, teamwork and community engagement opportunities. (Wiek et al., 2013, p. 443)

Wiek *et al*. clearly revealed the importance of developing student competencies through pedagogical innovation that facilitates students' experiential, collaborative and engaged learning, rather than utilizing lecture-based activities alone. ESD pedagogy that places an emphasis on real-world problem solving, transdisciplinary learning and society engagement has the potential to maximize the effectiveness of generic green modules and facilitate the innovation of teaching and learning approaches towards sustainability.

Second, the sustainability issues included in generic green modules, such as climate change, affordable and clean energy, and pollution control are urgent, long-term and highly complex problems, which cannot be solved with simple remedies such as *"technical fixes"* (Brundiers & Wiek, 2011, p. 109). Analyzing and solving these wicked problems requires a particular key set of sustainability competencies, such as system thinking, normative and strategic competencies that can generate, integrate and link use-inspired knowledge to transformational action (Wiek, Withycombe & Redman, 2011; Remington-Doucette, *et al.*, 2013). For instance, the module outline for Green Knowledge and Green Practice (see Table 1) reveals that students will not only learn

environmental knowledge and issues, such as ecosystems and global warming, in the classroom, but they will also need to work out how to deal with these issues (such as ways of controlling pollution) in the work process and in the work area. It could be argued that ESD pedagogy, which facilitates value-driven learning, participatory decision-making and adaptability in problem solving can contribute to the effective implementation of generic green modules, particularly modules that aim to encourage students to explore solutions for sustainability and develop their competencies in terms of solving complicated sustainability problems.

Finally, comparing with other forms of higher education such as academic-based undergraduate programs in university, TVET focuses more on equipping the future workforce with essential work skills. Since human capital development has been identified as an integral part of green growth strategies in the literature (e.g. OECD, 2011, Pavlova, 2015), it is important for the generic green modules in TVET to equip students with generic green skills required in almost any occupation so they are able to understand and address issues related to green growth. ESD pedagogy, which facilitates transformative learning by creating real-world learning opportunities for students to work on a practical level to solve sustainability problems, plays an important role in enriching the teaching and learning of generic green modules and further developing students' work skills in greening.

Based on the foregoing analysis of the ESD literature, it is now necessary to identify the potential ways that ESD pedagogy could be integrated into the teaching and learning of generic green modules, and to identify the relevant pedagogical strategies that will effectively facilitate the achievement of different learning outcomes and the development of generic green skills.

Table 1

Learning Contents and Indicative Contact Hours of "Green Knowledge and Practices"

Learning Contents	Indicative Contact Hours
Environment • Ecosystem, biotic and abiotic factors • Resources; materials cycles • Ways to treat and dispose waste • Pollution and its effects on the environment • Local environment of Hong Kong; main environmental problems in Hong Kong and their impacts; major environmental infrastructure and initiatives • Biodiversity and conservation	6 hours
Environmental law and regulations • Overview of environmental laws and regulations • Purposes and controls of environmental regulation; offences, codes of practices / technical memorandum • Trade-specific environmental regulation	3 hours
Sources, nature and control of pollution in the work process and work area • Review of various kinds of pollution problems • Sources, nature and impacts of pollutants arising from the work process or in the work areas • Ways to control pollution in the work process and work area	4 hours
Green office / workplace • Importance and proper work ethics towards waste reduction and resources conservation • Working tips and some latest developments to conserve resources use and minimize waste; good practices; case studies • Introduction to Environmental Management System (EMS) and ISO14001	6 hours
Climate change and carbon footprint • Greenhouse gases, greenhouse effect, global warming with industrial revolution, consequences, mitigation • Carbon footprint, ways to reduce carbon footprint	4 hours
Sustainable development and corporate social responsibility • Sustainable development: concept of sustainable development, ways to achieve, sustainability indicators • Corporate social responsibility (CSR): rationale, concept, CSR policy and program	3 hours

Note. The module syllabus was developed by the TVET institution in 2015.

2.2 Conceptualization and Classification of Generic Green Skills

"Green skills" is a relatively new research area as the first publications appeared after 2009, and there is a lack of consistency in interpreting what green skills are in the literature (Pavlova, 2017). As this study aims to explore how ESD pedagogy could be applied, and innovated, to facilitate the development of generic green skills[1] within TVET, the nature of green skills and its classification is discussed and conceptualized below.

Green skills have been identified as

> Technical skills, knowledge, values and attitudes needed in the workforce to develop and support sustainable social, economic and environmental outcomes in business, industry and the community. (NCVER, 2020, p. 23)

Another definition provided by Cedefop (2014) suggests that green skills are

> Abilities needed to live in, develop and support a society which aim to reduce the negative impact of human activity on the environment. (p. 101)

The definitions of green skills above reveal, firstly, green skills are proposed based on the concept of sustainability, which in turn highlights the significance of developing sustainable societies, economies and environments. However most considerations of green skills tend to place more emphasis on the sphere of environment. In addition, green skills are regarded as the skills for sustainability in some of the literature. For instance, skills for sustainability are considered to be the same as green skills in the policy paper of "The Australian Green Skills Agreement" (Council of Australian Governments, 2009). Acedo (2014) also analyzes the relationship between ESD and green skills, and suggests, "ESD is at the core of green skills… There can be no sustainable development without education and without appropriate green skills for employability" (p. 137-139). Secondly, it is considered that green skills should play a major role in the greening of business, industry and community; this raises challenges for TVET as it is expected to develop a future workforce to support greener economy and society. Accordingly, green skills could be regarded as the sustainability competencies that are specifically required for green growth (including environmental, social and economic aspects) within the TVET context.

Furthermore, the Cedefop (2010) study makes a distinction between specific green skills, generic green skills and the necessity of topping-up existing skills. Topping-up skills refers to upskilling or adding to existing core skills in order to enable a person to meet the requirements of a new occupation that is associated with the transition to low-carbon economies. Regarding the distinction between generic green skills and specific green skills, it is widely accepted in the literature that the former are generic/key/core competencies needed in almost any occupation, and the latter are task-oriented competencies required for a specific occupation (e.g. European Commission, 2009;

[1] Generic green skills are one type of green skills, see literature review below.

National Research Council, 2012; Pavlova, 2017). However, there is some ambiguity and terminological debates continue, in which the term "competencies" is associated with skills, abilities, capabilities, capacities, qualification and other concepts (Baartman et al. 2007; Wiek, Withycombe & Redman, 2011; Pavlova, 2017). This study adopts the definition of competency provided in Wiek, Withycombe & Redman (2011) that functionally links the complex of knowledge, skills and attitudes: "Applied to competencies in sustainability, these are complexes knowledge, skills and attitudes that enable successful task performance and problem solving with respect to real-world sustainability problems, challenges, and opportunities" (p. 204).

Pavlova (2017) also indicates that both types of competencies are utilized in a specific context with relevant knowledge, skills and attitudes (beliefs, dispositions and values). She argues attitudes and values should be an essential part of competence education:

> Development of green skills should be framed by values based on weak anthropocentric ethics as argued elsewhere (e.g. Pavlova, 2009, 2013) and a broad understanding of environmental and social processes in the globalised world combined with an active personal position. (Pavlova, 2017, p.938)

Therefore, green skills could be understood as the knowledge, skills and attitudes (including values) required for developing and supporting green growth, and which can also be categorized as generic green skills and specific green skills. Specific green skills include the specific competencies required for green industries and the topping-up existing competencies required in all industries. Generic green skills are the "general" competencies required in almost any occupation to facilitate the future workforce to understand green growth issues and increase their environmental awareness.

Specifically, Pavlova (2017) classifies the identified generic green skills into four categories, namely: cognitive competencies, interpersonal skills, intrapersonal competencies and technological skills. These generic green skills are identified through two approaches. The first approach identified a set of core skills necessary for green jobs. Initially, Pavlova (2017) classified these core skills into three categories based on the framework developed by the OECD (2013) and an analysis of generic green skills suggested by ILO (2011) as follows:

Cognitive Competencies

- Environmental awareness and a willingness to learn about sustainable development.
- Systems and risk analysis, skills to assess, interpret and understand both the need for change and the measures required.
- Innovation skills to identify opportunities and create new strategies to respond to green challenges.
- Understanding the complexity and interconnectedness of sustainable development issues and challenges.
- Identifying ways of being part of the solution.
- Ability to think about things differently.

- Awareness of habits in actions and thought.
- Ability to make judgments based on both evidence and sustainability values.

Interpersonal Skills and Technological Skills

- Strategic and leadership skills to enable policymakers and business executives to set the right incentives and create conditions conducive to cleaner production, cleaner transportation, etc.
- Coordination, management and business skills to facilitate holistic and interdisciplinary approaches that encompass economic, social and ecological objectives.
- Communication and negotiation skills to discuss conflicting interests in complex contexts.
- Marketing skills to promote greener products and services.
- Networking, IT and language skills to enable participation in global markets.
- Consulting skills to advise consumers about green solutions and to spread the use of green technologies.

Intrapersonal Competencies

- Adaptability and transferable skills to enable workers to learn and apply the new technologies and processes required to green their jobs.
- Entrepreneurial skills to seize the opportunities of low-carbon technologies.

Furthermore, the second set of generic green skills, which were collated based on the greening approaches utilized in Denmark Germany, the UK and the USA that relate to similar greening processes across sectors (Percapita Report, 2010, as cited in Pavlova, 2017), were also included in the generic green skills framework as a fourth category, namely **Technological Skills**. There include:

- Quantification and monitoring (waste, energy, water)
- Management systems (waste, energy, water)
- Procurement and selection
- Material use and impact quantification
- Impact and use minimization
- Impact assessment
- Risk management

After consideration of all the elements in this generic green skills framework, it can be seen that some more relate to the development of attitude, such as “Environmental awareness and a willingness to learn about sustainable development”; some need to be developed, based on specific knowledge requirements, such as “System and Risk Analysis Skill” and some need to follow specific operational processes, such as “Material use and impact quantification”. However, the development of all these competencies is correlated and integrated. More specifically, the knowledge and attitudes related to cognitive competence development can have a considerable influence on the development of other kinds of competencies in the framework. For example, students’ interpersonal skills (e.g. discussing sustainability issues, promoting greener products and services) need to be developed based on the knowledge and attitudes formulated in

cognitive competency. Therefore, the learning activities that facilitate the development and practice of these competencies should be comprehensively designed in a competency-based approach.

2.3 Learning theories underlying the developed models

This section provides a brief review of the learning theories that form the theoretical foundation for the learning models proposed in the discussion chapter, including transformative learning, experiential learning and reflective learning.

2.3.1 Transformative learning

A specific definition of transformative learning is in "Expanding the boundaries of transformative learning: Essays on Theory and Praxis" (Morrell & O'Connor, 2002):

> Transformative learning involves experiencing a deep, structural shift in the basic premises of thought, feelings and actions. It is a shift of consciousness that dramatically and permanently alters our way of being in the world. Such a shift involves our understanding of ourselves and our self-location; our relationships with other humans and with the natural world; our understanding of relations of power in interlocking structures of class, race, and gender; our body-awareness, our visions of alternative approaches to living; and our sense of possibilities for social justice and peace and personal joy. (p. xvii)

This definition is echoed in Mezirow's (1978, 1985 & 2000) earlier work, and Freire (1972); they suggest that transformative learning refers to transforming a problematic frame of reference to make it more dependable and inclusive that implies **an expanded** consciousness, consistency and cognition of the contextual reality of the learning situation (Sterling, 2011), and transforming perspectives to empower individuals to change their worldviews (Moore, 2005). This kind of learning, that leads to a deep and structural shift in thought, feelings and actions and arrives at new ways of thinking and being (Cranton, 2006), has been argued to play a crucial role in the development of sustainability competence. Stephen Sterling, who was at the forefront of promoting transformative learning for ESD, pointed out how transformative learning influences the levels of knowing, perception, and action:

> Transformative learning is normally taken to mean learning which touches our deeper levels of knowing and meaning, and, by so doing, then influences our more immediate and concrete levels of knowing, perception, and action. (Sterling, 2011, p. 22)

Sterling (2011) further distinguished "transformative learning" from confirmative and reformative learning by drawing on Gregory Bateson (1972)'s work on three orders of "learning and change", which correspond to increases in learning capacity. Specifically,

- First-order change refers to "doing 'more of the same', that is, change within particular boundaries and without examining or changing the assumptions or

values that inform what you are doing or thinking", which can be regarded as "Basic learning".

- Second-order change refers to "a significant change in thinking or in what you are doing as a result of examining assumptions and values, and is about understanding the inner or subjective world.", which can be regarded as "Meta-learning".
- Third-order change refers to "a shift of epistemology or operative way of knowing and thinking that frames people's perception of, and interaction with, the world.", which can be regarded as "Epistemic learning" .

(Sterling, 2011, p. 22-24)

The three learning levels are represented as in Table 2 with arrows indicating a shift towards higher order learning. It describes the change in the three learning orders and its influence on the desired outcomes as well as the implications for actions.

Table 2

Levels of learning

Orders of change		**Desired outcomes**	**Implications**
First order ⬇ Second order ⬇ **Third order**	Cognition Confirmative learning	Effectiveness/Efficiency	Doing things better
	Meta-cognition Reformative learning	Examining and changing assumptions	Dong better things
	Epistemic learning **Transformative learning**	**Paradigm change**	**Seeing things differently**

Note. Adjusted from "Transformative Learning and Sustainability: Sketching the Conceptual Ground", by S. Sterling, 2011, *Learning and Teaching in Higher Education, 5* (11), p. 25.

2.3.2 Experiential learning

Experiential Learning Theory (ELT) emphasizes the central role experience plays in the learning process. It defines learning as "the process whereby knowledge is created through the transformation to experience. Knowledge results from the combination of

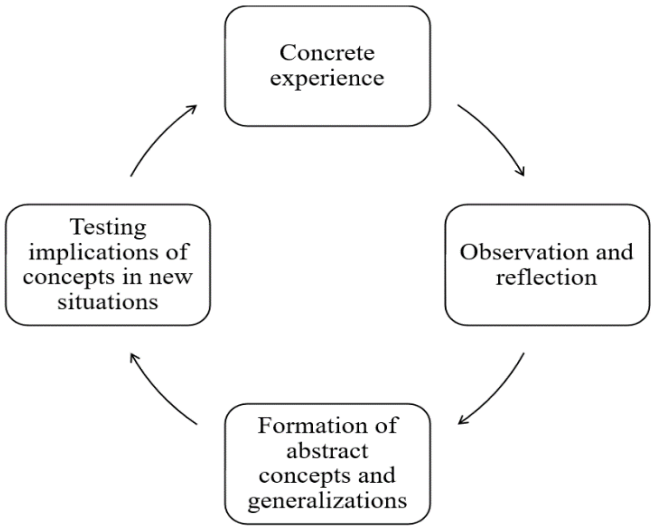
grasping and transforming experience" (Kolb, 1984, p. 38).

In the ELT model, grasping experience is dialectically related to learning stages of **concrete experience (CE)** and **abstract conceptualization (AC)**, while transforming experience is related to **reflective observation (RO)** and **active experimentation (AE)**. Learning, from this perspective, is conceived as a four-stage cycle as shown in Figure 5.

> Immediate concrete experience is the basis for observation and reflection. These observations are assimilated into a 'theory' from which new implications for action can be deduced. These implications or hypotheses then serve as guides in acting to create new experiences. (Kolb & Fry, 1975, p.34).

Figure 5

The experiential learning model



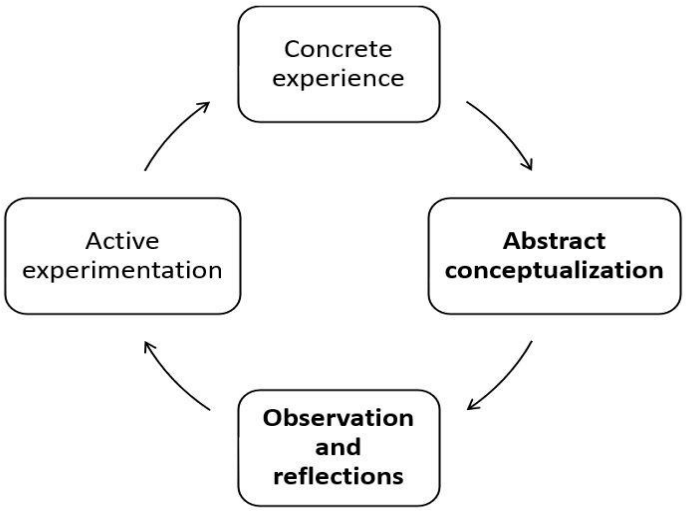
Note. From "Toward an applied theory of experiential learning", by D. A. Kolb and R. Fry, in C. Cooper (Ed.), *Studies of group process*, 1975, p.33. New York: Wiley.

Kolb & Fry (1975) regard learning as an integrated process, with each stage feeding into the next and being mutually supportive at each stage. The learner reflects on the experience and generates abstract concepts, which become the conclusions that can then be applied to new experiences. In addition, the cyclical nature of the model also means it is possible to enter the cycle at any stage and follow it through the logical sequence.

Moon (2004) later proposed a reproductive cycle that follows Kolb & Fry's terminology, but reverses "abstract conceptualization" and "reflection", as shown in Figure 6.

Figure 6

The reproductive experiential learning model



Note. From *A handbook of reflective and experiential learning: Theory and practice* by J. A. Moon, 2004, p.126. London; New York: RoutledgeFalmer.

Although the learning sequences in the two models differ slightly, the same key processes are involved – experiential learning facilitates the learner to transform concrete experience into active experimentation through reflection, and abstract conceptualization, in order to achieve change.

2.3.3 Reflective learning

Moon (2004) suggests that reflective learning simply emphasizes the intention of learning as a result of reflection. There are four ways reflection is involved in learning.

First, reflection is involved in the process of meaningful learning when a learner takes a deep approach in order to grasp the meaning of new material with reference to previous knowledge. Second, reflection is involved when learning is represented meaningfully (e.g. the act of teaching is an example of the representation of meaningful knowledge). During this process, the learning material needs to be modified to meet the requirements of the purpose as well as the format of knowledge representation. As a consequence, a greater understanding of new ideas can be gained if they are represented through the reformulation of current understanding.

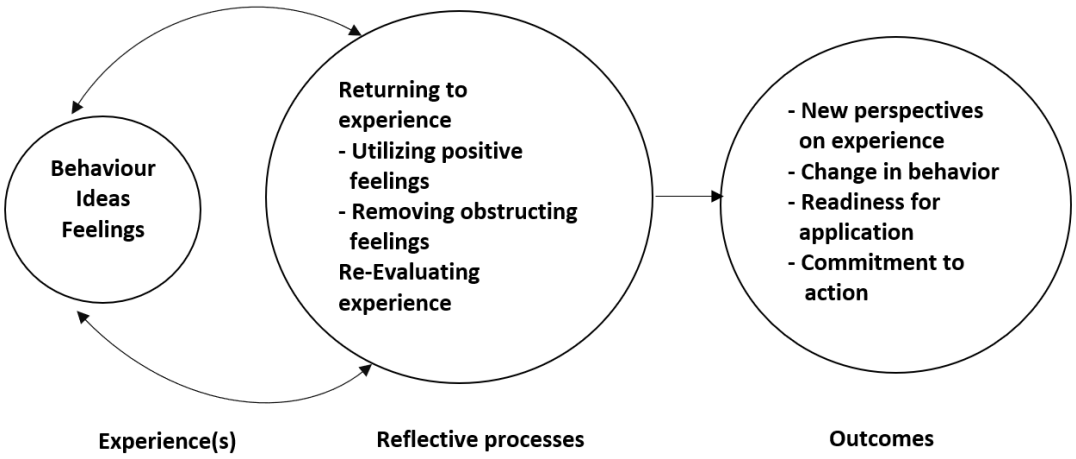
The third way reflection is involved in the learning process is by "upgrading learning", which means that although there may be nothing new to learn in terms of content, ideas

learned in a relatively non-meaningful way are reconsidered in the light of new experience in order to make less meaningful learning more meaningful ("deepened") (Moon, 1999). Thus, reflection on ideas is based on reconsidered experience. Finally, reflection is involved when learners generate apparently new and meaningful ideas, which are not immediately related to existing knowledge, but are based on what they "know" already (their prior experience). This process is similar to intuition, and is encapsulated in the phrase, "I saw the light" (Atkinson & Claxton, 2002, cited in Moon 2004).

Boud, Keogh, & Walker (1985) indicate that reflection in the context of learning is a generic term that refers to a learner's engagement in the exploration of experiences in order to gain new understandings and appreciations. They proposed a model that illustrates the reflective processes in learning (Figure 7).

Figure 7

The reflective process in context



Note. From "Promoting Reflection in Learning: a Model", by D. Boud, R. Keogh & D. Walker in D. Boud, R. Keogh & D. Walker (Eds.), *Reflection, turning experience into learning*, 1985, p.36. London; New York: RoutledgeFalmer.

This model reveals the relationship between experience(s) and different reflective processes. The totality of experiences includes: the behavior people have performed, the ideas of which people are aware and the feelings they have experienced. Each of these

experiences can become the subject of reflection by returning to the experience and re-evaluating it. The outcomes of this type of reflective learning are that learners gain new perspectives on their experiences, they make changes in behavior, and demonstrate readiness and commitment to act (Boud, Keogh, & Walker 1985).

Accordingly, Boud, Keogh, & Walker's (1985) and Moon's (2004) models both suggest that learners' prior experience, as well as new experiences, are the essential foundations for reflective learning. Through the cycle of returning and re-evaluating experience(s), learners become involved in the process of knowledge application and make changes to their behavior, attitudes and values.

2.4 The definition of engagement

The multidimensional construct of engagement has been discussed in the research literature (e.g. Fredricks, Blumenfeld & Paris, 2004; Reeve, 2012; Klassen, Yerdelen & Durksen, 2013), which defines engagement in three ways: behavioral engagement, emotional engagement and cognitive engagement. Fredricks, Blumenfeld & Paris (2004) point out that the concepts included in three components of engagement overlap with some constructs, such as student attitudes and interest that has been connected with emotional engagement, which means conceptualizing and examining the portions of literature that discuss "engagement" is potentially problematic, because it can result in a proliferation of constructs, definitions, and measures of concepts that differ slightly.

> In many ways, the concepts included in the three types of engagement overlap with constructs that have been studied previously. For example, research on behavioral engagement is related to that on student conduct and on-task behavior (Karweit, 1989; Peterson, Swing, Stark, & Wass, 1984). Research on emotional engagement is related to that on student attitudes (Epstein & McPartland, 1976; Yamamoto, Thomas, & Karns, 1969) and student interest and values (Eccles et al., 1983). Research on cognitive engagement is related to that on motivational goals and self-regulated learning (Boekarts, Pintrich, & Zeidner, 2000; Zimmerman, 1990). (p. 60)

Despite these problems engagement, as a multidimensional construct, can have considerable potential in uniting three of the highly intercorrelated components in a meaningful way (Fredricks, Blumenfeld & Paris, 2004). The fusion of behavior, emotion, and cognition under the idea of engagement can provide a richer characterization for making judgments concerning "how actively the participants were involved in the learning activity". Fredricks, Blumenfeld & Paris (2004) suggested examining antecedents and consequences of behavior, emotion, and cognition simultaneously and dynamically, to test for additive or interactive effects. Reeve (2012) proposed a framework that illustrates the interrelated aspects of students' engagement during a learning activity. Different studies that examined students' and teachers' engagement in classroom practice have been conducted based on the theoretical foundation developed for the three dimensions of engagement (e.g. Fredricks et al., 2011; Klassen, Yerdelen & Durksen, 2013; Schindler et al., 2017).

For example, Fredricks, Blumenfeld & Paris (2004) discuss how the three components of engagement have been defined, how the definitions vary, and where they overlap. This provides a framework for the analysis of the students' and teachers' engagement in the resource implementation in this study. The adopted definition for the three dimensions of engagement is presented below:

1) Behavioral engagement concerns "involvement in learning and academic tasks and includes behaviors such as effort, persistence, concentration, attention, asking questions, and contributing to class discussion (Birch & Ladd, 1997; Finn et al., 1995; Skinner & Belmont, 1993)."
2) Emotional engagement refers to "students' affective reactions in the classroom, including interest, boredom, happiness, sadness, and anxiety (Connell & Wellborn, 1991; Skinner & Belmont, 1993)."
3) Cognitive engagement refers to "students use metacognitive strategies to plan, monitor, and evaluate their cognition when accomplishing tasks (Pintrich & De Groot, 1990; Zimmerman, 1990)."

(Fredricks, Blumenfeld & Paris, 2004, p. 62-64)

A more specific description regarding the utilization of this engagement framework to assess teachers' and the students' engagement in the resource implementation was presented in the methodology chapter (section 3.5.1).

2.5 Resources Development for ESD Inclusion

The review of literature has identified very few studies, which specifically investigate the development of teaching and learning resources for ESD inclusion. Most of the ESD studies have been focused on identifying the challenges and approaches for curriculum orientation towards ESD (e.g. Brundiers, Wiek & Redman, 2010). However, in attempting to embrace a new approach, it is always necessary to develop teaching and learning resources as well as adopting relevant pedagogical strategies to support the practice and implementation. This section clarifies the nature of resources development and looks at a few resources development models in order to identify the key issues and challenges that have important implications for developing teaching and learning resources for TVET's generic green modules.

2.5.1 The nature of resource development

Resource development in this study can be understood as developing a set of teaching and learning materials that can be used to enrich existing courses/modules or to formulate a new course that focuses on developing students' generic green skills, or to be used as training materials for teachers' professional development with respect to greening TVET. It includes the selection of learning content, the design and writing of relevant learning activities, pedagogical instructions and assessments that support the transfer of "learning content" based on general rationale of ESD pedagogy (e.g. real-world problem solving) as well as the specific course rationale (e.g. who is this course for, what is the course about).

Compared to curriculum development, which is a far broader concept that includes all activities students engage in under the auspices of the school (Rodgers, 1989), resource development focuses more on preparing supportive materials that match the specific learning objectives and provide guidance about how to use the resources. However, it should be noted that a model for curriculum development could also be adapted into course design or resource development. For example, Richards (2001) proposed a model of curriculum development, which includes the processes of

- Needs analysis
- Situation analysis
- Planning goals and learning outcomes
- Course planning and syllabus design
- Providing for effective teaching (e.g. support for teachers, evaluating teaching)
- The role and design of instructional materials
- Evaluation

These processes identified in Richards's curriculum model are also the key elements in resource development. Developing resources also requires an analysis of learners' needs, consideration of the local context and the potential impacts, setting up specific learning outcomes, providing pedagogical support and training for teacher, and an evaluation of the effectiveness of achieving goals. Within all the identified elements, preparing teaching and learning materials is the central aspect. Figure 8 illustrates the resources development model, adjusted, based on Richards's. It indicates the central role of preparing teaching and learning materials in resource development and how this relates to the other processes. In other words, the development of materials should be based on a comprehensive analysis of the constituents in the figure, and contributes to each of the processes. For instance, in terms of "providing for effective teaching", an understanding of effective teaching and ways of achieving it are pedagogical issues that need to be addressed in preparing the materials, while developed materials that draw attention to effective teaching can be used as training materials to support teachers' pedagogical practice, as suggested by Richards (2001)

> In the case of inexperienced teachers, materials may also serve as a form of teacher training – they provide ideas on how to plan and teach lessons as well as formats that teachers can use. (p.251)

Figure 8

The resources development model

Note: This resources development model was developed based on the discussion on the processes of curriculum development in Language Teaching in *Curriculum Development in Language Teaching* by J. C. Richards, 2001). Cambridge: Cambridge University Press.

In addition, Rowntree (1997) suggested that good materials should do many of the things teachers would normally do during their teaching, including:

- arouse the learner's interest
- remind them of earlier learning
- tell them what they will be learning next
- explain new learning content to them
- relate these ideas to learners' previous learning
- get learners to think about new content
- help them get feedback on their learning
- encourage them to practice
- make sure they know what they are supposed to be doing
- enable them to check their progress
- help them to do better

(Rowntree, 1997, p.91)

The identified "things" that good materials should bring about can be reflected to the elements in the model (Figure 8). For example, "arouse the learner's interest" is very related to "need analysis" but not limited to that, while "remind them of earlier learning" is related to situation analysis that reflects on students' prior learning. Thus, preparing teaching and learning materials that encompasses the processes in the resource development model is practically similar to, making these "things" to work together as a sequence of activities. These activities should lead teachers and learners through a learning route which is engaging and provides motivating practices at an appropriate level of difficulty. It is worth noting that, addressing these "things" through different learning activities will increase the effectiveness of materials' design and implementation.

2.5.2 General issues and challenges in resource development

This section summarizes the issues and challenges of developing teaching and learning resources. It is mainly based on a review by Plewes and Issroff (2002), which critically discussed six prominent models that document the learning resources production process. Table 3, below, lists the key elements (e.g. tools, processes and cost curves) of each model and the issues they are concerned with.

Table 3

The key elements and issues in six resource development models

Models	**Elements**
Open University (OU) Course Materials Production Models (Rumble, 1976; 1992; 1997; Bates, 1994; 1995; 2000)	1. Course team with specialized division of labor, including subject experts, educational technologists, a BBC producer, designers, editors and a course assistant. 2. The development and approval of course materials are time-consuming and expensive. 3. Need to consider the organizational and pedagogical difficulties in a collaborative, iterative approach to the distributed authoring of course materials for a virtual university.
Course Lifecycle Model (Bacsich et al, 1999; Bacsich, Ash and Heginbotham, 2001)	1. A three-stage cyclic course model (planning and development; production and delivery; maintenance and evaluation) with the use of activity-based costing (ABC) methods to investigate the cost of product or service involved in resource production. 2. The student perspective is rarely considered. 3. It does not investigate the non-economic issues surrounding resource production.

The Pedagogic Toolkit Model (Oliver and Conole, 2000)	1. An online course design toolkit that enables teachers to input teaching activities and educational processes and to plan and cost the course development process. 2. Three elements, including • "Media rater" looks at the teaching activities to be used. • "Course modeller" allocates student time between the teaching activities. • "Media selector" considers the costs of staff time and resources required to support the course.
Cost Structures of Teaching Methods Model (Chiddick et al., 1997)	1. This model analyses the preparation and presentation time required to produce one hour of student learning for different teaching methods, including lecture and small group, external and in-house Resource-based Learning (RBL). 2. The analysis of cost curves for each of the methods recommended using the fixed-cost teaching methods (e.g. RBL) rather than the variable-cost ones (e.g. small group).
Student Preferences/ Consumption of Learning Resources Model (Hobbs and Boucher, 1997)	1. Student attitudes towards teaching methods should be considered through incorporating "end user preferences". 2. The optimal solution of student preferences coincident with lowest cost requires improvements in the quality of RBL materials.
Course Resource Appraisal Model (Laurillard, 1999)	1. This model tabulates the use of media forms (e.g. communicative) and particular technologies (Web seminar) among different learning activities. 2. It also looks at students' workload that distributed across various learning activities and media, and assesses the implications for the workload of academic, production and presentation.

The review highlighted the common issues in resource development, which include the division of labor (workload for different people in the resources development team), cost analysis, pedagogical consideration (teaching methods, technologies), students' preferences and teachers' preparation for the use of resources. Two challenges can be identified – time and quality assurance – since there can be several drafts and revisions during the development and approval of materials. In this study, all these common issues and challenges were considered comprehensively but particularly in student preferences and teachers' preparations for implementing the resources. These have been reflected to the learning activities designed based on the key characteristics of ESD pedagogy (e.g.

student-centered, applicability and locally relevant), and the resource formats designed to be flexible and time saving for teachers. In addition, among all these models in the table, the pedagogic toolkit model (Oliver and Conole, 2000), that constituted three tools, suggests main issues needed to be concerned when designing a learning activity. Specifically, the tools look at

- What teaching strategies can be used for different learning purposes (Media rater)?
- How many hours are students expected to spend in experiencing different learning processes (Course modeler)?
- What preparations and resources are required to support the activities (Media selector)?

This pedagogical toolkit model suggests designing a format that standardizes the writing of the resources.

Pavlova (2003, 2004) developed a framework for resources to be used for a student-centered approach during problem-oriented and project-based learning for design classes. Student worksheets included considerations of different learning objectives, and the teaching strategies, required resources and time, as well as an assessment that could meet the learning objectives. These resources have been widely used in teaching practices, and so have been validated by practice. A similar standardized approach is suggested for this study.

In summary, this section has clarified the meaning of the term ‘resource development’ for this study and has explained the importance of different elements working as a system to facilitate resource development. It also reviewed resource development models that suggested approaches to resource design. Although these models were not specifically focused on developing resources for facilitating generic green skills development, they provided a general understanding of the issues and challenges that need to be considered and addressed in the resource development for this particular study.

2.5.3 The essential of resource development in the greening of TVET curriculum

The requirement for TVET reorientation for greening has placed considerable emphasis on including ESD into curriculum (UNESCO, 2015; Pavlova, 2017). Using of POPBL model presented in the literature review above, has highlighted the importance of ESD resources that should not be only knowledge-based as the knowledge cannot be translated into sustained action by students beyond the courses (Nolet, 2009; McClam & Diefenbacher, 2015). Thus, for greening TVET curriculum, there is a confirmed need of developing suitable resources that can help to implement innovative pedagogical practices. This section further explains the crucial role of resource development for this study.

First, the development of resources can respond to the need of adjusting the teaching content to include more real-world learning opportunities contextualized in local sustainability issues and solutions. The teaching content with more local sustainability issues can increase students’ engagement and encourage students to be part of the

sustainability solutions.

Second, the resources developed based on POPBL model can act as the engine to facilitate the pedagogical innovation towards ESD inclusion. During the processes of learning to use and implement resources in classroom practices, teachers' capacity for pedagogical transformation and innovation towards ESD inclusion can be enhanced. Particularly, for the inexperienced teachers, the use of resources can serve as a form of teacher training, which provide ideas on how to plan and teach lessons that are problem-based and student-centered (Richards, 2001). Thus, with the availability of suitable resources, it would be more feasible for teachers to transform their pedagogical strategies to effectively engage students in sustainability learning.

Third, studies that focus on greening curriculum (e.g. Pavlova, 2017) and UNESCO-UNEVOC's guide to greening TVET (UNESCO-UNEVOC, 2017) have indicated for greening curriculum, it is essential to facilitate changes on a whole-of-system level which include all elements in curriculum design such as curricula resources, pedagogy, teacher training programs as an interrelated system. In this system, the development of suitable resources can work as the lever in changing the whole curriculum. Specifically, an effective implementation of resources developed for this study by a TVET institution, can require teachers to move to more student-centered and problem-based approach. The implementation of such resources also can provide peer-to-peer training for teachers when they were working with the researcher to facilitate students in different learning activities. Change in assessment methods can also put more focused approach on students' active engagement and problem-solving ability. As a result, the resources-driven approach has directed the curriculum transformation in a more systematic and holistic way.

In summary, this section explained how resource development can contribute to greening curriculum at different levels. Thus, for this study, development of resources plays a vital role in enriching the teaching and learning materials to increase students' engagement and facilitate change in teachers' pedagogy.

CHAPTER 3
METHODOLOGY

This chapter explains the overall design of the study following the identification of research gaps in chapter 1 and the literature review in chapter 2. As there are a very limited number of studies directly related to the issues of implementing generic green modules to confirm, or challenge, the original thinking that underpinned this research, a pilot study was conducted to observe classroom practices. From this perspective then, the formulation of the overall design for this study is grounded in practice as well as theory. This chapter presents the pilot study, explains the initial pedagogical model designed for this study and clarifies the overall research framework. It also explains why action research is the methodological approach in this study, and provides a definition of action research and adopts it to the study. The chapter also outlines the samples, instruments and procedures related to data collection and data analysis, and discusses the possible strategies, such as triangulation, for dealing with the identified validity issues.

3.1 Pilot study

This section reports on a pilot study conducted to understand the practice of generic green skills development in a TVET institution in Hong Kong. It examines the implementation of a generic green module in that institution and analyzes the problems and challenges identified from classroom observations and teachers' interviews. The findings and implementations of the pilot study provided evidence for developing an ESD pedagogical model and helped develop a theoretical framework as well as formulate the research questions for this study.

3.1.1 Research design for the pilot study

This small-scale study was conducted in one TVET institution in Hong Kong. It was designed to understand how students and teachers respond to a generic green module by analyzing teachers' pedagogical practice, students' participation and the challenges encountered by both teachers and students in teaching and learning this module. In addition, the study sought to identify the learning and teaching settings for this module, such as teaching and learning resources, course content, as well as the teachers' and students' learning backgrounds. This particular generic green module was developed by the environmental office of the TVET institution. It is an elective course that addresses topics such as environmental concepts, sustainable development, environmental laws and regulations, pollution in the workplace, green office/workplace, climate change and carbon footprints (see Table 1 above).

Research methods for the pilot study included in-class observations and on-site conversations. The data sources were derived from

1) Four in-class observations in two different classes (a total of 45 students) were conducted. The classes covered three different topics from the module:

Green office/workplace

Climate change and carbon footprint

Sustainable development and corporate social responsibility

2) Four on-site conversations, focused on teaching reflections, were conducted after every in-class observation.

3) One formal conversation was conducted at the end of the pilot study with the module leader to better understand the module settings and to discuss the findings from observations and teachers' reflections.

4) Attendance at the module team meeting (one time) at the end of the semester to understand the module review plan and discuss identified issues with attendees also formed part of the data collection. The module developer, the module team leader and three module teachers attended the meeting. The researcher discussed the problems and challenges faced by the teachers and students that she observed with all attendees and took notes during the meeting.

Observation notes and records of all conversations were taken during the two-month data collection process and these were subsequently analyzed. Recurring themes, patterns and issues were identified. The main two focuses of the analysis for this pilot study were the challenges and problems related to classroom practices during module implementation, as well as the level of students' engagement.

3.1.2 Identified problems and challenges in teaching this green module

Based on the analysis on the filed notes taken during the classroom observations and the reflections on it, and the transcriptions for the interviews as well as the meeting recordings, the challenges and problems related to teaching and learning this module identified in the pilot study are discussed below.

First, the lecture-based and content-centered pedagogical approach, which organized the lessons into one-way knowledge delivery, and which disregarded students' prior experience and learning needs, did not stimulate students' participation and learning motivation. Most of the time, students played the role of passive information receivers, as the teaching strategies did not provide them with opportunities to explore real-world issues or exchange ideas and learning experiences. The teachers explained that it is hard for them to create real-world learning opportunities for students, since there are very limited resources have been provided for this elective course. For example Teacher E mentioned that "I have tried to suggest the module team to include a field trip for students' final project, but this has been rejected for the reason of lack of enough resources".

In addition, the learning content was organized based on a fixed teaching and learning package, which had little local relevance and was barely related to students' different learning or working experiences. From this perspective, this module did not address diverse learning needs and neither did it support students to make connections between knowledge acquisition and application. In one of the classroom observations, the researcher found that the teacher kept giving lecture for almost two hours, which in order to deliver all the contents listed in the PowerPoint. He has well prepared for the lecture and included some interesting topics such as the promotion of electric cars in Hong

Kong. However, the students did not show to engage actively. They either played cell phones or slept or just did somethings else. The researcher conducted a reflective conversation with the teacher after this lesson. It was found that the teacher understood the importance of providing real-world learning experience for students in an interactive way, however he was concerned about he could not finish the delivery of all the learning contents required for this module.

Second, most of the teachers who delivered this module are primarily responsible for teaching other subjects, such as surveying. They did not specialize in, or were not familiar with, generic green knowledge and practice or sustainability issues that are complex and need to be considered in an interdisciplinary context. In addition, most of the students did not have any training or learning experiences related to sustainability issues. These factors also posed a serious challenge for the teachers who tried to facilitate a learning process whereby students could develop an understanding of sustainability issues and go on to generate solutions from different perspectives.

Third, although the assessment scheme included both continuous assessment and end-of-module assessment, some of the formats such as knowledge-based exams that require rote memorization may not have been effective in terms of evaluating students' sustainability competencies or for measuring intended learning outcomes. These assessment formats did little to encourage students' learning initiatives or explorations of real-world sustainability problems. The mini-project, as the end-of-module assessment, did not provide students with opportunities to explore any real-world sustainability problems either. In addition, the supervision and learning resources provided for supporting students' project implementation were insufficient.

These specific challenges are not specific to this TVET institution in Hong Kong; they seem to be common issues in sustainability education. For instance, Remington-Doucette *et al*. (2013) identified the main challenge for implementing a sustainability-related introductory course at a university to be "students' lack of basic knowledge, skills, and understanding of sustainability concepts and methodologies and a dearth of instructor capacity for coordination, supervision, and facilitation of a large number of real-world projects each semester" (p. 411).

The observations in this pilot study resonate with this situation: students lacked knowledge and practice related to sustainability and instructors had limited capacities to support students' learning throughout sustainability projects. However, since there was hardly any study examined the teaching and learning of the generic green modules in TVET context, the pilot study played an important role in providing insight into the understanding of the problems and challenges in implementing a generic green module in TVET from a practical perspective (based on classroom practices). It also sheds light on the innovation of pedagogical practice that contributes to effective implementation of the generic green modules for students' generic green skills development.

3.1.3 The implications of developing the ESD pedagogical model

According to the highlighted problems and challenges above, three essential aspects were identified that required improvement and which needed to be incorporated in the

proposed ESD pedagogical model: teaching content, pedagogy and assessment. The suggestions and reflections discussed here for improving these aspects were based on the analysis of and reflections on the observed practice.. These suggestions and reflections were further integrated into the development of a pedagogical model (see section 3.1.4) and the resources development (see chapter 4) for improving teaching and learning of the generic green modules.

Teaching Content

First, it is important to make full use of the campus resources to develop a curriculum, so the campus can act as a living laboratory for sustainability education. For example, "how to deal with waste management in the campus canteen" could be a practical question/case study for students to explore when they are learning about sustainability issues related to waste management. Moreover, the workplaces on campus that are used for practical training could be considered as real-world learning *resources* as well. For example, when exploring issues related to energy, students could visit the solar energy center on campus, and consider its advantages and disadvantages, as well as how such systems might work in different industries.

Second, it is essential to include students' prior experience into the learning content as well as the learning processes. This has the potential to turn the perceived disadvantage of "students' backgrounds are varied" to an advantage, whereby students' different backgrounds become a stimulus for cross-disciplinary learning and initiate discussions from different perspectives. As generic green skills are the core competencies needed in almost any occupation, the content for the generic module should relate to students' different learning fields and industrial practice as much as possible.

Third, the learning content should be reoriented to be more locally relevant in order to provide more real-world learning opportunities for students and to encourage them to address the sustainability issues that exist in their local community. In other words, more local case studies and learning activities should be included in the learning content to stimulate student discussion.

Pedagogy

In terms of pedagogy, the following four features should be explicitly applied.

1) Constructing learning environments based on a learner-centered approach, and adopting pedagogical strategies that encourage student participation and stimulate their engagement with learning, such as:

Participatory/collaborative learning

Problem-based learning

E-learning technologies

2) Making connections between this generic module and students' major subject areas through individualized learning, or inquiry-based learning, in small groups. For example, encouraging students to use specific cases related to their subjects to develop their understanding of a new concept, or to illustrate how they would utilize an identified strategy to solve environmental problems within their own professional contexts.

3) Integrating characteristics of ESD into pedagogical practice. A *value-driven* principle could provide an example of this. Plastic bottle recycling is a very significant problem in Hong Kong, but it also has a serious impact on the environment of some developing countries such as the Philippines, because garbage from Hong Kong is directly dumped there. This is a value-driven ethical issue, which could be presented to students as a case study to help them understand why waste classification and recycling is important and to explore better ways of tackling this issue in the workplace.

4) Creating more learning resources for students by collaborating with experts from different industries and inviting them to share their experiences and understanding of sustainability, such as how they deal with environmental issues to support green economic restructuring.

Assessment

In terms of assessment, the following points are important to address when designing the assessment for the module.

1) Adopt formative assessment to encourage greater class participation. Part of the assessment could be allocated to students' presentations on a specific topic as well as group discussions on different aspects of sustainability.

2) A learning portfolio could be used for reporting on the project's progress at least once a week, so teachers can provide more guidance based on students' reflections. This would also mean the quality of the project learning could be maintained.

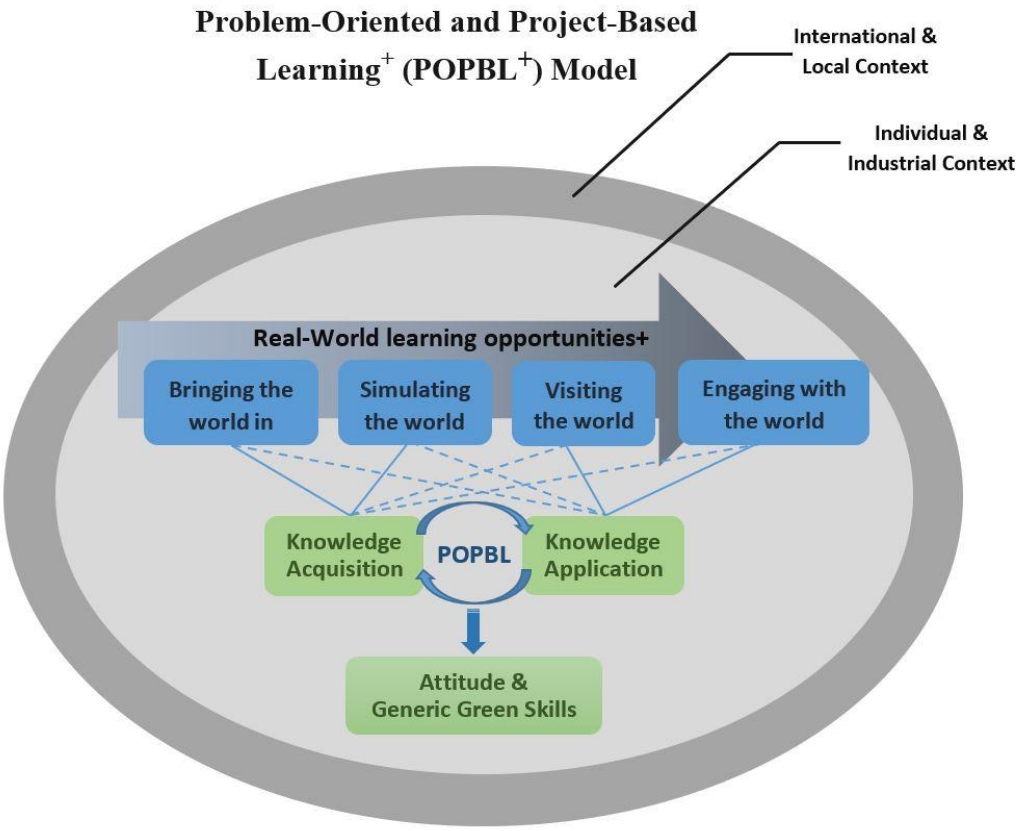
3) Evaluation of students' learning outcomes should be based on a more systematic competency framework, which clearly specifies the particular generic green skills students are expected to have. In turn, this may help teachers design lessons and learning activities based on more clear learning objectives, which are designed around a clear generic green skills framework.

3.1.4 ESD pedagogical model: problem-oriented and project-based learning plus (POPBL+)

Following on from these findings and conclusions, an ESD pedagogical model – POPBL+ (see Figure 9) was developed, based on the reflection on findings, as well as the review of theories and practices related to ESD pedagogy (see chapter 2). The model puts forward a Problem-Oriented and Project-Based Learning (POPBL) framework that includes real-world learning opportunities (+) into classroom practice as a pedagogical approach. This model was designed to facilitate the implementation of generic green modules to expedite the development of students' generic green skills.

Figure 9

Problem-Oriented and Project- Based Learning+ (POPBL+) Model



Note. This POPBL+ pedagogical model was adjusted based on "Facilitating the development of students' generic green skills in TVET: an ESD pedagogical model" by M. Pavlova and S. C. Chen, 2019, TVET@Asia, issue 12, p. 15 (http://www.tvet-online.asia/issue12/pavlova_etal_issue12.pdf).

The literature review highlighted the importance of learning through real-world problem solving and generating potential solutions in order to increase students' sustainability competencies. The identified ESD pedagogical models have a common focus, as they examine ways in which real-world learning opportunities can be included within a sustainability context as well as the implementation of ESD through real-world problem solving. However, as discussed in section 3.1.2, neither the pedagogical practices

(including learning contents, teaching and learning methods and assessment scheme), nor the learning resources provided for students could support their real-world learning. Restrictions in modalities of this green generic module in the TVET institution in Hong Kong does not allow students to go away from campus for teaching and learning activities.

Thus, the suggested POPBL+ model was developed to create real-world learning opportunities by bringing real-world sustainability issues into the classroom/campus and helping students to connect these issues with their previous and current everyday life and work experiences. The model places more focus on learning through real-world problem solving instead of learning in a real-world setting. At the beginning, students identify real world problem(s) or are exposed to real word problem(s). By understanding the solutions provided by the real-world case study, or working on finding solutions, students learn "knowledge" and think about how to apply that knowledge to a local context. In this way, classroom learning acts as a bridge between real-world sustainability problems and students' real-world learning and work experiences, so the process of knowledge acquisition shifts towards knowledge application as projects are conducted in the context of real-world issues. As soon as students conduct projects to solve the identified sustainability problems, they learn in practice and gain practical knowledge, so the process of knowledge application shifts towards knowledge acquisition too. In this way, POPBL approach can drive the learning cycle between knowledge acquisition and knowledge application, in which students' attitudes towards sustainability and their generic green skills will be developed.

Specifically, the POPBL+ model incorporates real-world learning opportunities into students' learning through four progressive processes (adapted from Brundiers, Wiek & Redman 2010), but these processes are not necessarily linear. The processes of "bringing the world in" and "simulating the world" mainly prepare students with the necessary knowledge and skills to further explore real-world problems, while the processes of "visiting the world" and "engaging with the world" mainly encourage students to apply their knowledge in their own learning and work areas. Nevertheless, learning processes for "knowledge acquisition" and "knowledge application" can be related to all four progressive processes. For example, visiting and engaging with the world can also facilitate knowledge acquisition by helping students identify knowledge and skills that help them to further engage in real-world problem solving. Here, two solid lines that connect "Bringing the world in" and "Simulating the world" to "Knowledge Acquisition" are used to emphasize the major roles of "Bringing the world in" and "Simulating the world" in preparing students with necessary knowledge and skills for further engaging in solving real-world problem.

When applying, and implementing, this model it is important to design pedagogical strategies, learning contents and learning activities so they can facilitate students' understanding of local issues within a global context and recognize that solutions to local problems can have global consequences, and vice versa. In addition, the model also suggests the importance of creating opportunities for students to connect their individual lives and industrial experiences to the identified issues in order to simulate their engagement with real-life contexts and to generate solutions. More specific learning

objectives and learning activities for each learning phase are suggested and presented in Table 12 (see section 4.2.1).

In brief, the significance of this model relates to its holistic approach in developing generic green skills through knowledge acquisition and application in the context of bringing real-world sustainable development problems into the classroom so students can engage in the real-world learning and problem solving. A framework presented the application of POPBL+ model in planning classroom activities and teaching strategies is described in chapter 4, together with the introduction of the resources developed based on it.

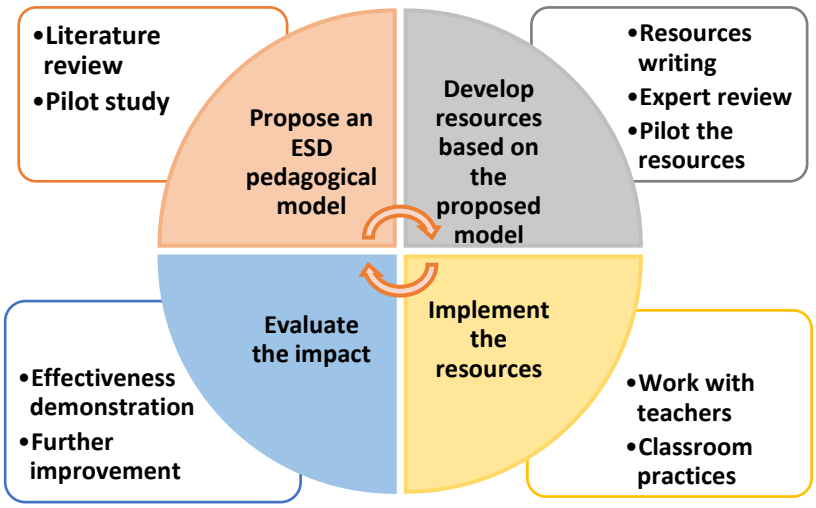
In summary, this pilot study confirmed a significant gap between the pedagogical approaches put forward in the literature on ESD and the pedagogical practices in the context of TVET**.** It also helped formulate an approach towards building a pedagogical model that presents a theoretical understanding of how to develop students' generic green skills.

3.2 Research framework

As stated above, the pilot study supported the findings from the literature review and enabled the development of a preliminary pedagogical model for the implementation of generic green module. In addition, the importance of teaching and learning resources that can support the suggested pedagogical practices were presented in chapter 2. Accordingly, the overall research framework for this study has been established: it begins with the development of the pedagogical model, followed by the development of teaching and learning resources with suggested pedagogical instructions for teachers, then the resources are implemented in TVET classrooms and finally an evaluation of the impact of the resource implementation on effective teaching and learning is conducted (see Figure 10).

Figure 10

The research framework for this study



Through this framework, the first research question: **What is an ESD pedagogical model that can specifically support pedagogical innovation for the purposes of improving the implementation of generic green modules implementation in TVET**, was not answered, based only on the preliminary findings from the pilot study and the literature review. More findings were generated throughout the study and a more comprehensive discussion for answering the first question is included in the discussion chapter.

The second research question: **How effective is the proposed ESD pedagogical model in terms of improving teaching and learning for generic green skills development**, can be answered, based on three aspects. They include:

1) development of teaching and learning resources that support ESD pedagogical practices and provide real-world learning opportunities for students to learn about, and engage in, sustainability problem solving (including teacher's guidelines for the planning and implementation of teaching strategies);
2) examining teachers' and students' acceptability and engagement towards the implementation of the developed resources; and
3) examining the impact of the resource implementation on students' generic green skills development, as well as teachers' competency enhancement towards greening of curriculum.

Accordingly, the effectiveness of the proposed ESD pedagogical model was explored through the data that demonstrate students' and teachers' acceptability and engagement

towards the resource implementation and the expected impact based on it (which includes students' generic green skills development and teachers' competency enhancement towards greening of curriculum).

Considering that the development of resources was closely related to a project, led by Dr. Pavlova, in which this researcher was closely involved, approaches toward resource development and the ways they are related to the suggested model are examined in chapter 4. Next in this chapter, the methodological approaches towards the last two aspects of the second research question are considered. Given the qualitative nature of this study, and the need to closely work with teachers in the classroom context, it is suggested that action research is the most appropriate for this study.

3.3 Methodological Approach – Action Research

This section argues for the utilization of action research; it defines action research, justifies its adoption and suggests the ways in which it is used in this study to design the intervention plan.

Theoretical gaps in knowledge, as well as a lack of understanding in practice how generic green skills can be developed effectively, provide an opportunity to combine theory and practice, as Oquist (1978) argues, in order to generate new knowledge:

> The production of knowledge begins with practical problems…Values are the purposes which guide behavior toward the resolution of problems. The actions which are undertaken to maximize desired values are guided by ideas...The ideas which guide action must be translatable into concrete operations…The justification of knowledge is judged by the consequences of an operation. (p.152)

This quotation unravels the process of knowledge production. Oquist suggests that experience and knowledge, regarding how to respond to the changes (problems), are generated through experiencing consequences and working on them. Therefore, whether the solutions work or not, can only become clear when the consequences of an action are considered, and it is much more than trial and error approach. Pragmatism puts forward the view that knowledge is generated in action and reflection. Hammond (2013) argued that pragmatic action research, which has a focus on pedagogical implications of problem solving, can be positioned within the work of Dewey (1920) who had earlier suggested that pragmatism views knowledge as being generated through reflection on actions in order to address particular problems.

Considering the intention of this study is to identify practical problems that TVET students have in developing generic green skills and teachers have in greening the curriculum and to suggest solutions to address these problems, action research has been accepted as the overall methodological approach, in which pragmatism has been adopted as the overall paradigm. Oquist (1978) summarizes the consistency of action research with such a pragmatic position as follows:

> Action research is scientific research within the pragmatic position. It corresponds to the pragmatist view of how man produces and justifies knowledge and is

> backed by the pragmatist positions with regard to the union of theory and practice and the place of values and ideology in the process of the production of knowledge. (p.154)

The section below provides the definition of action research and justifies the ways it is used for this study. The overall methodology is presented in Table 4.

Table 4

The methodology framework for this study

Research Paradigm	**Theoretical Perspective**	**Research Methodological Approach**	**Data Collection Methods**
Pragmatism	• Deweyan pragmatism • Research through design	Action research	• In-class observation • In-depth interview • Focus group interview • Questionnaire • Document analysis

Dewey's position on experience and knowing offers one of the most widely discussed perspectives about pragmatic thinking. He proposed an ecological view of experience, based on the connection of an active organism and its environment:

> The organism acts in accordance with its own structure, simple or complex, upon its surroundings. As a consequence the changes produced in the environment react upon the organism and its activities. The living creature undergoes, suffers, the consequences of its own behaviour. This close connection between doing and suffering or undergoing forms what we call experience. (Dewey,1920, p. 86)

3.3.1 Action research – Definition and cycle model

Cunningham (1993) defined "Action research" as "a term for describing a spectrum of activities that focus on research, planning, theorizing, learning, and development" (p.4). He reviewed the origin and development of action research and indicated that action research has been used in both the pragmatic study that focuses on collaborative problem-solving and joint learning, and the experimental study that focuses on theory building and experimentation.

In addition, the general definition of action research, and its applications from different perspectives, implies that action research, which includes a spectrum of activities carried out in different processes for different objectives such as research, planning, theorizing,

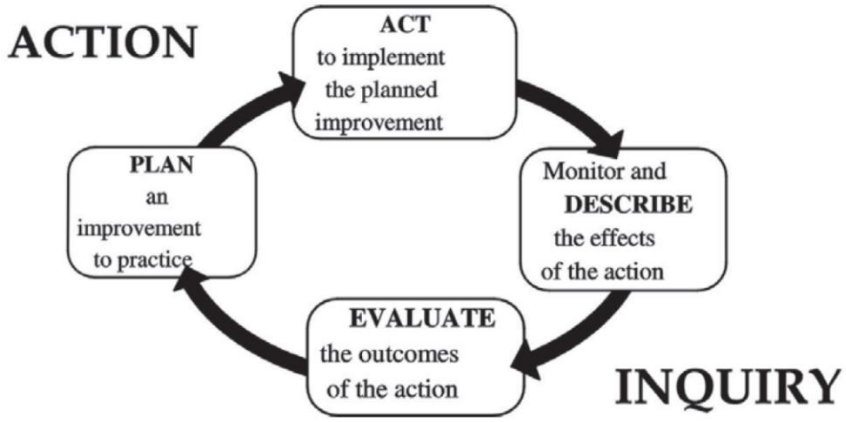
learning, and development, can be applied in different settings. Tripp (2005) pointed out two difficulties involved in defining action research as "first, it is such a natural process that it comes in many different guises, and second, it has been developed differently for different applications." (p. 2). However, with the increasing popularity and wide application of action research, it has now become a loosely applied term used to describe different kinds of attempts to focus on improving or investigating practice (Tripp, 2005).

Therefore, action research in this study is regarded as a series of actions, such as developing learning materials and conducing classroom observations, in order to improve classroom practice, facilitate change in developing students' generic green skills and conceptualize how ESD pedagogy can facilitate the effective implementation of the generic module to develop students' generic green skills.

Furthermore, action research is regarded as one type of action inquiry (see Figure 11), which follows "a cycle to improve practice by systematically oscillating between taking action in the field of practice, and inquiry of them" (Tripp, 2005, p.2).

Figure 11

The four-phase representation of the basic action inquiry cycle



Note. From "Action research: a methodological introduction", by D. Tripp, 2005, *Educacao e pesquisa*, *31*(3), p. 2 (https://doi:10.1590/S1517-97022005000300009).

The inquiry begins with planning an improvement, followed by implementing the planned improvement, and then monitoring and describing the effects of the action. The end of the cycle is evaluating the outcomes, which can also be the beginning of the next cycle. It should be noted that different actions will be required at each phase and they will begin in different places, according to the applications and developments of this basic action inquiry cycle.

Furthermore, the spiral model of action research cycle below (see Figure 12) reveals that the *problem-focused improvement process* is a central feature of the design of most action research projects (Barbour, 2008, p. 175). It moves continuously as an iterative process through the four stages:

1) Identification of the problem

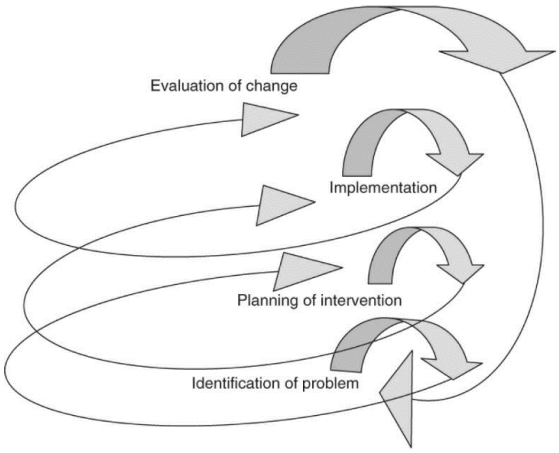
2) Planning of the intervention

3) Implementation

4) Evaluation of change

Figure 12

The spiral of action research



Note. From Introducing qualitative research: a student's guide to the craft of qualitative research by R. S. Barbour, 2008, p. 175. Los Angeles, CA: SAGE Publications, Ltd.

The end of the one cycle is the beginning of next cycle. For this study, it means that the evaluation of pedagogical change in the current cycle will be the beginning of next cycle, where further actions need to be planned, based on specific problems that emerge in classroom practice, as well as the teachers' and students' responses and reflections about current and previous actions. Thus, according to the spiral model and the consideration of appropriate aims, practices, participants and situation (enablers and constraints), this study was structured into four phases (as visualized in Figure 10):

I. Pilot study and literature review (Identification of problem)
II. Resource development based on the POPBL+ model (Planning of intervention)
III. Implement the resources in a TVET institution in Hong Kong (Implementation)
IV. Evaluate the impacts on students and teachers (Evaluation of change)

3.3.2 Justification for the use of action research

This study utilizes action research as its methodological approach to answer the research questions for the reasons outlined below.

First, as Waterman *et al*. (2001) pointed out, action research is problem-focused, context-specific and future-oriented; it seeks to explain the situations while implementing change. Good action research that integrates theory, practice and meaningful applications of the research results will support change in schools, empower individuals to collaborate mutually, stimulate teacher reflection, and explore new methods and ideas (Mishra, 2005). Action research that intends to improve the implementation of a generic green module developed by a TVET institution in Hong Kong provides an opportunity for the researcher to explore ESD pedagogical strategies within the TVET context. It encourages the module teachers to work with the researcher to develop better teaching materials and to improve teaching strategies according to the practical situations identified through in-class observations and in-depth interviews with tutors and students. An intervention to be implemented in the classroom is to improve students' learning outcomes and teachers' pedagogical practices, with a particular focus on developing students' generic green skills. Thus, action research that focuses on problem solving and change implementation as a methodological approach is consistent with the research objectives: to improve classroom practice and facilitate change in developing students' generic green skills.

Second, action research not only provides opportunities to improve practice, it also facilitates the development of theory for addressing a specific problem or situation by investigating issues of process that lead to deep conceptualizations about what can happen in practice and the reasons for this (Huxham, 2003). The application of this form of conceptualization in theory development is embedded in the evidence collected from practice, which in this study is the data collected in the process of implementing the developed ESD resources, based on the ESD pedagogical model. Accordingly, employing action research in this study can contribute to conceptualizing the ways ESD pedagogy helps improve the teaching and learning of generic green modules and facilitates the development of students' generic green skills.

Third, action research that promotes collaboration coequally between participants and researchers can contribute towards a systemic collective thinking on exploring ESD pedagogical practice. Salite *et al*. (2016), explored action research strategy for including ESD into continuing education programs, and they argued that

> If sustainability is studied as a wicked problem, there is no other way than to understand and explain the action research (1) as a unique complex phenomenon and interaction of complex processes; (2) as a strategic approach to research and learning integration at different levels; (3) as an action research method that can contribute to research participants' transition from "the piecemeal approach" to an approach of systemic collective thinking, which is in good agreement with the participatory action research cases and the goals of the undertaken research. (p.144)

This quotation highlights the implications of action research for the study of

sustainability, which with an openness toward systemic collective thinking can create an environment that has the potential to contribute to educational reorientation and development towards sustainability. Within this environment, the researcher and participants (teachers and students in this study) can work together to explore the complex nature and wicked problems of sustainability through the **"**action process", from a holistic perspective, that relate to *"the development of complex phenomena and their interaction in the modern world"* (Salite et al., 2016, p. 148). Thus, action research plays a crucial role in this study as it provides an approach and an open environment for the researcher to work with the involved teachers in order to explore the use of ESD pedagogy through the action process in a practical setting. This can further facilitate the researcher' and teachers' competency development in greening curriculum and research.

3.4 Research Design

This section explains the general framework and the sample of this study.

3.4.1 The general framework of the research

Regarding the design of action research, Mills (2018) pointed out that

> Action research designs are systematic procedures completed by individuals in an educational setting to gather information about and subsequently improve the ways in which their particular educational setting operates, how they teach, and how well their students learn. (cited in Creswell & Guetterman, 2019, p. 587)

This study, which aims to improve the teaching and learning of a generic green model for students' generic green skills development as well as teachers' competency enhancement towards greening curriculum, was designed according to the spiral model (see Figure 12 in section 3.3.1) which illustrated the procedures involved in conducting action research. More specifically, this action research includes four phases.

I. In phase I, a pilot was conducted to familiarize the researcher with the context and to enable the formulation of the research framework and methods for this study. It also identified pedagogical problems through in-class observation (that supports the findings from the literature review) and reflection, as well as in-depth interviews with the teachers involved at a TVET institution in Hong Kong.

II. In phase II, the researcher worked with the resource development team to develop the teaching and learning resources based on the POPBL+ pedagogical model to address identified problems and challenges. The resource development took place under a university project: "Creating an Impact: Setting up a Green Skills Hub at the EdUHK". The researcher worked as a resource developer on this project. The resources used in this study were developed by the researcher and reviewed by Dr. Pavlova as well as the module team leader. The pilot of the developed resource was conducted in a three-hour workshop for TVET teachers in the training program, "Green Skills and New Economy for Sustainable Development".

III. In phase III, the researcher worked with four teachers to implement the developed resources. Two cycles of intervention on two selected topics (1. Closed-loop economy and 2. Green technology) were implemented in four different classes.

IV. In phase IV, there was an examination of 1) students and teachers' acceptability and engagement towards the resource implementation and 2) the impacts on students' generic green skills development as well as teachers' competency enhancement in greening the curriculum.

Table 5

Research design

<table>
<tr><td>Phases</td><td colspan="2"><u>I. Pilot Study</u>:
A TVET institution in Hong Kong</td><td><u>II. Resource development</u></td><td colspan="4"><u>III. Implementation:</u>
A TVET institution in Hong Kong</td><td colspan="4"><u>IV. Impact evaluation</u></td></tr>
<tr><td rowspan="4">Samples</td><td>Class 1</td><td>Class 2</td><td rowspan="4">None</td><td>Class A</td><td>Class B</td><td>Class C</td><td>Class D</td><td>Class A</td><td>Class B</td><td>Class C</td><td>Class D</td></tr>
<tr><td>Full-time Students</td><td>Full-time Students</td><td colspan="2">Full-time Students</td><td colspan="2">Part-time Students</td><td colspan="2">Full-time Students</td><td colspan="2">Part-time Students</td></tr>
<tr><td>Teacher 1</td><td>Teacher 2</td><td colspan="2">Teacher A&B</td><td colspan="2">Teacher C&D</td><td colspan="2">Teacher A&B</td><td colspan="2">Teacher C&D</td></tr>
<tr><td>Interventions</td><td colspan="2">None</td><td>None</td><td colspan="2">Cycle i
Cycle ii</td><td colspan="2">Cycle i
Cycle ii</td><td colspan="4">None</td></tr>
<tr><td>Objectives</td><td colspan="2">1. Observe classroom practice to identify the problems and challenges existing in current teaching and learning.
2. Formulate the research framework and methods based on the findings.
3. Develop a preliminary ESD pedagogical model.</td><td>1. Develop the teaching and learning resources based on the developed ESD pedagogical model that can be used to
1) improve the implementation of the generic green module in the involved TVET institution;
2) facilitate students' generic green skills development and support teachers' competency enhancement towards greening of curriculum.</td><td colspan="4">1. Implement the resources in four involved classes in two cycles:
Cycle i - Concept learning: Closed-loop economy
Cycle ii - Case study learning: How much energy do data centers use (Green technology)
2. Collect different kinds of data for the impact evaluation in next stage.</td><td colspan="4">1. Improve the proposed pedagogical model based on the findings.
2. Identify teachers' and students' acceptability and engagement of the resource implementation.
3. Evaluate the impact on 1) students' generic green skills development; 2) teachers' professional competency enhancement towards greening curriculum.</td></tr>
<tr><td>Data sources</td><td colspan="2">1. Classroom observation checklists (completed by researcher)
2. Reflective conversations (Teachers)
3. Research memos, field notes</td><td>1. Peer reviews
2. Expert reviews
3. A survey for the resources pilot (The pilot was conducted through the training program, "Green Skills and New Economy for Sustainable Development (Hangzhou, China)".</td><td colspan="4">1. Classroom observation checklists (completed by researcher)
2. Reflective conversations (Teachers)
3. Research journals, field notes</td><td colspan="4">1. The data collected in previous stages.
2. In-depth interviews (Students and Teachers)
3. Self-evaluation survey (Teachers)
4. The students' assignments and mini-project reports (Group work)</td></tr>
</table>

The summary of the research design is presented in table 5 above, which lists the samples, interventions, objectives and data sources in each phase of this study. As shown in the table, this study began with a pilot study (as discussed in section 3.1) to understand how the generic green module was developed and implemented in a TVET institution in Hong Kong. This contributed to the formulation of the general research framework and the pedagogical model for the whole study. First, the proposed pedagogical model (POPBL+) (see section 3.1.4) and its principles provide a pedagogical framework for the resource development (see chapter 4). Second, the teaching and learning interventions (resource implementation) were planned, based on the module setting and reflections about the pilot study, which include two cycles in four classes. Third, the impact evaluation was formulated to answer the research questions, which included an examination of the proposed POPBL+ model, teachers and students' acceptability and engagement towards the resource implementation and the impacts on students' generic green skills development as well as teachers' competency enhancement for greening of curriculum.

Finally, as *the mutual adaptation approach* (which refers to "adaptation of both the project design and the institutional setting" in Berman & McLauhglin, 1976, p. 352) proposed for educational innovation indicates:

> The initial design of an innovative project must be adapted to the particular organizational setting of the school, classroom, or other institutional hosts, and, at the same time, the organization and its members must adapt to the demands of the project. (Berman & McLauhglin, 1976, p. 349)

Staff and administrators should also be involved in a collective learning process to facilitate the relatively unspecified innovations to fit into their own context too, while their role behaviors are simultaneously expected to adapt to support a full achievement of the project goals. This study was conducted in a collective mode throughout all four phases, in which the researcher "learned" from the teaching staff involved to understand the pedagogical problems and challenges they faced in the institutional context, while the teaching staff were also required to change their teaching behaviors to support the achievement of the mutual project goals. However, the resource implementation did not only involve a commitment between the researcher and the involved teachers – the module team leader, the director in environmental office and the director of the project were also involved in the initiative to jointly facilitate the implementation.

3.4.2 Samples

Creswell (1994) indicated that the informants in qualitative research need to be purposefully selected in order to best answer the research question. After considering the research questions and the research design formulated to answer the questions, the following selection conditions were set.

As mentioned before, this study was designed based on the findings of the pilot study conducted in a TVET institution in Hong Kong. Following the results, a series of teaching and learning resources were developed, and the study was formulated to

examine the effectiveness of the developed resources on students' generic green skills development and teachers' competency enhancement towards greening the curriculum. Therefore, the participants of this study were to be the students and teachers involved in the generic green module, "Green knowledge and practice" in the TVET institution. In addition, the learning resources that were developed based on the POPBL+ model are industry related and real-world problem oriented, which helped facilitate the classroom learning to be reflected on, and connected to, students' working experiences. In this way, the students who had work experience and/or know about their industries might tend to gain more benefit from the developed resources. In order to understand how different groups of students responded to the resources and identify the impacts of the resources on different group of students, the sampling included both full-time students who, for the most part, did not have much working experience and part-time students who already worked in specific industries.

Therefore, this study needed to recruit the teachers and both part-time and full-time students to be involved in this generic green module. After consulting with the module leader and introducing the study to the teachers who would teach this module, four teachers expressed an interest in being involved in the study. Two of them are full-time lecturers working under the engineering department; the other two are part-time teachers who were specifically responsible for the implementation of this module for part-time students. Four classes of students (a total of **115 students**), who took the generic green module "Green Knowledge and Practice" in semester three (2019-2020) were involved in this study. Two classes were part-time students majoring in construction-related subjects such as surveying, while the other two were full-time students majoring in a variety of subjects such as hotel management, IT and early childhood education, etc. The researcher worked with four teachers to include the selected resources into the current module through two classroom sessions (three hours each) and one final group project. One session was focused on green technology; the other was the closed-loop economy. The final project was design based on the concept of sustainable innovation and its relevant case studies, which aimed to address "Urban innovation for the sustainable development in Hong Kong".

3.5 Multiple Data Collection - Methods and Procedure

This section justifies the methods used for data collection (how the data can answer the research questions) and explains the instruments developed for data collection in this study. The data collection methods used in this study included participant observation, in-depth interviews, survey and document analysis. Using multiple methods for data collection is common in qualitative studies and the purpose of combining methods have been well discussed in literature. With reference to a discussion in Maxwell (2013), this study used multiple methods and these are outlined below.

First, triangulation, which involves verifying the results and strengthening a particular conclusion by using different methods to check on against another, to ascertain whether a single conclusion can be supported by information gained from different methods with different strengths and limitations. This strategy has generally been used as a method of dealing with validity threats, since it can reduce the risk that a conclusion only reflects

the biases of a specific method, as well as to provide a more secure understanding of the issues under investigation.

Second, complementarity and expansion, which refers to the use of different methods to gain information that reveals different aspects of an examined phenomena from divergent perspectives (Greene, 2007). In this approach, different methods are used to broaden the range of aspects or phenomena that a study addresses, but the purpose is to gain a greater depth of understanding rather than simply greater breadth or conformation of the results of a single method. This was emphasized as "*a dialectic stance*" for combing methods, which indicated the essential of generating a dialogue among results of different methods and an engagement with differences in findings, to forces researchers to reexamine the understanding of what is going on (Greene, 2007, p. 79-83).

Each sub-question of question two was answered based on the data collected from at least two different methods (see table 6), some methods also included multiple data sources such as participant observation (see Table 7 in section 3.5.1).

Table 6

The data collection methods for answering the sub-research questions

Research Sub-Questions	**Data Collection Methods**
1. What is the level of teachers' and students' acceptability towards the teaching and learning facilitated by the developed resources?	1) In-depth interview 2) Participant observation
2. How do teachers and students engage in the implementation process? (How teachers and students engage in the classroom practices)	1) Participant observation 2) Reflective conversation
3. What is the impact of the implementation of the ESD resources on students' generic green skills development as well as the enhancement of teachers' competencies in terms of greening of curriculum?	1) In-depth interview 2) Survey 3) Document analysis 4) Participant observation

To clarify, for the first sub-question, in-depth interviews were used to gain a detailed description of how teachers and students appreciate the resources, while participant observation was used to provide an objective understanding of their acceptance of the resources during teaching and learning. In term of the second sub-question, participant observation was used to describe how students engage in the learning activities and how teachers interact with students based on the observable elements. This was a powerful

way of examining how teachers and students engaged in the classroom practices; however, reflective conversation as a form of interview revealed teachers' perceptions about students' engagement, and also provided complementary information from the teachers' perspectives. Regarding the third sub-question, in-depth interviews (including reflective conversations with teachers after each lesson) was used to gain information that demonstrated the impact on students' generic green skills development through the teachers' own voices, while participant observation was used to describe the "behaviors" that demonstrated students' generic green skills development and evaluate observable and quantifiable elements. Document analysis of students' assignments from two workshops and their group reports for the final projects was used to further strengthen and complement the results with specific evidence and quantifiable elements identified in students' works. The impact on teachers' competency enhancement was identified through a self-evaluation survey , which meant teachers were asked to self-evaluate the changes in the domains of professional knowledge, practice and engagement towards ESD inclusion, while participant observation was used to gain a description of how teachers embraced and used ESD pedagogical strategies. These two methods combined helped check the consistency of "what I thought" and "what I practically have done". In addition, in-depth interviews were used to gain additional information that was missed in observation (e.g. what facilitates the changes) and to broaden the range of elements that demonstrate the impact.

Apart from the data sources mentioned above, the researcher's notes also play an important role in gaining information throughout the whole study. The notes were a record of what had been observed as well as reflections on the observed phenomena. The researcher also wrote down key points generated from conversations with teachers after each lesson in the research journals. Key points could be generated from a story told by the teacher that described how the project-based learning worked in the program he/she managed before, or any immediate statements, like "students are so focused on the discussion" made by the teachers.

In summary, different data collection methods have been synergistically used to enhance the accuracy of information and to provide a dialectic stance for perspectives gained from one single method, in order to achieve a greater depth understanding of the addressed issues. In this study, the joint use of multiple methods helped to answer the research questions sufficiently. Some of them provided the researcher with direct access to witness what happened, and how it happened, in the classroom, while others provided indirect access for the researcher to understand why it happened and what made it happen. All the data collection methods used in this study are specified in the following section.

3.5.1 Participant observation

Participant observation combines particular data collection strategies, which may include data from limited participation, field observation, interviewing, and artifact collection (McMillan & Schumacher, 2001). It allows researchers to observe different participants in different situations, which elicits data with unique kinds of information that are nearly impossible with other approaches (Wilson, 1977). The multiple data sources gained from participant observation therefore allow corroboration among different perceptions and

validation between what individuals think they are doing and what researcher thinks they are doing based on the data (McMillan & Schumacher, 2001).

In this study, the researcher evaluated the effectiveness of the ESD pedagogical model by examining the implementation of the resources developed based on the ESD model. It examined the impact of the resource implementation on students' classroom engagement and generic green skills development, as well as teachers' ESD pedagogical practices and competency enhancement towards greening the curriculum. To demonstrate the impact on students, the study needed descriptive data that could corroborate the perceptions from the researcher, teachers and students themselves. Similarly, in order to evaluate the impact on teachers, observations needed to corroborate the data from students' voice, researcher' observations, and very importantly, from teachers' self-reflections. When the researcher participated in students' learning activities and interacted with them, he/she can obtain information from different situations, which occur in the natural environment. This allows the researcher to understand participants' intrinsic perceptions of the events and processes articulated in their actions and expressed as feelings, thoughts and beliefs (McMillan & Schumacher, 2001).

Therefore, participant observation was used throughout the whole study, in which the researcher acted as a co-teacher to implement the resources alongside the course teachers. During classes, the researcher observed students' responses to the learning activities and noted how they engaged in the learning activities. The researcher also interacted with students in different ways during group activities through discussions, providing learning guidance and feedback, as often the most valuable data would come from the conversations with students during the intervention.

In addition, the researcher also discussed the lesson plan with teachers before the class (casual conversation), and observed how teachers interacted with students during the lesson. After class, the researcher talked with teachers (casual conversation) to reflect on specific classroom incidents, teaching strategies or students' responses etc. Students' discussion memos and their assignments were collected for the impact analysis too.

Accordingly, the multiple data sources from participant observation in this study were listed in a table that clearly illustrates the strategies, participants and situations in data collection (See Table 7).

Table 7

Multiple Data Sources from participant observation

Multiple strategies	Observation: field notes, classroom observation checklists
	Casual conversations: personal journal (reflective records)
	Documents: discussion memos, assignments, final project reports
Multiple participants	Students
	Teachers
	Researcher
Multiple situations	Students listened to the lectures delivered by course teachers
	Students engaged in the learning activities (interactions among students)
	Students interacted with the researcher
	Students interacted with the course teacher

Moreover, in order to make the participant observations more focused and effective, the researcher developed two observation checklists for reflective records (See appendix A and appendix B). One was for identifying students' generic green skills development (Checklist 1), the other was focused on examining students' engagement and the teachers' interactions with students in different learning activities (Checklist 2). During the lesson, the researcher could not fully focus on completing the checklists since she was working with course teachers to facilitate the learning activities. However, the checklists have been used as the guide for note taking in the field and the researcher also filled in all the information as soon as possible after each of the lessons. All these checklists are very important data sources for this study.

Checklist 1 was developed based on the classification of generic green skills. The first column listed four categories of generic green skills, the second column listed all the items in four categories based on Pavlova (2017) (see section 2.2). In the third column, the observer was required to use **Limited =1, Moderate =2, Fully Present =3** to describe the development level of the targeted skills, based on "observable elements" listed in the blank column. As stated in checklist 1, before the observation the observer was required to check on, and identify, the specific items (targeted skills) suggested for the learning activities (listed in student worksheet and teacher guidelines) and think about what

"evidences" occurred in the classroom can demonstrate the development of the targeted skills. The preview and pre-think of the checklists can help to keep the observer's focus on the targeted skills, which also makes the field note a valid reference for subsequent completion of the checklists.

Checklist 2 was developed based on the pedagogical framework of POPBL+ model (see section 4.2.1). As shown in checklist 2, it listed the possible pedagogical strategies suggested for each of the learning phases and the learning activities designed based on them. The observer needs to carefully go through the lesson plan or discuss it with course teachers to understand what pedagogical strategies and learning activities are going to be used in the coming lesson, and fill in the first two parts of the checklist before the observations. During the lesson, the observer needs to make field notes that describe how the teacher interacts with students and how students engage in the learning activities. Again, after the lesson, the observer needs to fill in the checklist as soon as possible based on the field notes and the reflection based on it.

All the observable elements identified in checklists 1 and 2 and the field notes (including reflections on the reflective conversations with the teachers) were used as evidence to demonstrate the students' and the teachers' engagement in different learning activities. The researcher attempted to categorize all the observable elements based on the three dimensions of engagement discussed in Fredricks, Blumenfeld, and Paris (2004), namely: behavioral engagement, emotional engagement and cognitive engagement (more discussion can be found in section 2.4 in the literature review). The description of the three dimensions for categorizing teachers' and students' engagement in this study were adjusted based on it.

More specifically, students' engagement includes:

1) Behavioral engagement: how students behave. It concerns involvement in learning and academic tasks and includes behaviors such as effort, persistence, concentration and attention, and interaction with peers and teachers.
2) Emotional engagement: how students feel. It refers to students' affective reactions to learning, including the presence of task-facilitating emotions, such as interest (enjoyment of the activity) and the absence of task-withdrawing emotions, such as distress. Emotional engagement is presumed to influence students' willingness to work, and their attitudes, interests and values towards learning.
3) Cognitive engagement: how students think (strategic learning). It is defined as the student's level of investment in cognitive learning, which draws on the idea that students who use deep strategies (e.g. connecting existing knowledge to new experiences) tend to exert more mental effort, create more connections between ideas, and achieve greater understanding of ideas.

Teachers' engagement includes:

1) Behavioral engagement focuses on teachers' behaviors that indicate an involvement in teaching such as being well prepared for the lessons and teaching materials, and behaviors that reveal teachers' interaction with students such as how they facilitate discussion and provide comments to students' presentations.

2) Emotional engagement focuses on teachers' passion about and commitment to using the resources to teach the generic green module. It also includes teachers' affective reactions to implementing the resources, such as enjoyment in teaching (interests) and the importance of teaching (attitudes).

3) Cognitive engagement focuses on teachers' use of teaching approaches, pedagogical strategies and how they learnt to use the resources by working with the researcher.

3.5.2 Interviews

Interviewing is very important in qualitative research; it provides opportunities for the researcher to acquire information about beliefs, perspectives, and views from participants (Boudah, 2020). It is a valuable, and often the only, way of gaining description of actions and events that took place in the past or for situations in which the researcher cannot gain observational access for events (McMillan & Schumacher, 2001). Interviews in this study play an important role in providing useful information that cannot be observed directly from participants such as students' emotional engagement and the influence of teachers' ESD-related experience on their engagement.

Specifically, the interviews in this study included informal conversational interviews and standardized, open-ended interviews. The former provides opportunities for the researcher to engage the participants in conversation about specific events, interactions, or perceptions relevant to the situation which occurred within the setting where the study was taking place (Boudah, 2020). The latter requires the researcher to determine the interview questions based on the research aims and questions and allows the participants to take the responses which are vary by individual into an area that the researcher might not have considered (Boudah, 2020). In this study, informal conversations mostly occurred as reflective conversations with teachers after each class in a one-on-one format, so the researcher could ask questions regarding teachers' perceptions of the ESD pedagogy and the impact on students' learning engagement and generic green skills development. Some also occurred during the classes while the researcher was engaged in students' discussions or dealing with specific situations such times when a few students were not engaged in any learning activity. Standardized, open-ended interviews were conducted with the four teachers in a one-on-one format and with four groups of students in the form of a focus group interview at the end of the semester. In the focus group interviews, the students from four classes were involved voluntarily and randomly.

To ensure that both the teachers and students all received two cycles of intervention before the interviews, the interviews were scheduled at the end of the semester. The interviews with the four teachers were conducted after the last class in the teacher's office or in the classroom after the class. Each interview lasted for 30 minutes to one hour depending on the teacher's time and the length of the conversations. In terms of the students' focus group interviews, the researcher invited all the class participants before the last class. The students who were interested in taking part in the interviews were asked to either come 30 minutes before the lesson or to stay 30 minutes after the lesson. All the focus group interviews were conducted in the classroom.

In terms of how to create good interview questions, the discussion in Maxwell (2013) inspired this researcher:

> Carol Gillligan (personal communication) emphasized the value of asking your interviewees real questions, ones to which you are genuinely interested in the answer, rather than contrived questions designed to elicit particular sorts of data. Doing this creates a more symmetrical and collaborative relationship in which participants are able to bring their knowledge to bear on the questions in way that you might never have anticipated. (Maxwell, 2013, p. 101)

Maxwell points out the importance of asking interviewees real questions that enable them to contribute their knowledge to the research questions from different perspectives (which may not have been anticipated by the researcher), instead of trying to extract particular sorts of data to answer the questions without deep insights. Thus, the interview questions in this study were generated based on the researcher's reflections on the classroom observations and their connection to the research questions. In this way, the interview questions could bring out real ideas, perceptions and values regarding the implementation of the resources and the impact on teachers' and students' competency development, which could, in turn, help the team to further improve and maximize the effectiveness of the resources developed for generic green skills development, rather than simply confirming that the resources were useful.

Two maps demonstrate the links between the research questions and the interview questions generated for the teachers (figure 13) and the students (figure 14), and they also reveal how the interview questions answer the research questions. As shown in the figures, the interview questions were specifically formulated to gain insights into students' and teachers' acceptability and engagement with the resource implementation as well as its relevant impact. In order to stimulate the interviewees to reflect on the questions and to bring out detailed information and deep insights, the interview questions were formulated using "Why", "What" and "How" questions to encourage more than single-word answers.

Figure 13

A map linking research questions an interview questions for teachers

Research sub-questions	Interview Questions: Teachers
1. What is the level of teachers' and students' acceptability towards the teaching and learning facilitated by the developed resources?	1) In what ways do you think the resources are helpful to you? (e.g. teaching preparation, lesson design or professional development… could be anything) 2) How do you think the resources, which included more interactive learning activities, can improve students' engagement? 3) What has been the students' feedback on the lessons designed based on the resources? 4) How do you think students' feedback influences your acceptance of the resources?
2. How do teachers and students engage in the resource implementation process?	1) How did you spend time learning the materials and designing the lessons based on them? 2) How do you like the teaching practice transformed based on the resources? 3) Can you describe how you used the resources?
3. What is the impact of the implementation of the ESD resources on students' generic green skills development as well as the enhancement of teachers' competencies in terms of curriculum greening?	1) How do you think the resources help to develop students' generic green skills? 2) How do you think implementing the resources helps to enhance your professional competency towards greening the curriculum? Can you give some examples based on your teaching experience to describe it further?

Figure 14

A map linking research questions an interview questions for students

Research sub-questions	Interview Questions: Students
1. What is the level of teachers' and students' acceptability towards the teaching and learning facilitated by the developed resources?	1) What do you want to learn from this course? In what ways do you think the resources help to meet your learning expectations? 2) Do you think the case study can help to connect your learning experience with real-world problem solving? Can you give me some examples of what you have learnt? 3) Comparing lecture-based learning (sit and listen) with more case study and group work (interactive learning), which one would you prefer? Why?
2. How do teachers and students engage in the resource implementation process?	1) How do you like to work in small group? Such as group discussion and mini projects? 2) Do you think engaging in the inquiry learning that focuses on sustainability topics is interesting and important to you? Why? 3) Do you think you engaged more in the learning activities designed based on the resources? Why?
3. What is the impact of the implementation of the ESD resources on students' generic green skills development as well as the enhancement of teachers' competencies in terms of curriculum greening?	1) What have you learnt in these two workshops and the mini project? 2) How do you think the learning resources help to develop your generic green skills? (Students' understanding and self-evaluation of generic green skills development) 3) Do you think you will/can apply these more environmentally friendly solutions/ideas to solve the environmental problems at workplace (Part-time students)? Or do you think the resources can support you to make a contribution to environmentally friendly practices at your future work or help you find a job (Full-time students)? Why?

3.5.3 Questionnaires developed for self-evaluation

De Vaus (2002) clarified questionnaires is a structured approach to data collection and analysis; it is misleading to typify survey using the quantitative/qualitative distinction. The distinguishing features of surveys are the forms of the data (a structured or systematic set of data collected from at least two cases) and the method of analysis (systematic comparison between different cases on the same variables or characteristics) (De Vaus, 2002). as a tool to systematically collect data, is the most common method of collecting structured, or a systematic set of data in a survey study, which can be used in both quantitative study that aims to make generalizable claims about whole populations, and qualitative study that uncovers the influence of a specific context on people, their behavior, attitudes and opinions, and their perception and awareness of specific issues (De Vaus, 2002; Parfitt, 2005; Herbert, 2010; McGuirk and O'Neill, 2016). McGuirk and O'Neill (2016) highlighted the unique role of questionnaires in qualitative research as "identify variability" and pointed out that "one of the strengths of using questionnaires in qualitative research is their ability to identify variability in understanding and interpretation across a selected participant group, providing groundwork for further investigation through additional complementary methods such as in-depth interviews" (p. 269).

It revealed the value of using questionnaires to identify the differences across the involved cases in qualitative research, which provides the groundwork for jointly using different methods to gain a greater depth understanding of the explored issues.

In addition, Lundberg (1942) classified different types of questionnaires as 1) questionnaire of fact, which requires only facts from the respondent without any reference to his/her opinion or attitude about them; and 2) questionnaire of opinion and attitude in which the informant's opinion, attitude or preference regarding some phenomena is sought. In this study, a self-evaluation questionnaire was designed to collect information on teachers' opinions regarding the enhancement of professional competencies towards ESD inclusion. It was believed that teachers' opinions, based on their self-reflection, can provide reliable and valid information about "to what extent do the teachers think that their competencies towards ESD inclusion have been enhanced".

The self-evaluation questionnaire was developed based on the competency framework, *"Teachers' standards specific for greening curriculum"* proposed in *UNESCO-UNEVOC Resource Guide for Teachers: Embedding Greening Skills in Classroom Instruction* (Pavlova, 2019) (see appendix C). The standards developed were focused on three domains, namely professional knowledge, professional practice and professional engagement. In each of the domains, the focus areas are highlighted and the proficiencies that teachers are required to have in order to effectively implement greening of curriculum are specified too. With reference to this competency framework, the questionnaire (see appendix D) was designed in three sections, and each section included statements based on a specific description of the competencies. The teachers were asked to rate each of the statements listed in the questionnaire twice: one refers to "Before the implementation", while the other refers to "After the implementation". In other words, the evaluation of "Before the implementation" was designed to gather data that describes each teacher's baseline of the examined competencies; while the evaluation of "After the implementation" was designed to demonstrate the "enhancement" in each competency. In addition, the questionnaire was formulated using the Likert scale , which has been used extensively in questionnaires since it allows fairly accurate assessments of beliefs or opinions

(McMillan & Schumacher, 2001). This approach requires the formulated statements to reflect particular attitudes or opinions, and the respondents are asked to indicate their level of agreement or disagreement with the statements (De Vaus, 2002). In this study, respondents were asked to indicate their rating for each statement by giving it a score out of 5. On a scale of 1 to 5, 5 refers to "very proficient", and 1 refers to "not at all proficient", the teachers were asked to check the place on the scale that best reflects their opinions on the listed competencies.

It is worth noting that the questionnaire was reviewed by Dr. Pavlova, who developed the competency framework (Pavlova, 2019) and is a professional expert and knowledgeable in the assessed area (curriculum development and teacher education towards greening TVET). It helped to make sure all the items in the questionnaire were clear, unbiased and concise. After the review, the researcher created the online questionnaire through the "Form" function provided by Google. All four teachers involved in this study completed the questionnaire through the link sent by email.

3.5.4 Documents

Documents can be a valuable source of information to help researchers understand central phenomena in qualitative studies (Creswell & Guetterman, 2019). This study collected different kinds of documents as a source for text data, including the researcher's research notes, the students' assignments and group discussion memos, and their group report for the mini projects.

1) Research memos included the field notes taken during the observations and the research notes written after each class that noted reflections of different situations and conversations. The former played a role in supplementing the observation checklist and reminding the researcher of the critical moments that happened during the observations.

The latter constituted research reflections, which helped the researcher to focus the study on the research questions.

2) The students' assignments that were collected included both the individual and group work designed in the worksheets. These focused on learning the concept of the closed-loop economy and the case study about green technology (See the sample of collected assignments in Appendix E). The group discussion memos that contain the students' note taking during the group discussion were also collected after each lesson as part of the data (See the sample collected group discussion memos in Appendix F).

3) The group reports for the mini projects and involvement in the students' group presentations for the mini project are viewed as additional important data to evaluate the impact of the intervention on students' generic green skills development. It is acknowledged that not all items can be accessible by the researcher, however every example available has been evaluated.

In summary, different kinds of documents have been purposefully collected to understand the implementation of the resources and intervention's impact on both the teachers' and students' competency development. They were used to complement the data collected from other sources to answer the research questions, but particularly for evaluating the impact on students' generic green skills development.

3.6 Data Analysis – Methods and Procedures

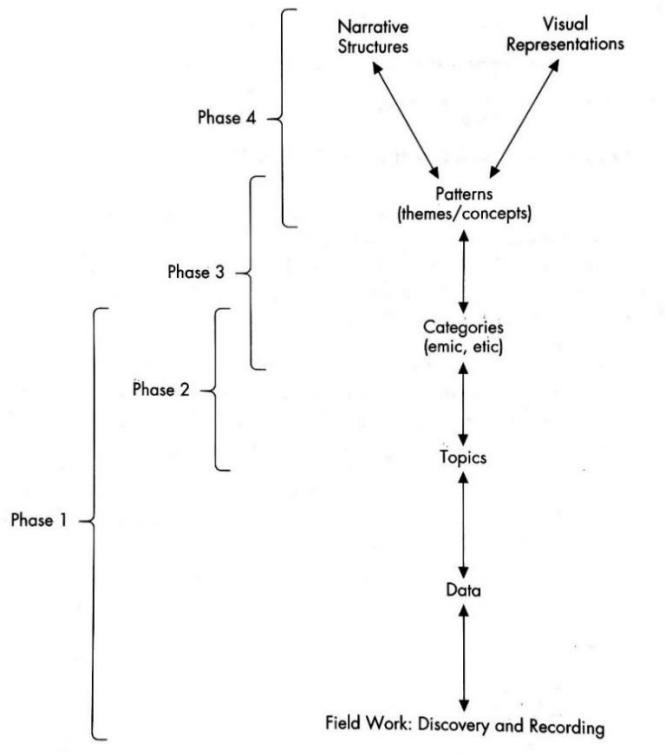
This section explains the data analysis methods and procedures for analyzing the qualitative data and the questionnaire. In particular, it explains how the qualitative data were analyzed using different strategies and to help answer the research questions.

3.6.1 Approach for qualitative data analysis

Data analysis is an ongoing cyclical process, which begins as soon as data collection begins and is integrated into all phases of qualitative research (Boudah, 2019). Figure 15 clearly shows that data analysis entails several cycles within four overlapping phases, and each phase provides the analytical foundation for the next. McMillan & Schumacher (2001) explain, "Notice that as the researcher moves to more abstract levels of data analysis, she or he is constantly returning to the prior level of abstraction, always double-checking and refining her or his own analysis and interpretation" (p. 462).

Figure 15

Process of Inductive Data Analysis



Note. From *Research in education: A conceptual introduction* (5th ed.) by J. H. McMillan and S. Schumacher, 2001, p. 463. New York: Longman.

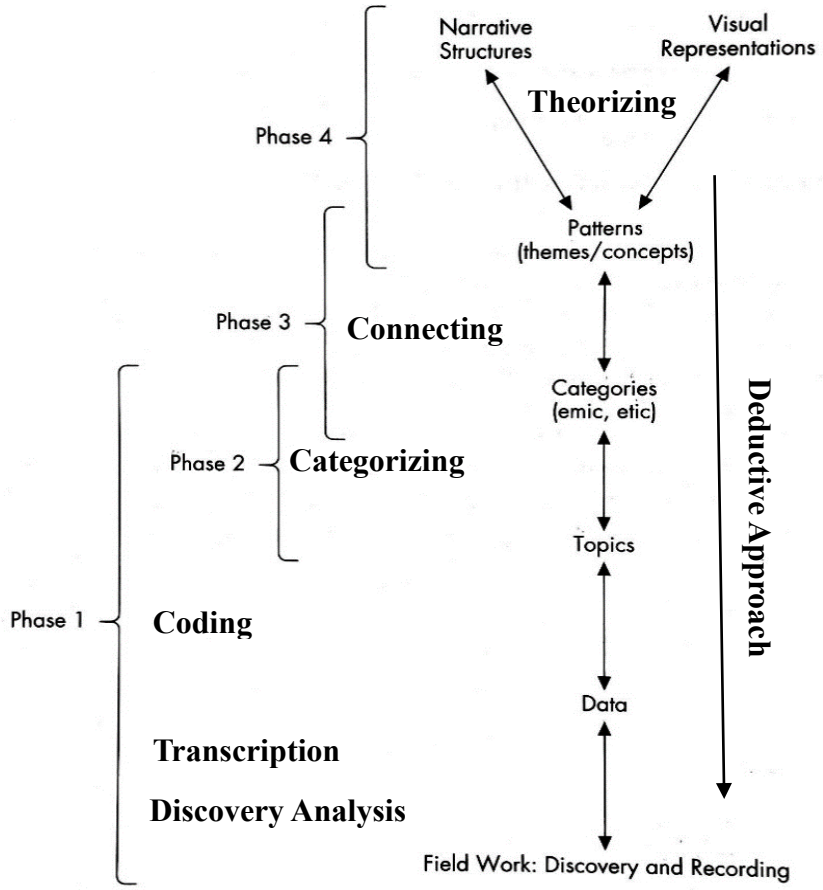
Figure 15 highlights the importance of connecting the data analytical processes and strategies in different phases as the researcher moves to more abstract level of data analysis. The double-headed arrows within the analytical processes also illustrate the moving back and forth in coding data, and show that all the processes in data analysis may or may not be linear.

Based on the process of inductive data analysis (McMillan & Schumacher, 2001) above, this study proposed a data analysis framework as shown in figure 16. This framework specifies the analytical strategies that are used intensively in different processes, and highlights the importance of using a deductive approach in recasting the tentative analysis and validating more abstract levels of synthesis, as McMillan & Schumacher (2001) explain "although the data analysis is inductive, a deductive mode of thinking at appropriate times is used — moving back and forth between analyzing raw data and recasting tentative analyses at each phase of building to more abstract levels of synthesis." (p. 462)

The processes and strategies for data analysis in this study are specified below.

Figure 16

Data Analysis Framework



Note. This data analysis framework was adjusted based on *Research in education: A conceptual introduction* (5th ed.) by J. H. McMillan and S. Schumacher, 2001, p. 463. New York: Longman.

1. Discovery analysis

As mentioned before, discovery analysis began with data collection. In this study, the researcher mainly employed two strategies to generate tentative and preliminary ideas and make decisions in different stages of data collection.

1) Writing "observer comments" in the field notes to identify the emergent themes or highlight the terms, actions and explanation mentioned by participants that revealed the themes. These kinds of "Emic categories" represent the insider's own meanings and understanding of the situation (Maxwell, 2013) or their views that are distinctive to the setting or people (McMillan &

Schumacher, 2001). These identified themes or categories may help formulate a deeper or detailed interview question or be the theme in reflective conversation when the researcher talked with teachers after the lessons. These "observer comments" were sometimes written during the lessons, and at other times after a few observations as a summary.

For instance, after the first observation for two classes (one is full-time students, the other is part-time students), the researcher reviewed the field notes and observation checklists, and wrote down a short comment, "*the common problem is students got nothing to do except sitting there to listen*". When the researcher came to the third class (part-time students), she found that the situation was almost the same, although the teacher's lecture was more interesting and included some real-world examples. Thus, after the lesson, the researcher talked to the teacher, "*you gave a great lecture, but do you think students engage enough in your lesson?*" The teacher responded as follows:

> yes, it is hard to ask students to do something since they were just off work and didn't get any preparation for this lesson in advance, they just come for listening. So, what I was trying to do is using some examples that are related to their works to help them to understand the concepts and keep their attention. So, it was really like if teachers gave a better lecture, they will get more audiences, if not, they won't have audiences. (Teacher D)

Here, the researcher kept the teacher's reply in her field notes and highlighted the word "audiences", because she considered it reflected how the teacher perceived his relationship with students. In other words, instead of being a co-learner, the teacher regarded himself as a knowledge giver while the students were knowledge receivers.

2) Writing summaries of reflective conversations as soon as possible after the "talk". The focus of the summaries was a reflection on what needs to be further adjusted before the next lesson or what needs to be discussed with the teacher before the next lesson. The researcher also wrote summaries for interviews, as this can "force the researcher to selectively pull out the important aspects and rearrange those aspects in a logical order" (McMillan & Schumacher, 2001, p. 465), which is similar to using intuition to catch the most impressive information the first time and which helps to focus the study. For example, after an interview with teacher C, the researcher summarized it in the reflective journal as:

1) Case study can enrich their learning experience.
2) Since the case is not that related to their workplace, and the application has lots of constraints too, it is hard to apply in the workplace. But it can open their minds, give them some new ideas.
3) Assessments and the learning objectives should be matched.
4) Suggestions: the instructions should be clearer; the content should be easy to understand.

Next step:

1) How to do the pre-read?
2) How to design reflective assignment?

In addition, for the transcription of interviews, the researcher carefully listened to each interview

tape and transcribed them down word for word. During the listening, the researcher also kept notes and memos on what she found in the data and developed tentative ideas about categories and relationships.

2. Intensive analysis - coding, categorizing, connecting and theorizing

Furthermore, the researcher intensively read the data to identify topics, develop categories and further explore their relationships for pattern seeking that could lead to a theory about a phenomenon that in turn responds to the research question. This intensive data analysis process includes coding, categorizing, connecting and theorizing.

1) Coding

Maxwell (2013) described the goal of coding as "to fracture the data and rearrange them into categories that facilitate comparison between things in the same category and that aid in the development of theoretical concepts." (p. 107).

Coding plays a vital role in dividing data and developing categories for further comparison and connection in order to build a theory or an explanation of the examined phenomena. Instead of understanding coding as a general process or strategy in data analysis, coding in this study specifically refers to "the process of dividing data into parts by a classification system - segmenting the data into units of content called topics and grouping the topics into larger clusters to form categories." (McMillan & Schumacher, 2001, p. 467).

Since the final set of categories is not totally predetermined, but generated from the data itself according to the synthesis of emerging topics, developing a classification system for data division is an inductive, generative and constructive process. Noted below is the five-step framework proposed in McMillan & Schumacher (2001), which was used for developing a classification system for data analysis in this study.

Step 1: Get a sense of the whole

Step 2: Generate topics from the data

Step 3: Compare for duplication of topics

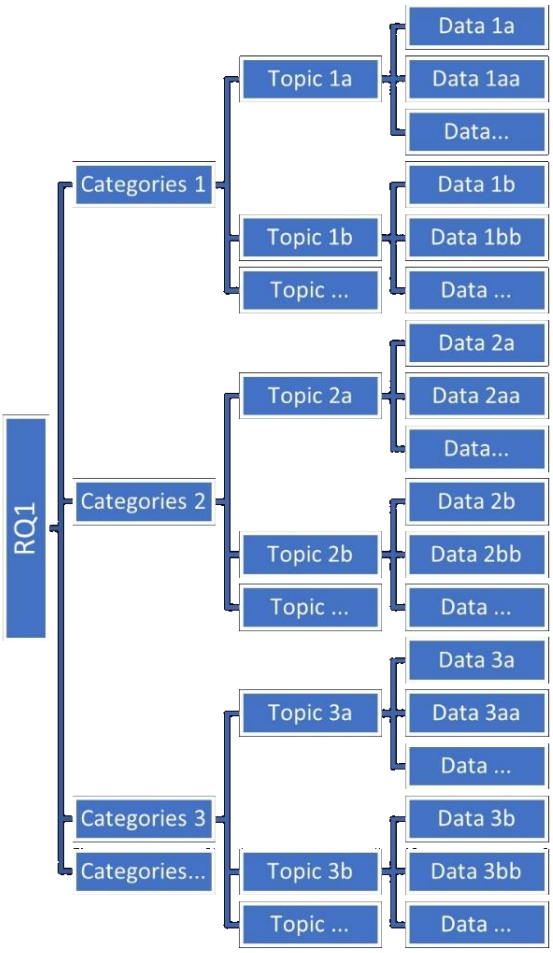
Step 4: Try out your provisional classification system

Step 5: Refine your organizing system

Figure 17 (below) is the framework of the classification system, which indicated how the data answers the research questions through an inductive, generative and constructive process.

Figure 17

The framework of the classification system



Data collected for each research sub-question have been summarized in tables. For example, for the research question: **"What is the level of teachers' and students' acceptability towards the teaching and learning facilitated by the developed resources?"**, the data relevant to both the students and teachers' acceptability were presented in a table (see table 8).

After organizing the data according to the research sub-questions, the data was further analysed with the intension of developing categories and identify patterns.

Table 8

Data representation relevant to both the students and teachers' acceptability

Students' acceptability:			
Class A	**Class B**	**Class C**	**Class D**
1) perception of case study learning			
2) preference of case study learning			
Teachers' acceptability:			
Teacher A	**Teacher B**	**Teacher C**	**Teacher D**
1) How the resources support teachers' lesson preparation and classroom teaching			
2) Teachers' Perception of using case study as the pedagogical strategy			

2) Categorizing and Connecting

McMillan & Schumacher (2001) made a very simple, but clear, definition of category: "A category is an abstract name that represents the meaning of similar topics." (p.478), which emphasized the focus of similarities in developing categories and the use of constant comparison in qualitative research to compare and contrast to determine the distinctive characteristics of each topic and category. Many of the qualitative research guidebooks also pointed out that similarities and differences are generally used to define categories and to group and compare data by

category in qualitative data analysis (e.g. Maxwell, 2013; Creswell & Guetterman, 2019). However, similarity relations (involve resemblances or common features**)** that identified based on comparison can be independent of time and place, which may create analytic blinders that lead to the neglect of "the actual relationship of things within a specific context" (Maxwell, 2013, p. 112). Specifically, a clear statement of "the actual relationship" was found in L. Smith (1979):

> At a practical level, while in the field, the thinking, searching and note recording reflected not only a consciousness of similarities and differences but also an attempt to look for unexpected relationships, antecedents, and consequences within the flow of items". (p. 338, cited in Maxwell, 2013, p. 106)

Maxwell (2013) further generalized this mode of relationship as "Contiguity-based relations" (p. 106) and defined the strategies that focus on contiguity as connecting strategies. Connecting analysis considers the relationships among different parts of a transcript or field notes holistically, which attempts to understand the data in context and use various methods to identify the relationships between different elements of the text (Maxwell, 2013). The process of fracturing the initial text into discrete segments and re-sorting the segments into categories needs to be considered holistically and contextually, and the identification of relationships should go beyond similarities and differences to gain a deeper understanding of "what is going on" by seeing actual connections between things within a specific context. However, the purely connecting analysis that is limited to understanding particular individuals or situations, also leads to a failure in developing a more general theory to explain "what is going on" based on the categorization of these individuals and situations (Maxwell, 2013).

Thus, this study attempted to integrate the analytic strategies of categorizing and connecting to address the limitation of merely using one kind of strategy to provide a well-rounded account throughout by:

1) Identifying connections among different elements of the text for developing category; and
2) Identifying connections among different categories and themes for building theory.

This approach requires researcher to understand the data in context and pay considerable attention to actual connections between things within a specific context when fracturing the initial data and grouping them into categories. Simultaneously, the process also looks for relationships that connect the data from a general perspective when developing categories for further analysis.

Specifically, below are the strategies that help the researcher to develop category based on the integrated approach.

- Case study. It connects all the data that related to a participant or a group as a case study and understand the information in a whole. For instance, the analysis of the impact on Teacher A, B, C and D individually.
- Open coding. It attempts to capture new insights through inductive analysis and developing the coding categories based on what data seem most important. (Maxwell, 2020). For example, the analysis of the interview question, "In what ways do you think the resources are helpful to you?" has used open coding. When reading four teachers'

answers, the researcher further categorized the data into teacher guidelines, examples related to new concepts, case study and pedagogical instructions.

- Contextual analysis. Understand the connections within, and between, categories referring to specific context, such as identifying the challenges and constraints on teachers' competency enhancement. In this study the contextual analysis needed to refer to the specific institutional system.
- Connection maps. Draw connection maps that demonstrate the relationships among different topics and categories. See the figures in the discussion section as specific examples of this.

Different examples of how different data have been categorized are presented in the results chapter. The data analysis at this stage has identified the main categories and subcategories in the transcripts, which gave a description of what has been found in this study. However, as Gibbs (2007) indicated it is more important to continue the analysis to identify patterns, make comparisons, produce explanations, and build models.

3) Theorizing

After developing categories from massive data to reveal, "what has been found in this study?", the analysis turned to integrating the categories into themes and then interconnecting the themes to develop a theory about the phenomena studied that responds to the research questions.

This process is usually a circular one of returning to the data to validate each pattern that indicated a relationship among categories and then modifying or recasting the idea as part of a larger abstraction, which is a deductive mode of thinking – moving back and forth among topics, categories, and tentative patterns for confirmation (McMillan & Schumacher, 2001). At this stage, a deductive approach can also be used to seek patterns that fit a theoretical model of what the study expects to find, or issues needing to be addressed (Nishishiba, Jones & Kraner, 2014). However, Barbour (2008) pointed out the importance of using both the data collected for a study and notes from reading and rereading the relevant literature to interrogate theoretical frameworks and refine the explanations of the findings.

> This is what we should be aiming for in our analysis of our own data…, the distinction between the findings of our own studies and those of others is a permeable one — at least in terms of using both sources to refine our explanations. (p. 235)

The researcher believed it was important to combine the inductive and deductive approach and refer the data and findings to relevant literature in theorizing analysis. This helps to:

1) Balance the researcher's prejudice as an "insider" and the "taken-for-granted" views (Schutz, 1972, as cited in Barbour , 2008, p. 234) with the actuality of what the data reveal.
2) Determine how well the data illuminate the research questions and which data are central to the issues that are unfolding in the studied phenomenon.

Therefore, the theorizing process in this study included:

1) Developing themes from the categories that generated from data; or from the predetermined categories that generated from the theoretical framework (POPBL+ pedagogical model) of this study.
2) Moving back and forth to the data to confirm all the identified connections and relationships.
3) Comparing results generated from the data with relevant literature to refine the explanations of the findings.

To illustrate further, we can take the example of the first research sub-question that examines the students' and teachers' acceptance of the implementation of the developed resources. For the students' acceptability, the researcher specifically focused the analysis on students' perceptions and preferences of using case study learning to bring real-world learning opportunities into classroom, and developed the predetermined categories based on the proposed POPBL+ model which includes knowledge acquisition, knowledge application, attitude and real-world learning opportunities. However, after moving back and forth to examine the data and validate the patterns, the researcher modified the categories to represent the data more closely. She modified knowledge acquisition to *information*; knowledge application to *application areas, reflection on solution adaption and responses to professional connection*; attitude to *environmental awareness and mindset transformation*; and real-world learning opportunities to *real-world case study learning*. For the teachers' acceptability, the categories were developed through open coding. This included categories generated from "how the resources support teachers' teaching", namely guidelines, examples related to new concepts, case study and pedagogical instructions; and the categories generated from teachers' perceptions of using case study as pedagogical strategy, including effective pedagogical strategy as well as the challenges and constraints. Subsequently, the researcher looked at all the developed categories and found that the teachers' reflection on case study teaching and learning is highly consistent with the students'. Thus, she further developed a theme based on all the identified categories for the first research sub-question, that is pedagogical strategies and contents that support real-world based learning.

In addition, the researcher further compared the results with two main studies that informed the design of this study. The first one revealed real-world learning opportunities can align well with key competencies in sustainability, and these competencies need to be built by engaging in the opportunities that are incorporated in collaborative design, coordination between different faculties and introductory courses (Brundiers, Wiek & Redman, 2010). The second explored the effectiveness of a transdisciplinary course that focused on real-world problem solving on undergraduate students' sustainability competencies. She found that, both the teachers and students mentioned the case studies that bring real-world learning opportunities into the classroom help to develop certain kinds of generic green skills (knowledge, values and attitudes), which is consistent with the first study. She also found that the full-time students with different learning backgrounds had higher acceptability of the real-world case study learning and more impact on their generic green skills development, which is similar to the results of second study that indicated the students who were majoring in another traditional discipline, but taking sustainability minors, improved all the examined competencies. Based on the analysis, the researcher generated a preliminary finding that the case study is effective in integrating the pedagogical strategies (e.g. inquiry learning) and content (e.g. greening industry) that support real-world based learning in TVET.

In brief, the analysis of qualitative data in this study was based on the inductive approach that generates findings from the process of identifying topics from data; developing categories from topics; further developing themes by exploring the relationships and connections among different categories; and finally moving to more abstract levels of data analysis that aim to build a theory or an explanation of the examined phenomena. It also made use of the deductive approach in recasting the tentative analysis as well as validating and refining the analysis and interpretation in prior level of abstraction. In addition, the interrogation of theoretical frameworks and refining the explanation of the findings with reference to the relevant literature also drew the researcher's attention in qualitative data analysis.

3.6.2 Approach for questionnaire data analysis

The questionnaire was analyzed preliminarily based on a simple calculation technique to identify the changes between the "Before" and "After" individually and the differences across four teachers for each item. After that, the results of the questionnaire were interpreted with reference to the results generated from the in-depth interviews and participant observation in order to gain a comprehensive understanding of the impact on teachers' competency enhancement towards ESD inclusion, and more importantly, to identify the implications on teacher's professional development towards greening the TVET curriculum.

As mentioned earlier in this chapter, compared with the in-depth interviews or participant observation (which provides detail information for a greater depth understanding of the examined issues), questionnaires usually provide information that is relatively superficial if it is simply analyzed with statistical techniques. However, questionnaires play an essential role in identifying regularities and differences and highlighting incidents and trends that go beyond simply determining attitudes and opinion (De Vaus, 2002; McGuirk and O'Neill, 2016). An important aim of using a self-evaluation questionnaire (as one of the methods) was to identify the impacts on teachers and to gain structured information regarding how teachers "rated" (evaluated) themselves in a systematic way, which allowed for a systematic comparison within individuals and across all the teachers. By comparing the "Before" and "After" scores of each competency, the questionnaire identified the impact on individuals. While comparing the scores of each item across four teachers, it allowed a deeper understanding of each case and provided a chance for the researcher to explore further the incidents and trends that cause any of the differences.

As the sample of this study was small, the use of statistical analysis was not possible, however, the comparison of "Before" and "After" provided a confirmation as to whether "teachers considered their competencies were enhanced after using the resources" and provided an indication of "to what extent teachers' competencies have been improved". It complements the results obtained through the other methods to bring out a triangulated conclusions drew on the understanding of how teachers improved themselves through resources implementation. In addition, the use of multiple data sources and integrated analysis can measure the alignment between the results generated from the questionnaire and other data sources, which helped to improve the validity and reliability of the questionnaire results. However, the results of the questionnaire generated from a small sample that specifically focused on four involved teachers may not be applicable to a larger population, particularly in terms of identifying regularities and trends. Limitations regarding the applicability of this study are addressed in chapter 6.

3.7 Validity threats in data collection and data analysis

Validity threat as the key concept for validity illustrates the way “you might be wrong” (Maxwell, 2013. P.123). This section analyzed the validity threats (e.g. Reactivity, which refers to “the effect of the researcher on the individuals studied” (Maxwell, 2013, p. 124)) in data collection and data analysis, and discussed the possible strategies for dealing with the identified validity threats. As discussed in the data collection (see section 3.5) for this study, triangulation – collecting multiple data sources using a variety of methods – has been used as a crucial strategy in dealing with the validity threats in this study. In addition, collecting rich data that are detailed and varied enough to provide a full and revealing picture of what is going on (Maxwell, 2013), was also used as the main strategy in dealing with the validity threats.

Table 9 is a matrix that focused on the validity concerns in different data collection and data analysis methods. More specific illustration regarding the use of possible strategies to deal with the validity threats was provided under the table.

Table 9

A matrix focused on validity concerns related to data collection and data analysis

Data collection methods	**Data sources**	**Analysis Plans**	**Validity Threats**	**Possible strategies for dealing with validity threats**
Participant observations	1) Observation checklists 2) Field notes	1) Rate the examined items using the scale of "Limited =1, Moderate =2, Fully Present =3", based on the observable and quantifiable elements. 2) Compare the ratings across four classes.	1) Reactivity 2) The use of number to represent the qualitative results	1) Triangulation 2) Intensive, long-term involvement 3) Rich data
In-depth interviews	Transcripts	Analyze based on the data analysis framework: transcription, coding, categorizing, connecting, theorizing.	1) Reactivity 2) Researcher bias	1) Avoid leaning questions 2) Open coding that minimizes indications of researcher bias 3) Rich data
Documents	1) Students' assignments 2) Group discussion memos	1) Compare the results across four classes in general. 2) As a supplement to the data for demonstrating the students' engagement and generic green skills development.	1) Researcher bias (the selection of data)	1) Respondent validation 2) Triangulation
	3) Final project reports	1) Mark the students' group projects based on the developed rubric (see Appendix K).	1) The validity check of the rubric	1) Respondent validation 2) Provide detail regarding how the researcher mark the reports
Questionnaire	Questionnaire for self-evaluation	1) A simple calculation technique to identify the changes between the "Before" and "After" individually and the differences across four teachers for each item.	1) The validity check of the questionnaires 2) The effectiveness of self-evaluation across four teachers	1) Triangulation 2) Rich data

1. The main validity threats for participant observation in this study include:

1) Reactivity

In observational studies, there is a potential for bias that is related to the presence of the researcher. However, in natural settings, an observer is generally much less of an influence on participants' behavior (Becker, 1970, cited in Maxwell, 2013, p. 125). In order to "see" the teachers and the students to present their actual teaching and learning, all the classroom observations were conducted in a natural setting. The researcher also explained the purposes of this study to the teachers at the very beginning and told them that "The observation is not for evaluating teachers' performance, it is for improving the teaching and learning of this module, therefore you can all just keep doing what you used to do". For minimizing the influence on the students, the researcher usually sat among the students and engaged in the learning activities together with them .

In addition, for each class, the researcher at least been present three times (3 hours each time) for conducting the classroom observation. This intensive involvement not only helped the researcher to get more complete data, but also helped to check and confirm the inferences from the observations.

2) The use of number to represent the qualitative results

The researcher recognized that, describing the teachers' and the students' engagement (see Table 19 and Table 20) as well as the students' generic green skills development (see Table 22) using numbers, based on the researcher's own judgment instead of a rating standard, might be a threat to validity. Therefore, all the rating were made based on rich data that mainly composed of detailed and descriptive note taking of the teaching and learning that the researcher observed. A specific example regarding how the researcher generated this rating can be found after Table 22. In addition, the results generated from the observations were verified through triangulation with other source of data such as interviews and documents. The detailed description of the result presented through the ratings was also provided based on rich data.

2. For interview, the validity threats are mostly relevant to:

1) Reactivity

The researcher is aware that "what the informant says is always influenced by the interviewer and the interview situation" (Maxwell, 2013, p. 125). Therefore, leading questions were avoided during the interviews. All the interview questions were designed as open questions formulated using "Why", "What" and "How" to bring out detailed information and deep insights (See the interviews questions in Figure 13 and Figure 14). In addition, in order to encourage the teachers and the students to present their actual views in interviews, the researcher has explained to them that, their right to privacy will be retained, therefore their personal details will not be revealed. This has also been explained in the consent form.

2) Researcher bias

The way that how the researcher understands the interviewees' responses also influences the validity of the inference draw from interviews, therefore it is important to use the

evidence collected during the interview itself to make this kind of threats implausible (Maxwell, 2013). Therefore, rich original data from the transcripts have been used in interpreting the results and findings of interview. In addition, as presented in figure 17, the data classification system indicated that coding in this study is an inductive and generative process, in which the results were generated from the data itself. In particular, open coding was used as an important data analysis strategy in developing categories. It can be argued that these strategies can help to minimize the researcher bias in analyzing the interview data.

3. Documents

1) Researcher bias (the selection of data)

The researcher was aware that the selection of data that fit her preconceptions might be a potential validity threat in analyzing the documents, as the documents (the students' assignments and group discussion memos) were viewed as a supplement (examples) to the evidences that demonstrate the improvement of students' engagement and generic green skills development. Therefore, the researcher has further verified the preliminary findings through discussing students' assignments and their group presentations with the teachers and the module team leader. In addition, as discussed above, triangulation between different data sources was also used to strengthen the validity of a particular conclusion.

2) The validity of the developed rubric

In term of analyzing students' final group reports, a potential validity threat was identified as the lack of validity check of the rubrics used for marking reports. To address this threat rubrics were developed based on the learning objectives of the module and the researcher has solicited feedback about the rubrics from the module team leader. In addition, the researcher also discussed her marking with the teachers and provided detailed justification for her marking of each report (see the sample presented above table 23). All the collected reports were marked, based on the detailed analysis of the whole reports, which could be used for respondent validation.

4. Questionnaire

1) The validity check of the questionnaire

The lack of validity check of the questionnaire could be a potential validity threat in data collection. However, this questionnaire was developed based on the competency framework "Teachers' standards specific for greening curriculum" proposed in *UNESCO-UNEVOC Resource Guide for Teachers: Embedding Greening Skills in Classroom Instruction* (Pavlova, 2019) (see Appendix C) and further reviewed by the author of this framework to ensure all the items in the questionnaire were clear, unbiased and concise. This helped to strengthen the validity of the questionnaire.

2) The effectiveness of self-evaluation across four teachers

As discussed in the result chapter, some of the teachers were found to overrate or underrate themselves in self-evaluation. This is related to the lack of a standard that can guide teachers to do self-evaluation, thus a validity threat that can influence the

effectiveness of using questionnaire for self-evaluation. Therefore, triangulation together with rich data collection played a critical role in measuring the alignment between the results generated from the questionnaire and other data sources, which could be argued to improve the validity of the conclusions drawn from questionnaire.

In summary, the validity threats in this study were mostly related to reactivity, researcher bias and the validity check of the developed instruments for data collection and data analysis. The influence of these validity threats has been minimized through the integrative use of the strategies discussed in this section.

CHAPTER 4

RESOURCE DEVELOPMENT

The resources used in this study were developed under a large project that aimed to set up a green skills hub in Education University of Hong Kong to support the teacher training and curriculum reorientation for ESD inclusion in TVET. A survey was conducted at the very beginning of the project to collect data on current greening of curriculum practices in TVET institutions within the Asia Pacific to identify good practices and challenges that needed to be resolved to improve the practices. The results of the survey confirmed there was a need to improve teachers' capacity in conjunction with resource development for greening of curriculum towards ESD. Therefore, resource development, which ultimately helps teachers innovate pedagogy, plays a crucial role in improving the teaching and learning of generic green modules.

This chapter introduces how the resources were developed based on the theoretical framework of the POPBL+ model. Specifically, it highlights the processes of resource development in this study and reports on the results of the pilot for the subsequent developed resources. The chapter also clarifies the pedagogical design framework developed, based on the POPBL+ model, and demonstrates the consistency of the developed resources with the principles underlying the model by introducing the key features of the resources with specific examples.

4.1 Description of resources development in this study

This section specified the processes of resources development in this study and reported on the results of the survey conducted for the resources piloting. More detailed illustration regarding the components of the resources was presented in 4.2.2.

4.1.1 The processes of resource development in this study

The processes of resource development in this study included building the project team, developing the resources framework, agreeing on formats for the resources, planning the number of stages involved, writing the resources following the planned schedule and, finally, piloting the developed resources. The development processes were formulated based on Richards's (2001) suggestions for managing a material writing project.

1. Building the project team: Working on creating a team for the project needed to address how many people would take part in it and what will their roles and responsibilities would be.

The project team in this study included the following people:

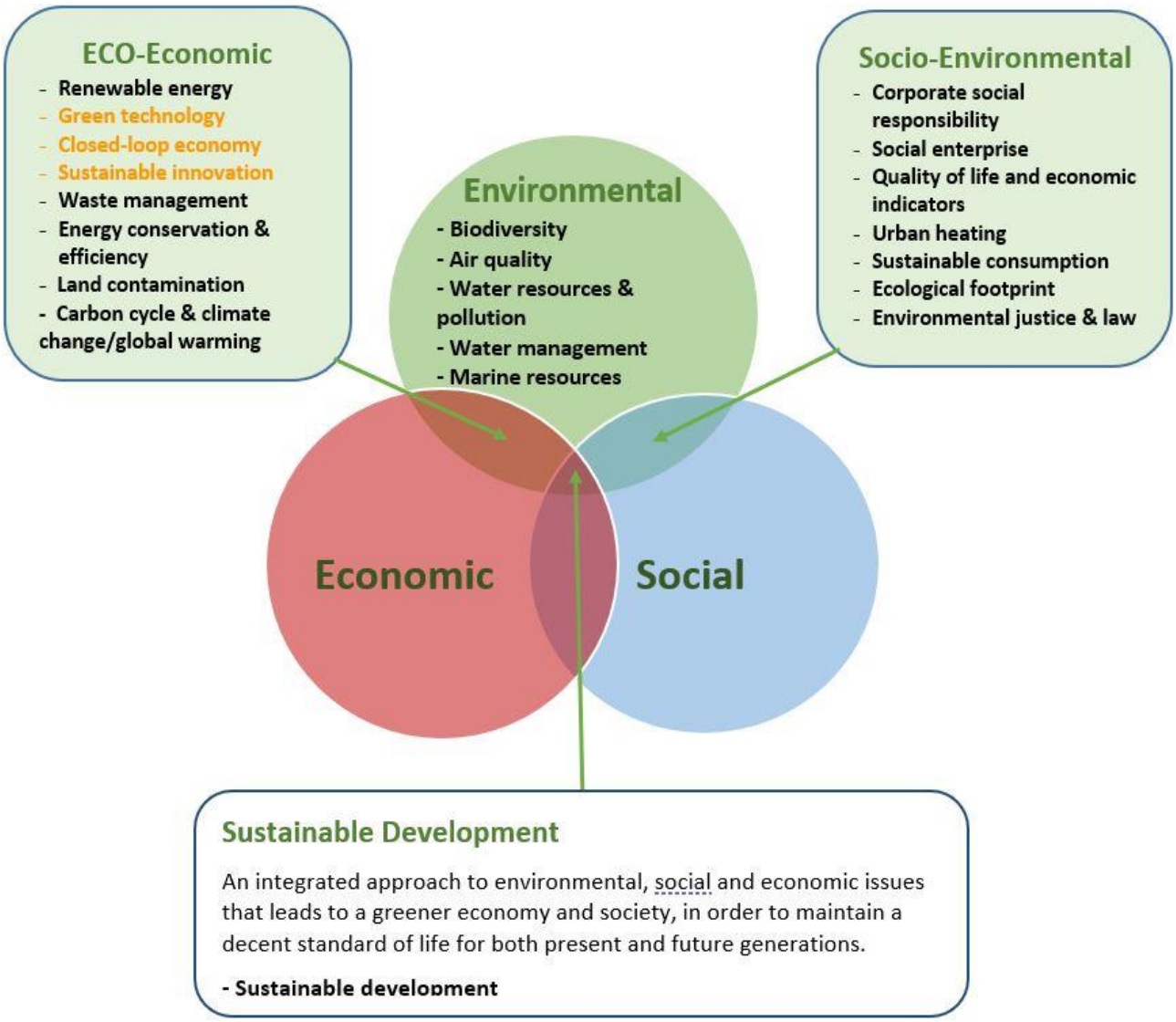
- *Project director and reviewer:* a supervisor in charge of the overall management of the project. She developed an approach to the research based on previous projects (Pavlova, 2003; 2004) and ideas for the case studies, and checked progress to ensure targets were met. She is an expert experienced in ESD inclusion in TVET and curriculum development for TVET. She also reviewed everything from the writers and provided comments for revision.

- *Writers:* two PhD students whose research areas and interests were focused on curriculum development for ESD inclusion, and a research assistant for the project.
- *Editor:* an editor edited everything that had been reviewed and prepared the final version of the resources for publication or duplication.
- *Illustrator:* university students who were skilled at illustration. They were responsible for illustrating the materials to make them look more appealing.
- *Designer:* a university student majoring in visual art design. She was responsible for designing the layout, graphics and overall format of the materials.
- *Web developer*: an IT technician helped develop an online platform for sharing and promoting the resources.

2. Developing the resources framework: This was first step for resource development in this study. The research team firstly reviewed and discussed existing ESD resources, results of surveys, regional reports on SDGs implementation, and the notion of greening. Based on this, the team listed the specific "concepts" (e.g. waste management) that were most relevant for decreasing the environmental impacts of economies and which could be included in the TVET curriculum (in TVET's generic green modules, such as Green Knowledge and Practice). The identified concepts included environmental-specific issues (e.g. global warming) and sustainability measures (e.g. green technology) which are highly relevant to greening the economy and society. Based on the understanding of the interrelatedness of three pillars in the sustainability framework, all the identified concepts were organized in the framework presented in Figure 18.

Figure 18

Resources framework for generic green modules



Note. From "Generic Green Skill for TVET: Teaching and Learning Resource" by M. Pavlova, S. C. Chen & A. Saral, 2019 (https://greenskillsresources.com/).

3. Agreeing on the resource formats: Since members of a team wrote the resources, it was necessary to have a set of agreed formats that different writers could use for the materials. After many discussions, drafts and peer-reviews by the project team, the

teaching and learning resources were structured according to the following formats.

1) **Concept information sheet.** Resources related to a single concept include an information sheet. The sheet provides generic knowledge about that concept, including a definition, examples of daily application, case studies of industrial practice and relevant sustainability issues. The overarching intention here was to help students and teachers to understand how the concepts and issues are specifically related to a green economy and society
2) **Case study content sheet**. Each concept includes at least one case study that tells the real story of green practices in different industry sectors. The case study content sheet clearly lists which concepts/issues and industry sectors the case study is relevant to, and specifies the green practices in the "story", which can be used as the prepared reading material. For example, the case study might demonstrate how the proposed solutions help solve food waste problems.
3) **Student worksheet.** In order to adopt a student-centered approach each concept information sheet and case study content sheet has an accompanying student worksheet, which clearly states the activities students need to do. The worksheet also specifies the learning objectives and its contribution in terms of selected generic green skills development. It outlines in detail the resources needed, time required and assessment for the learning activity.
4) **Teacher guidelines.** Each student activity sheet is complimented by teacher guidelines that are structured in a similar way as the student worksheet. It provides suggested teaching strategies and instructions, potential answers/examples of activities and assessment methods in order to assist teachers with the implementation and to reduce their time for class preparation.

The format of the resources was designed specifically to address the problems and challenges identified in the pilot study and to support classroom practice in a more flexible way.

Thus, each concept in the framework includes two sets of materials. One is designed to facilitate the understanding of the concept (concept information sheet, student worksheet and teacher guidelines), and the other was designed to provide students with industrial cases that created opportunities for them to experience the "knowledge application" (case study content sheet, student worksheet and teacher guidelines). For instance, the resources designed for the concept of green technology include the materials listed below in Table 10:

Table 10

Example of resources: Green technology

Concept: **Green technology**	**Case study: Green technology**	
	Case study1: How much energy do data centers use?	Case study 2: Green buildings
Concept information sheet	Case study content sheet 1	Case study content sheet 2
Student worksheet 1	Student worksheet 2	Student worksheet 3
Teacher guidelines 1	Teacher guidelines 2	Teacher guidelines 3

4. Planning the number of stages involved: a resource-writing project necessarily goes through several stages of development. This project included the following stages:

- First draft
- Team comments on first draft
- Second draft
- Further comments by reviewer
- Third draft
- Further comments by reviewer
- **…** Until no further comments
- Final revisions of resources (editing)
- Illustration design and formatting

As can be ascertained from the stages listed above, each of the resources had at least three drafts as well as comments from team members and the expert reviewer. This helped improve the quality and consistency the resources.

5. Writing resources following the planned schedule: A writing schedule was developed with dates assigned to the different stages in the process. The resources used in this study were developed as a priority; they were reviewed by experts and revised several times according to the comments before the final editing and illustrations.

6. Piloting the resources: Piloting of the developed resources involved trying out resources with a representative group of TVET teachers and leaders before they were made available for wider use. Piloting sought answers to the following questions:

1) Are the materials comprehensible with clear instructions?

2) Are the materials sufficiently interesting and engaging?

3) Do they enrich classroom practice?

4) How are they useful for teachers?

5) What can be further improved?

After the piloting, the researcher conducted a survey (see Appendix G) to understand the involved teachers' perceptions of the developed resources. The pilot of the resources and a report on the results are presented in section 4.1.2 below.

4.1.2 The pilot of the developed resources

The developed resources were piloted in May 2019 at a training workshop. The three-hour workshop was part of the training program, "Green Skills and New Economy for Sustainable Development", which was organized in China for TVET teachers in the region. Initially, the researcher briefly introduced how the resources were developed and explained how to use them for preparing and organizing teaching and learning activities. Following the introduction, the researcher used materials related to the concept of "green technology" as a sample (these included the concept information sheet, case study content sheet, the student worksheet and teacher guidelines designed for the case study) to simulate a real classroom-teaching situation. All the participants played the role of student in order to experience the learning processes designed, based on the sample resources.

Twelve participants from different countries (Bangladesh, Fiji, India, Malaysia, the Maldives, Myanmar, Nepal, Pakistan, Papua New Guinea, Philippines, Sri Lanka and Thailand) participated in the training workshop. Some of them had more experience in greening the TVET curriculum in their countries (e.g. Malaysia), the others had less. The survey was developed to examine teachers' perceptions of the resources in enriching teaching and learning and facilitating students' generic green skills development. The questionnaire for the survey was formulated based on the specific features of the resources (e.g. facilitating knowledge application) and the expected impact on teaching and learning for generic green skills development. Participants were required to rate the extent to which they agreed with the statements listed in the questionnaire. On a scale of 1 to 5, 5 refers to "**Strongly Agree**", and 1 refers to "**Strongly Disagree**. The results of the survey are presented in Table 11 below. The results indicated were calculated according to the number of ratings that scored 4 (agree) and 5 (strongly agree) out of the total number of participants and averaged the total scores of each question.

Table 11

Survey result of the piloting of the resources

Section 1: Perception of the resources for students' generic green skills development	
1. To what extent do you think the resources can enrich your classroom practice in terms of pedagogy?	
1) Information sheet for concept understanding	9 out of 12 (3.83)
2) Case study for concept application	7 out of 12 (3.58)
3) Student worksheet for the case study	7 out of 12 (3.5)
4) Teacher guidelines	7 out of 12 (3.83)
2. To what extent do you think our resources can support you in terms of preparation for a lesson?	
1) Saving time	**10 out of 12 (4.08)**
2) Providing good ideas for your own resource development	**11 out of 12 (4.5)**
3) Providing opportunities to learn about different concepts yourself	**11 out of 12 (4.25)**
3. Which type of the resources will be mostly useful in lesson preparation?	
1) Information sheet for concept understanding	9 out of 12 (3.58)
2) Case study for concept application	9 out of 12 (3.75)
3) Student worksheet for the case study	8 out of 12 (3.83)
4) Teacher guidelines	**10 out of 12 (4.08)**
4. To what extent do you think the resources can facilitate student to transform the learning from knowledge acquisition to knowledge application?	**11out of 12 (4.08)**
5. To what extent do you think the resources can help to develop students' attitude toward green practice?	**10 out of 12 (4)**

6. To what extent do you think the resources can help to develop students' generic green skills?	
1) Cognitive competence	**10 out of 12 (4.17)**
2) Interpersonal skills	**11 out of 12 (4.42)**
3) Intrapersonal competence	**10 out of 12 (3.92)**
4) Technological skills	**9 out of 12 (4)**
7. To what extent do you think the resources can help to influence students' behavior change toward sustainable practice?	**10 out of 12 (4.25)**
Section 2: Teaching and learning	
1. To what extent do you think the identified concepts can be integrated into your module/course?	**10 out of 12 (4.08)**
2. To what extent do you think students will be interested in the case study developed for Green technology?	**9 out of 12 (3.92)**
3. To what extent do you think students are interested in the learning activities developed for Green technology's case study?	8 out of 12 (3.75)
4. To what extent do you think the interactive pedagogical approaches can be implemented in your classroom practice? For example, industry-based learning, real world problem solving outside and inside the classroom.	**9 out of 12 (4.17)**
5. To what extent do you think you can effectively conduct the activities based on the teacher guidelines?	**11 out of 12 (4.17)**
6. To what extent do you think students can understand how to engage in the activities based on the student worksheet?	9 out of 12 (3.75)

The results revealed teachers' perceptions towards different kinds of materials, and their contributions to students' generic green skills development. Generally, teachers were very positive towards the resources. From their perspective, the **Teacher Guidelines** are most useful in supporting the lesson preparation: 11 teachers out of 12 (4.17 out of 5 – section 2.5) believed that they could effectively implement the suggested learning activities based on the teacher guidelines. However, the perception of the usefulness of a **Student Worksheet** ranked lower, it was rated as 3.75 by the teacher respondents (section 2.6). Teachers believed that students could encounter some difficulties in understanding how to engage in activities based on the student worksheet. The same, relatively low rating

shows the teachers believed the use of the student worksheet would enrich their classroom practice in terms of pedagogy (3.5 out of 5 – section 1.1.3) and agreed the student worksheet would be helpful in lesson preparation (3.83 out of 5 – section 1.3.3). Similarly, the **Concept Information Sheet** was less as popular than the teacher guidelines too, although the majority of the teachers (10 out of 12, 4.08 out of 5, section 2.1) considered the identified concepts could be integrated into their current module/course. Regarding the **Case Study**, it was ranked with a lower satisfaction level among the provided materials. To a slightly less extent, the teachers believed the case studies were helpful in enriching classroom practice (3.58 out of 5 – section 1.1.2) and agreed they are helpful in lesson preparation (3.75 out of 5 – section 1.3.2). In addition, the majority of the teachers (9 out of 12 – section 2.2) considered the case studies provided in sample resources (1. green building; and 2. renewable energy used for powering the data center) were interesting to students, although the teachers indicated a relatively low rating in the extent to which they believed students would be interested in the learning activities designed for the case study (3.75 out of 5, Section 2.3).

Although the numbers provided a general indication of the teachers' reactions, more understanding was gained from teachers' comments in the open questions of the survey. Specifically, half the teachers indicated that the case studies should be contextualised, as the examples provided related to Hong Kong, a context the teachers were not familiar with. For example, a teacher mentioned that "The sources are very impressive however, it needs to be contextualized to individual country need".

The results implied that non-contextualized resources may cause a lack of a sense of connection toward the sustainability story in the case study, so it could be less attractive and inspiring for learners. However, from the teachers' perspectives, the non-contextualized resources could still provide them with good ideas to develop their own resources and provide opportunities for them to learn additional differing concepts relevant to sustainability (theoretical knowledge) by themselves.

In addition, a few teachers also indicated their concern about the language, since it would have implications in terms of students' understanding, and suggested the wording should be simplified. In addition, for all these teachers, English was not their first language, so these comments could also be applied to them. For example, "[Need] a more simplified wording. The students guide has lengthy words."

Two teachers also pointed out the importance of online learning and suggested more online learning resources and activities should be included:

> Organize online discussion (scheduled activity like TVET conferencing) and incorporate on the website. (TVET teacher from India)
>
> The case studies that linked to good videos will attract current generation of learner. (TVET teacher from Sri Lanka)

In summary, the unfamiliar context of the case studies (including the stories that described green practices and the learning activities for transforming knowledge acquisition to application, which are all focused on the Hong Kong context) have both

advantages and disadvantages and should be complimented by contextualized case studies if these case studies are used outside Hong Kong. The wording of resources should be simplified to allow students from non-English speaking backgrounds to use the resources effectively. Finally, different forms of learning activities should be designed for online learning.

Furthermore, with reference to questions 4 to 7, which focused on identifying teachers' perceptions towards the impact of the resource implementation, the results indicated a positive response. The teachers highly agreed the resources could make an impact on facilitating knowledge application (1 out of 12, 4.08 out of 5, in section 1.4), attitude (10 out of 12, 4 out of 5, in section 1.5) and behavior change (10 out of 12, 4.25 out of 5, in section 1.7) toward sustainable practice. In terms of contributions to students' generic green skills development, the teachers ranked the help to interpersonal skills development highly (11 out of 12, 4.42 out of 5, Section1.6.2,) since all the learning activities were designed to be interactive, whereby students are required to work in small groups to discuss questions and share different ideas. While for the cognitive competence and intrapersonal competence, both had 10 teachers agreeing the resources were helpful (section 1.6.1 and 1.6.3).

Furthermore, teachers' comments about the resources indicated their appreciation that the resources could facilitate students' generic green skills development. Eleven teachers out of 12 clearly indicated they are interested in trying out the resources in their institutions although contextualization is needed first. Most of the comments from teachers mentioned "useful", "systematic" and "helpful":

> The resources are very useful. They can help our TVET students to develop the green skills and attitudes towards it. (TVET teacher from Philippine)
>
> The resources are systematically developed and the formats are clear to us. (TVET teacher from India)
>
> No doubt these resources add very much in green skills and sustainable development. Hope that they can be shared among trainees as well as to managers and administrators. (TVET teacher from Pakistan)

In summary, the pilot study revealed that the teachers regarded the developed resources as a useful tool to be applied in classrooms for the purpose of developing generic green skills. The results of the survey and teachers' feedback indicated the resources are appropriate in content (including concepts and measures towards greening the economy and society), approach (industrial-based case study, interactive project-based learning activities) and that they address both learners and teachers' needs. In particular, the impact of the resources on students' generic green skills development and their attitude and behavior change toward green practices were highlighted. In addition, the results of this trial also highlighted that in order to achieve the maximum impact, case studies should utilize examples from local contexts. Thus, the resources that were developed based in the Hong Kong context are very likely to benefit TVET institutions within Hong Kong, in particular the case studies and learning activities that were designed to focus on

Hong Kong sustainability issues. In order to simplify the wording, the resources were all checked by the writers and edited by the editor to try to simplify the long sentences and have technical terms explained more clearly. In addition, the resource development team took into consideration the advice of applying ICT-based learning, such as online learning formats (e.g. online discussion) and online learning materials (videos, materials that designed based on virtual technology) and will develop this in the future. Thus, for this study, the resources developed for the Hong Kong context are appropriate and they were used for the intervention in order to provide real-world learning and problem-solving opportunities for students in this study.

4.2 Justification of the consistency of the developed resources and the principles underlying the POPBL+ model

This section first elaborates the generation of the pedagogical design framework based on the proposed POPBL+ model, which helps transform the theoretical hypothesis into practical implementation. Following from this, it further illustrates the approaches that demonstrate the integration of the model principles and specifies the strategies developed based on the approaches for resource development. Finally, this section uses the "Green Technology" resource package as an example to demonstrate how the resources were developed based on the specific strategies, which reflected the consistency of the developed resources with the principles underlying the POPBL+ model.

4.2.1 Pedagogical framework for the implementation of the POPBL+ model

To apply the POPBL+ model in practice, a pedagogical framework (Table 12) was designed to provide suggestions for pedagogical strategies and activities for use during lessons. They were identified based on the review of ESD pedagogical strategies and a consideration of the learning setting within the involved TVET institution. Each pedagogical strategy suggested in the framework is grounded on specific learning objectives that correspond with the development of green skills in different learning phases. Both pedagogical strategies and learning activities are indicative and can include additional forms of learning, which provide ESD learning opportunities for students and encourage them to engage in the exploration of sustainable development issues.

Thus, this pedagogical framework was used to support the transformation of the POPBL+ model into classroom implementation. The researcher and the project team have used these suggested pedagogical strategies and learning activities to achieve consistency as well as an effective application of the POPBL+ model in resource development. The consistency in resource development specifically refers to, the unified framework used to address different concepts via pedagogical design that is based on the suggested pedagogical framework (POPBL+ model). In addition, different parts of resource were developed by different project members, therefore consistency in approaches was essential.

Table 12

Pedagogical framework developed based on POPBL+

Learning Phases	Learning Objectives	Generic Green skills	Pedagogical Strategies (e.g.)	Learning Activities (e.g.)
Bringing the world in	• Identify and formulate the real-world sustainability problems. • Understand the key concepts and current situation related to the identified issues.	Cognitive competence.	• Lecturing. • Case study (problem-oriented).	Draw a concept map. Analyze the critical incidents within international and local contexts (e.g. compare different solutions).
Simulating the world	• Experience the dynamics of communication. • Learn how to deal with various perspectives and conflict resolution.	Cognitive and interpersonal skills.	• Stimulus activities/ discussion. • Debates. • Peer-review activities.	Reflection on related videos, photos and documents.
Visiting the world	• Connect students' learning and work experience to the identified issues.	Intrapersonal and interpersonal competencies.	• Group discussion. • Case study (Industrial context).	Poster presentation (present a real-world sustainability problem explored in the group project).
Engaging with the world	• Propose potential solutions and strategies for the identified issues.	Cognitive, technological and interpersonal skills	• Group project.	Interview. Questionnaire. Field observation.

4.2.2 Linking the development of resources with the pedagogical model

To ensure that the resources match the pedagogical model described in section 3.1.4, the principles underlying the model and the relevant approaches and strategies that address the integration of the principles were applied for resource development. Table 13 illustrates the linkages between these elements, based on the learning and teaching package, “Green Technology” that was used for the intervention in this study.

Table 13

Linking resource development to the pedagogical model – using the Green Technology learning and teaching as an example

Principles underlying the model	**Approaches: how to integrate the principles into the resource development**	**Specific strategies: how to develop resources based on the approaches**	**Examples that demonstrate the integration of the principles: taking the resource package "Green technology" as the example**
Principle 1: Create real-world learning opportunities	Four progressive processes: 1) Bringing the world in 2) Simulating the world 3) Visiting the world 4) Engaging with the world	Introduce the real-world sustainability issues and relevant concepts and examples.	The information sheet was developed to introduce the concepts related to suitability issues (e.g. global warming) or mitigation measures (e.g. closed-loop economy). The sheet included a concept definition and the goals/principles/models related to the concept, the concept application in daily life and specific industries and the description of local issues with international perspective. For example, the information sheet for green technology, introduces what green technology is and what it includes, such as renewable energy and smart buildings innovation. It also exposes local issues that need to be addressed through green technology such as: 1) Electricity consumption in building-related activities in Hong Kong, which accounts for 60 percent of the city's greenhouse gas emissions. 2) Low application of renewable energy in Hong Kong and the scope for growth is limited. Following on from this, it introduces 1) What green building is and the standards of green building in Hong Kong and Mainland China. 2) Specific application of renewable energy in Hong Kong and the relevant policies.

			Please see the concept information sheet for "Green Technology" in Appendix H
		Include industry-based case studies that connect students' learning/working experience to real-world sustainability issues.	All case studies for the project are industry-based and locally relevant (however they do include some international examples), which help to connect students' learning to real-world problem solving. Please see the Case Study Summary Sheet in Appendix I that lists all the developed case studies and their relevant industry sectors. For instance, the case study, "How much energy do data centers use?" (Renewable Energy Sector) introduces: 1) How Microsoft, Apple and Google achieve energy efficiency. What renewable energy has been used to power their data center and 2) What has been done by the local data center, Hong Kong Broadband Network (HKBN), to reduce energy and carbon emissions which also reduce costs. The case study aims to help students understand how renewable energy works in different data centers and to think about how the use of renewable energy could be improved or which green technology related to electricity consumption could be used to solve the energy consumption issue in Hong Kong.
		Design learning activities that facilitate students to work on, and propose, solutions for real-world sustainability problems.	All learning activities were designed to create real-world learning opportunities to engage students in the process of learning through real-world problem solving. For example, a learning activity designed to facilitate students to understand the concept of green technology and to connect students' learning to problem solving regarding using green technology to address sustainability issues on campus included the following tasks: 1) Identify green technologies used on your campus. 2) Identify issues that can be solved through the use of green technology. According to the criteria of green technology stated in the information sheet, propose a green technology that can help to deal with an identified environmental issue on campus (e.g. food waste management in campus' canteen, green office).

Principle 2: Facilitate knowledge acquisition to shift towards knowledge application	Problem-oriented and project-based learning	Design resources using a problem-oriented approach and expose students to specific sustainability problems to stimulate their learning motivation towards knowledge acquisition.	The resources were developed to facilitate problem-oriented learning that aims to equip students with knowledge regarding "what is it" and "how to use it to solve problems". For example, the learning of green technology was developed to address: What is green technology? Why do we need green technology? How does green technology help to solve problems? How does the identified green technologies in your campus work? What other issues can be solved on campus (e.g. food waste management in campus canteen, green office) through the use of green technology? Furthermore, students are exposed to different sustainability issues and the relevant solutions during different learning processes. For instance, the case study "How much energy do data centers use" indicated: A data center consumes a lot of energy to enable web users to stream videos, downloads books and perform other online activities. The energy consumed for this around the globe is about the same as it takes to power 30 nuclear power plants. According to Green House Data, data centers around the world use about 30 gigawatts, or 30 billion watts of electricity. While U.S. data centers account for nearly one-third of that amount, according to estimates compiled by the *New York Times*. Powering data centers with renewable energy sources, like wind or solar, is an obvious solution to energy problems globally. After the introduction of the electricity consumption issue in data centers, the case study introduces different solutions implemented by Microsoft, Apple, Google and a local company HKBN and asks students to discuss: 1. What green technologies have been used by the Microsoft, Apple and Google data centers? Please specify how these solutions help save energy, or which green technologies have been used to address the energy consumption issue. 2. What solutions have been implemented in Hong Kong? How do they work? 3. If you are the owner of HKBN and you want to further improve the energy

			issue of this data center, what solutions do you think could be applied, based on the experience from the data centers introduced in this case study, and why? Can the cost of electricity be reduced?
		Facilitate students to engage in group work and apply what they learnt to solve the real-world sustainability problems identified on campus, living places or workplaces.	In the designed learning activities, students are always asked to identify problems and further explore solutions or understand how a measure help to solve a problem through different kinds of learning activities and group projects. For example, in the green building case study, the activity included: 1) Discuss what green technologies have been used in the selected building. How do they work? 2) Discuss what, and how, identified technologies could be used to green your campus (or workplace or community). You can reflect on the environmental issues identified on campus or on other sites from your previous activity. 3) Make a poster (in draft format) to market technologies you propose could be used on campus (or workplace or community). 4) Present your group poster (ideas are more important than artistic presentation) to the whole class. Let several students in your group (or everyone if time permits) give part of the presentation.
Principle 3: Facilitate the understanding of the interaction between international and local contexts, as well as individual and industrial contexts	Locally oriented and industry-based learning content	Develop locally oriented case studies that cover different industry sectors.	The resources include local case studies covering 10 industry sectors, namely: Agri-and aquaculture, transportation, waste management, manufacturing, public administration, renewable energy, knowledge sector, construction, retail and the hotel industry. All the developed case studies are relevant to local sustainability issues in Hong Kong. For example, case studies under the concept of green technology include: 1) Green buildings (construction sector) Example 1: Hong Kong Science Park Example 2: Zero Carbon Building Example 3: Town Gas Headquarters 2) Renewable energy sector: How much energy do data centers use? (Google,

			Apple, Microsoft and HKBN) Please see the Case Study Summary Sheet in Appendix I to find out more case studies that cover different sectors.
	Multiple perspective approach	Introduce local sustainability issues from a global perspective and include examples and cases from both local and international contexts.	In the concept and case study information sheets, local sustainability issues are explained with a global perspective. For example, the electricity consumption of building-related activities was introduced in the information sheet as follows: Today, as industrial manufacturing is no longer the main economic activity in Hong Kong, the major source of electricity consumption is from buildings like housing estates, offices and malls. Building-related activities account for around 90 percent of Hong Kong's total electricity consumption, **compared to a global average of 40 percent**. In turn, this high level of energy consumption from buildings accounts for 60 percent of the city's greenhouse gas emissions. Therefore, green buildings play a crucial role in achieving energy savings in Hong Kong, and are also **a global target set by the Paris Agreement 2015.** In addition, the examples and cases used in the resources also included both local and international ones. For instance, the examples used for demonstrating how green technology helps to solve sustainability includes: 1) The sideways-growing trees in Singapore 2) The thermoGreenWall™ (tGW) at Yale University 3) The energy saving escalator in Hong Kong 4) The Dyson Airblade Tap used in different countries The cases used in the case study "How much energy do data centers use?" includes Google, Apple, Microsoft and HKBN. Thus, based on these teaching and learning resources, teachers can further facilitate students to compare the case from different perspectives, analyze the issues and relevant solutions within both local and international contexts and understand the interaction effect between different contexts (e.g. Why do green buildings play a crucial role in Hong Kong? How about the other countries?).

Table 13 demonstrates that different kinds of resources were used to address different learning needs and that together they work through different learning processes. For example, information sheets were designed to play a key role in the learning process of "bring the world in" by introducing real-world sustainability issues and relevant concepts and examples. However it also prepares students with the knowledge required to engage in activities that facilitate deep learning and knowledge application. In particular, the case studies are developed based on the following principles:

- **Industry-based:** The case studies developed in the resources included green practices from different industries such as Sludge treatment in T. Park (waste management industry) and Clean air – SMOG FREE PROJECT (manufacturing industry). These case studies were developed to facilitate students investigate the real-world sustainability problems and reflect on the innovative solutions provided in the cases.
- **Problem-oriented:** The problems exposed in the case studies were designed to work as stimulators to facilitate students to engage in inquiry learning and group projects. The local problems that students are experiencing (e.g. urban heating) or those that students are already getting used to (e.g. waste generated by the fashion industry) can further facilitate students to reflect on their workplace and/or lifestyle.
- **Engagement-based:** The case study created opportunities for discourse on sustainability issues among learners, as well as learners and teachers instead of the simple knowledge delivery directly from the teacher to students. It required students to engage in different classroom activities, and group projects, and apply what they learnt to solve the real-world problems.
- **Locally relevant:** Most of the case studies were developed based on local issues and local contexts, which help to engage students in becoming active participants in local problem solving. Twenty-one out of thirty of the cases are focused on the Hong Kong context. In addition to this, local sustainability issues were introduced from a global perspective, which led students to consider the issues and the impacts of different solutions from both the local and global contexts.

These developed case studies play an essential role in providing real-world learning opportunities for students and facilitate the transformative learning between knowledge acquisition and knowledge application. In addition, they also expand students' understanding of sustainability issues and the relevant solutions proposed from both local and global perspectives.

Thus, different kinds of resources work as a whole to facilitate the implementation of the principles underlying the POPBL+ model, in order to improve the teaching and learning of generic green modules for students' generic green skills development.

CHAPTER 5
RESULTS

This chapter presents the results generated from different data sources to answer the second research questions: How effective is the proposed ESD pedagogical model (the POPBL+ model that wasdeveloped based on literature review and the pilot study) in terms of improving teaching and learning of generic green modules for generic green skills development? The answer and discussion relevant to the first research question are presented in section 6.1.

The intention of this chapter is to present results to address three sub-questions of this study:

1) What is the level of teachers' and students' acceptability towards the teaching and learning facilitated by the developed resources?
2) How do teachers and students engage in the resource implementation process?
3) What is the impact of the implementation of the ESD resources on students' generic green skills development as well as the enhancement of teachers' competencies in terms of greening of curriculum?

To contextualize the results presented here, three issues should be further clarified.

First, the nature of a typical class. This background is important to understand interventions conducted during this study. In all four classes, content-based lecturing was always the main teaching strategy. The teachers used to this way of delivering teaching and learning packages (including PowerPoints, and the notes for each session to allow preparation). The students hardly had any learning activities rather than listening to the lectures. The majority of them, instead of focusing on the classroom learning, just did somethings else, such as playing cellphones, sleeping and using their laptops to watch videos.

Second, the generic green module involved in this study was redesigned during the study using the developed ESD resources (see Table 14). Compared to the original design (see Table 1), the new one has integrated the principles underlying POPBL+ model, therefore it was designed based on student-centered learning. Topics included in this study were closed-loop economy and green technology (which have been included in two classroom sessions) and sustainable innovation (which has been used to design the final group project).

Last, As explained in the methodology chapter, as well as highlighted by the data analysis, full-time and part-time students responded differently to the resource implementation, so the results related to students will be presented based on these two categories.

Table 14

The learning content of "Green Knowledge and Practice"

Green Knowledge and Practice (Elective module)	
Learning Content	Indicative Contact Hours
Topic 1- General environmental awareness and principles in daily life • **Closed-loop economy** Case study 1: How sustainable fashion contribute to the closed-loop economy; Case study 2: Sludge treatment in T. Park • **Sustainable consumption** Case study 1: Wood-based fibers could lead sustainable fashion out of the woods	6 hours
Topic 2- Environmental law/regulations, environmental standards within occupations occupation • **Environmental law and regulation** (included Environmental Management System (EMS) and ISO 14001) Case study 1: Green buildings in Hong Kong: 1) Hong Kong Science Park; 2) Zero Carbon Building; 3) Town Gas Headquarters)	4 hours
Topic 3- Pressing local and global issues • **Waste management** Case study 1: Hong Kong's awareness on waste management • **Sustainable development** Case study 1: Greening of the hotel industry in Hong Kong • **Water resources and water pollution** Case study 1: Wastewater treatment in Hong Kong	6 hours
Topic 4- Greening workplace: application and impact on occupation / workplace practice • **Green technology** Case study 1: How much energy do data centers use?	6 hours

• **Sustainable innovation** Case study 1: Clear air-SMOG FREE Project; Case study 2: Over packaging in retail sector: Can Air-Carbon help?	
Topic 5- Social / economic impact • **Corporate social responsibility (CSR)** Case study: How can Hong Kong's CSR experience enhance the success of the Belt and Road initiative? • **Social enterprise** Case study: Riders for health in Africa	4 hours

Note. The learning contents for the generic green module "Green Knowledge and Practice" were redesigned after the resources were initially developed, based on the POPBL+ model.

5.1 The level of teachers' and students' acceptability towards the teaching and learning facilitated by the developed resources

The notion of acceptability was discussed in section 1.3.2, and it mainly refers to the extent to which students and teachers appreciate the resources developed based on the proposed ESD pedagogy model.

5.1.1 Students' acceptability

It should be acknowledged that the level of students' engagement can also demonstrates the "acceptability", however this aspect of measuring the effectiveness of the model application will be reported in section 5.2 below, which specifically examines how the students interacted with resources during their learning.

This section is focused on students' perceptions and preferences with respect to the use of resources, mainly based on their self-reflections in interviews. In particular, students' perceptions and pedagogical preferences in relation to the case studies for learning will be examined, as the main difference between the developed resources and the original resources was the use of case studies from different industrial sectors and the use of student-centered pedagogy. The results are as follows:

1. Students' perceptions regarding the use of case studies to bring real-world problems into the classroom to connect their learning experience to real-world problem solving.

Table 15 below briefly lists the results of the students' perceptions of learning through case studies. They were generated based on the data from group interviews. The categories listed in the table were either taken from the students' own words (e.g. information) or summarized from their statements (e.g. mindset transformation). Each category has been connected to specific

properties. The relationships between different categories were further demonstrated through a connection map that presented in the discussion chapter. These results were obtained based on coding described in the methodology chapter. A more detailed description is provided after the table.

Table 15

The results of students' perceptions regarding case study learning

Category	**Properties**	**Dimensions (Students' perceptions)**	
		Full-time students	**Part-time students**
Information	Cognitive competence	Reported in the same level	
Environmental awareness	Cognitive competence	Higher level	Lower level
Reflect on solution adaption	Intrapersonal Competence	Higher level	Lower level
Application area	Intrapersonal Competence	Broader range other than work	Daily work
Mindset transformation	Cognitive competence	Change mind	Broaden mind
Respond to the limitation of professional connection	Interpersonal skills	Positively: make connection to current learning and future career	Negatively: Limit by constraints in workplace

1) All four groups of students strongly agree during the interview that the case study helped them to connect their learning experience with real-world problem solving, and that the selected cases are very impressive and innovative; they provide them with "information" (real-world examples) on what solutions are working now.

> Of course, it can. I never heard about this (Transform CO2 into usable plastic such as plastic package), I learnt new things about greening. (Full-time student in group A)

> Yes, case study can provide us some information about that (real-world problems and solutions). (Part-time student in group C)

> They are very innovative and impressive. (Part-time student in group D)

2) However, the perceptions of how the case study connected them to real-world problem solving were quite different between full-time students and part-time students. Full-time students reported more on the development of environmental awareness and the reflection of how to adapt the solutions to solve the problems relevant to their majors or the local context. For instance,

> It makes us to jump out of getting used to waste and thinking waste is part of our life that made us ignore actually we can have a better way to live with the earth. (Full-time student in group B)

> It helps to change my "old" mind and know more about how to apply the green knowledge and practice into engineering such as using what replacement can reduce the energy consumption. (Full-time student in group A)

> It facilitates us to think about how to adapt the solutions to use in Hong Kong such as the final project that focused on solving urban sustainability issues in Hong Kong. (Full-time student in group B)

3) They also connected the case studies to a broader range of applications such as daily life, waste management policy and the influence of climate change on different groups of people. While part-time students tended to reflect on the case studies specifically in terms of their daily work and to make connections based on the objects in the case studies (e.g. data center and restaurant) instead of the critical issues such as using renewable energy in data centers or developing waste management strategies based on the closed-loop economy.

> The case study such as data center, it is something totally won't be considered in my work. There won't be data center in construction industry. (Part-time student in group D)

> Case study make me think about the solutions such as how to decrease the waste in my work, however what the restaurant has been done is something very small scale. (Part-time student in group C)

4) It is also worth noting that, full-time students considered the case study could "change my mind", while part-time students considered it could "broaden my mind".

> It helps to change my "old" mind and know more about how to apply the green knowledge and practice into engineering, such as using what replacement [in equipment or procedures] can reduce the energy consumption. (Full-time student in group A)

> The cases are not really related to my work. However they are very innovative, so I feel like they can broaden my mind. (Part-time student in group D)

The difference between "change" and "broaden" revealed the different degrees of students' mindset transformation stimulated by using case studies to bring real-world sustainability issues and solutions into classroom learning. Full-time students, who considered the case studies could change their mind, indicated a higher level of transformation than part-time students.

5) In addition, both the full-time and part-time students highlighted that they would like the course to provide more connections to their professional learning/majors (full-time students) and professional development/working context (part-time students). However, since the students' learning and working backgrounds were so diverse, it is almost impossible for one case study (that was developed based on a specific industry context/sector/company) to meet all students' expectations about "professional connection". The two groups of students' responses to this limitation were different again. Part-time students seemed to be confined to the idea that "this is not related to my work" instead of trying to make connections and reflecting on how this might relate to their work. They tended to consider that promoting green practice was their superiors' responsibility, and that they didn't possess the autonomy to make any changes.

> The cases were hardly related to us. We can't apply. Thinking about how to save electricity is managers' stuff. (Part-time student in group D)

> We can just follow the provisions to do things. What have been provided by the company, we will just use them. (Part-time student in group C)

On the other hand, the full-time students who didn't have any working experience were less limited by the experience gained from work or the constraints on work that stopped them to think further. When they were asked, "Do you think the resources can support you to contribute to green practices at future work?" they displayed positive attitudes and tried to make connections between their current learning and future careers.

> I think so, I am majoring in early childhood education though, but I can share what I have learnt with the teachers or even think about how to integrate the green knowledge into children's course design. (Full-time student in group B)

> It gave me some ideas to think about applying the solutions to address the issues in my major courses. It is really helpful, because I am majoring in construction, it made me to think about how to design and make the materials to be more environmental-friendly. (Full-time student in group B)

In short, the students perceived the case study learning to be able to bring real-world learning experiences into the classroom, however, in response to transforming the learning to real-world applications, full-time and part-time students indicated different attitudes and experiences. Full-time students who were not limited by current working situations tended to be more positive in terms of trying to make changes.

2. Students' pedagogical preferences regarding learning through lecturing (the dominant pedagogical strategy in teaching this module) or through the case study (the interactive pedagogy suggested for this module).

It was found that the pedagogical preference influenced the students' acceptability of the developed resources. Table 16 briefly lists the results of students' pedagogical preferences, which were generated from data from group interviews and participant observations. The categories listed in the table were summarized from both students' statements and the researcher's field notes. These results were obtained based on the coding described in the methodology chapter. A more detailed description is provided after the table.

Table 16

The results of students' pedagogical preference

Category (Real-world case study learning)	**Dimensions** (Students' preferences)	
	Full-time students	**Part-time students**
Interactive learning	Higher level	Lower level
Discussion and reflection	Higher level	Lower level
Time used for preparation	More time	Less time
Assessment (Learning motivation)	Learning-driven	Assessment-driven
Work in small group	More used to	Less used to
Learning environment	Both reported to be a lack of support in interactive learning	
Learning behavior	Both observed to be passive learner with low learning motivation	

1) The pedagogical preferences between part-time and full-time students were in absolute contrast. The full-time students indicated they preferred learning with case study and considered it facilitated interactive learning and stimulated high level reflection and engagement, which was much better than just sitting and listening.

> Case study need to think and reflect, but for listening, I just "heard", after that seems nothing left. (Full-time student in group B)
>
> I prefer more case study, because lecturing is very boring. More case study can increase our understanding of the environment problems. (Full-time student in group A)

On the other hand, the part-time students considered learning through lectures was better for them. According to the interviews with part-time students and teachers, as well as classroom observations, the reasons for this were:

- They were tired after work, and lectures that do not require engagement leave them free to do whatever they want to do in classroom.

- The case study usually requires discussion or interaction, but very few part-time students were willing, or were used to, engaging with others, which resulted in comments such as, “I cannot find classmates to interact with”.
- To make good use of case study, students needed to do some preparation in advance, but they did not think they had time to do it.

2) In addition, part-time students in class D who could only go to class after work mentioned that the workload they assigned to different tasks was dependent on the assessment, and the assessment should be designed based on what they learnt and how they learnt. In other words, if the lessons were designed based on case study, the final test should not be formulated as a multiple-choice test which only focused on rote learning with rigid knowledge.

> If discussion has a big part in assessment, that will be another story. Because now the assessment is test and exam, we won’t spend a lot of time to prepare discussion. (Part-time student in group D)

> Case study or test, only one of them, and it should match with the assessment. (Part-time student in group D)

These opinions are very similar to teacher A’s comment, which stressed that the assessments should align with the change in pedagogy and materials otherwise it would not make sense for teachers and might even increase their workload.

3) Furthermore, in terms of how students liked to work in small groups, particularly in group discussion, which is the main activity in the case study, the participant observations revealed that full-time students were more used to working in small groups. After understanding what they were going to discuss and report, they quickly started to assign work and roles and work on the questions. Part-time students seemed to be less organized. Usually, each group only had one or two students working on the group tasks for group reporting, which could not be regarded as high-quality interaction.

4) From the interviews, both full-time and part-time students pointed out the constraints on working in small groups. Full-time students indicated the difficulty of ensuring everyone was responsible for their parts. For those whose group mates did not work on anything, they found they had to do more work because the marking was based on whole-group work.

> I would like to do more group work, but we got some problems too. For example, your groupmates don’t want to work on group tasks or even don’t engage in any group work, then you have to do their part, especially in elective course. (Full-time student in group B)

For part-time students, the situation seemed even worse. They explained,

> Let’s think about that, the classmates around you all fell asleep, how can you be interactive? We can’t find people who really engaged in learning. (Part-time student in group C)

> Lecture is better, because if I want to listen, I can listen, if not, then still ok. (Part-time

student in group D)

These comments reveal that the learning environment students were used to did not support interactive learning and this was the main problem in facilitating students' group learning. When the researcher observed class C for the first time, less than one third of the students were listening or involved in the learning (the teachers giving lectures based on PowerPoints). This also became the main challenge for the researcher in implementing the resources. It is acknowledged that changing the learning culture takes time and the two intervention workshops were not enough to change the culture. Based on the research conducted by Pavlova (2003, 2004), change requires a prolonged engagement among students in student-centered learning to increase their motivation for group learning, using the student worksheet that guides students' activities. Nonetheless, compared with having long lectures and the test (which accounts for 30% of the assessment), a few part-time students in class D considered it was not bad to have some group work/project as part of the assessment. For example,

> If group work/project can substitute some test or lecture time, that's not bad." (Part-time student in group D)

To sum up, the full-time students preferred learning with the case study, which facilitated deeper learning and reflection. They were more used to group activity and had higher learning motivation than part-time students. For part-time students, it appeared to be quite difficult to use the case study to facilitate them to learn in a more interactive and reflective way, although some of them considered the selected cases were very impressive and innovative. This difficulty related to personal reasons, such as it being hard to learn after a whole day at work, however, it could be argued that the learning environment and students learning behaviors contributed towards the situation to a great extent.

Therefore, to answer "how did the students believe the resources are helpful to them", it can be concluded that, all the students believed the resources that brought real-world sustainability issues and solutions into classroom through case study learning were helpful in building the connection between classroom learning and real-world experience, although the extent of acceptability between part-time and full-time students was quite different. Full-time students who considered the case study to "change their mind" indicated a high degree of "mindset transformation", and they also tried to connect the case study to wider applications unlike part-time students who mainly focused on work-related outcomes. In addition, full-time students who preferred learning through case study and who were more used to group work tended to reflect a higher acceptability of the resources. Following on from this, a critical discussion that explained the vital role of mindset transformation in developing students' generic green skills as well as an approach that designed to facilitate students to make professional connections in case study learning were provided in the discussion chapter.

5.1.2 Teachers' acceptability

Compared to the students' acceptability, which indicated differences between part-time and full-time students, the teachers' acceptability towards the resource implementation was very similar even though the four involved teachers have different teaching and learning backgrounds as well as work experience related to sustainability.

The identification of teachers' acceptability was based on in-depth interviews and reflective conversations with teachers. As outlined in the methodology chapter, open coding was adopted to analyze the teachers' perceptions regarding the ways they thought the resources had been helpful to them as well as their perceptions of using case study as a pedagogical strategy in implementing the generic green module. The analysis of the data and understanding of the teachers' different perceptions also referring to their teaching experience and industry backgrounds. The results are as follows:

1. How the resources support teachers' lesson preparation and classroom teaching.

All four involved teachers showed a high level of acceptability of the resources. In particular, they considered the teacher guidelines, examples of the concepts, the selected case studies and the designed pedagogical instructions were helpful in supporting teaching and learning (see Table 17 below).

Table 17

How the resources support teachers' lesson preparation and teaching

Category	Dimensions (Be helpful for teacher)
Teacher guidelines	Clear instructions, teaching standards
Concept examples	Explain new concepts, stimulate discussions, facilitate application
Case study	Innovate ideas, enrich teaching and learning, develop students' problem-solving ability
Pedagogical instructions	Change teaching behaviors

1) The teacher guidelines were useful in helping teachers to prepare the lesson. They provide clear instructions about how to implement the lessons and specified the suggested answers/examples that helped teachers to prepare classroom discussion and which could be used as the teaching standards to ensure consistency in the implementation in different classes.

> I think the teacher guidelines are very important. They are properly designed, which do not provide too much detailed instructions that limit teachers' lesson design or only provide abstract description that make teachers don't know how to do. (Teacher D)

> It is good that the resources have teacher guidelines. I can follow the instructions to prepare and implement the lessons. (Teacher A)

2) The examples provided in the information sheets were helpful in explaining the new concepts, stimulating classroom discussion and facilitating application.

> If I only introduce theories without examples, it is hard to stimulate discussions. For me, the most useful part is the examples. I can use the examples, to inspire students, and to facilitate them to think about how to solve a problem from different perspectives instead of simply telling them we need to consider a problem from different perspectives. (Teacher D)

> Although the provided examples can't fit each student's learning and working background, the discussions that guide students to reflect on workplace or daily life help to facilitate the application of what they learnt. (Teacher B)

3) The selected case studies are inspiring and connected to the real-world problem solving, which help enrich the teaching and learning and develop students' problem-solving ability.

> The selected case studies are very innovative such as the one introducing transforming CO2 into plastic to further use as packaging materials. It really inspires students to think out of box and understand when we talk about solving environmental problems, it doesn't have to be reducing, transforming waste into usable materials is a great idea. (Teacher D)

> The selected cases that related to students' real-world experiences have make the discussion to be more meaningful. They help to develop students' problem-solving competences. (Teacher A)

4) The pedagogical instructions were designed based on a student-centered approach, helped to change teachers' teaching behaviors (lecturing) and teaching role (knowledge deliverer), and left more time for students' inquiry learning.

> It is effective to use questioning strategy to guide students to think further. For instance, in the group activity of designing a closed loop referring to your industry, I asked students 'what is the main waste in your workplace? How you deal with it? Do you think we can turn the waste into something useful?' Based on students' answers, I provide some suggestions or do online search with students together. (Teacher D)

> It is good to reduce the lecturing time and have more time for students to engage in group learning activities. (Teacher C)

> Teaching and learning in activity-based lesson design, will not be that boring. (Teacher A)

From the researcher's observations, she found that the teachers with less learning and work experience in sustainability indicated a higher degree of acceptability towards the "content". They perceived the resources to be very helpful in providing examples and industry stories and, because of this, they did not need to spend extra time preparing materials. On the other hand, the teachers with rich experience in sustainability were less focused on the content. They could provide examples or explain the concepts and issues based on their knowledge and practice and have deeper discussions with students. This indicated higher confidence in teaching the module

using the provided resources. They also embraced more the student-centered pedagogy that facilitates interaction and engagement instead of going through PowerPoint that focuses on knowledge delivery. For example, Teacher A pointed out that

> I personally prefer to teach in a more interactive way, so I think the resources are good although the students are not that get used to it.

In short, the teachers pointed out that the resources could support their teaching in different ways, but particularly in terms of the provision of teaching guidelines and facilitating students' learning. This demonstrated that the developed resources can meet teachers' needs and support their practice in implementing the generic green module. The teachers also perceived the resources to be very helpful and timesaving in terms of lesson preparation.

2. The teachers' perceptions of using case study as the pedagogical strategy in implementing the generic green module.

Generally, the teachers perceived the case study as an effective pedagogical strategy in implementing this generic green module, however they also identified some challenges and constraints in practice (see Table 18).

Table 18

The results of teachers' perceptions towards using a case study to teach

Category	Teachers' perceptions towards case study teaching
Effective pedagogical strategy	Facilitates engagement, stimulates learning interest, enriches learning experience and application.
Challenges and constraints	1) Teachers' professional experience influences their confidence of using case studies to teach (spend time learning before teaching, need more support, less connection to professional learning).
	2) The assessment scheme does not support the use of case studies (workload increase, a lack of motivation)
	3) Students' learning motivation and behavior (a lack of lesson preparation and engagement, time limited, low learning motivation).

1) Four involved teachers reflected on the use of the case study in classroom teaching. Data showed that the teachers all perceived the case study as an effective pedagogical strategy in improving classroom engagement and enriching students' learning towards real-world problem

solving.

> I saw students engaged more and they showed interest in the case study when you taught in my class. It is quite different from when I just give lecture. (Teacher B)

> Case study can enrich students' learning experience through introducing ideas and examples that showed students how to 'think out of box'. When I use case study to teach, I focused more on how to analyze a problem and its relevant solutions rather than just the learning contents. (Teacher D)

> I found students applied what they learnt (a design that make the green plants in walls can adjust their angle based on the intensity of sunlight) to propose solutions to solve the problems in the case study. (Teacher A)

2) However, the teachers also indicated the challenges and constraints in using the case study from different perspectives.

First, the teachers' insufficient knowledge and competence related to sustainability contributed to some extent in less confidence in terms of using the case study to teach this generic green module. Of the four teachers, only one part-time teacher possessed work and teaching experience related to sustainability, the other three were simply assigned to teach this module. Two of these are full-time teachers teaching engineering, the other is a part-time teacher who majored in chemistry and mainly teaches mathematics related courses. After comparing their classroom practices, it was found that the teacher with rich experience in sustainability indicated more confidence in using the case study in classroom teaching particularly for facilitating student discussions. He inspired students by sharing his own industry experience and by introducing relevant sustainability solutions. He mentioned that

> I am more used to using case study to teach and I don't need to spend time to prepare because everything is in my mind, I can give examples and discuss with students based on my professional experience. (Teacher C)

The other three teachers tended to follow the content and instructions in the teacher guidelines, and usually only provided general comments to response to students' discussions and presentations since they were not experienced in, or familiar with, the topics or issues. They also needed more support in implementing the case study.

> Some topics/case studies are very new, and I need to learn them by myself before I try to implement in classroom. (Teacher D)

> I would like the teacher guidelines to include some guiding questions that help us to facilitate students' discussion. Particularly if the cases are not related to students' working backgrounds, it is important to think about how to guide students to reflect on them. (Teacher A)

> I can see students engage more in case study learning, however, the teaching become more challenging. (Teacher B)

Second, assessment that focuses on knowledge rather than attitudes and competences decreases the effectiveness of using the case study to facilitate students' engagement and learning. The teachers all raised the concern that the assessment scheme did not support the use of the case study, whereby teachers were required to go through all the fixed content in order to help students pass the multiple-choice tests which were very knowledge-based. The students mentioned this too, when they questioned whether what they learned was matched to the assessment. Thus, the teachers suggested reducing the teaching content and modifying the assessment methods in order to improve students' motivation to engage in case study learning and to balance both the teachers' and the students' workload.

> It is good to include more case study learning, however the module contents need to be reduced so that students can have more time to explore the group works. (Teacher C)
>
> I would like to have more interactive communications with students, however the teaching and learning contents in the module are too complicated and too much to finish. (Teacher A)
>
> I need to go through all the contents in the ppt because the range of the tests covers all of them. (Teacher B)
>
> I try to make the lectures not that boring by including some real-world examples, but at the same time I also need to help students to pass the tests. (Teacher D)

Third, students' learning behavior towards actively engaging in case study learning needs to be further motivated and developed, particularly for part-time students who do not possess high learning motivation and need to balance their work and study. The situation among full-time students seemed to be better. However some of them were forced to select this elective, as they could not enroll in others they may have been more interested in, so many just attended to gain credit.

> Students hardly do any preparation for the case study discussion. They just come and spend time for not failing in this course. (Teacher D)
>
> It is difficult to facilitate in-depth discussion, particularly the class time is limited, and part-time students don't really engage in and get used to discussion. (Teacher C)
>
> The full-time students in my class are majoring in different subjects, some of them even can't find any connection with this module such as music composition and IT. They just have to get the credit and graduate. (Teacher B)

To sum up, the teachers indicated high acceptability of the resources in supporting their teaching. They also believed the case study, as a pedagogical strategy, can facilitate more classroom engagement and enrich students' learning although there are challenges and constraints in teachers' professional development, assessment methods, and students' learning behavior and motivation. More discussion on how the resources can be used to support teachers' teaching and professional development was provided in the discussion chapter.

5.2 Teachers' and students' engagement in the process of resource implementation

This section reports the results of how the students engaged in the learning activities designed in the resources and how the teachers engaged in implementing the resources (including how the teachers learn to use the resources). The results are organized based on the typology of engagement (Fredricks, Blumenfeld, and Paris, 2004), which classified engagement into three highly intercorrelated aspects, namely: behavioral engagement, emotional engagement and cognitive engagement (see section 2.3.4 in literature review for detailed discussion).

The results of four involved classes and four teachers are listed in Table 19 and Table 20 below. All the ratings were generated based on the comprehensive analysis of the observation checklists, the field notes, the students' discussion memos, mind maps and assignments, as well as the researcher's teaching experience (e.g. facilitating students' group discussion) when she worked as a co-teacher to support the resource implementation.

5.2.1 Student engagement

The identified elements of students' engagement have been categorized based on the adjusted engagement typology presented in the methodology chapter and were listed in Table 19 (column 2). As stated in the methodology chapter, limited engagement was rated as 1, moderate engagement was rated as 2, and fully present was rated as 3. All the listed items were rated based on the consideration of both engagement rate and engagement level. For example, no less than half of the students (engagement rate) listen carefully (engagement level) was rated as moderate.

Table 19

The results of students' engagement in three dimensions

Engagement dimensions	List of the observable and quantifiable elements that demonstrate students' engagement	Class A	Class B	Class C	Class D
Behavioral engagement ✓ on-task attention and concentration ✓ High effort ✓ High task persistence ✓ Interaction with peers and teachers	Students do the pre-reading before lesson.	1	1	1	1
	Students listen very carefully.	3	3	2	3
	Students read the materials attentively.	3	3	2	2
	Students work on the group work actively.	3	3	1	2
	Students make group presentations.	3	3	2	2
	Students ask questions and discuss with teacher.	2	2	2	2
	Students engage in group and whole class discussion.	3	2	2	2
Emotional engagement: ✓ Affective reactions to learning ✓ Attitude ✓ Interest ✓ Value	Students are interested in the case study.	3	3	1	2
	Students show curiosity in learning.	2	2	1	1
	Students feel satisfied after solving a problem or getting something understood.	3	3	1	1
	Students did not feel bored with the learning activities.	3	3	1	1
	Students did not feel discouraged in learning.	3	3	1	1

	Students think what they learnt is useful (value)	3	3	1	1
	Students enjoy learning new things in class (interest).	3	3	1	2
	Students want to learn more from the case study (attitude, value).	3	2	1	2
Cognitive engagement: ✓ Use of deep learning strategies ✓ Seeking conceptual understanding rather than surface knowledge ✓ Knowledge application	Students do online research when they find something they are interested in, or they have questions about the issue.	3	3	1	1
	Students give specific examples to demonstrate their understanding of the concept in relation to daily life and/or working situation.	3	2	2	3
	Students reflect on the identified sustainability problem and propose some solutions.	2	2	2	2
	Students express their thoughts from different perspectives in relation to different stakeholders.	2	2	2	3
	Student applied what they learnt to find solutions for a sustainability issue.	2	2	2	2
	Students critically analyze the adaptability of a solution to Hong Kong	2	2	2	3

1. Behavioral engagement

Behavioral engagement was rated based on the observations that noted how students behaved during the classroom learning. The reporting results have been referred to a comparison, which revealed the differences between students' engagement in lecture-based learning (The teachers present PowerPoints. This was observed before the implementation of the interventions.) and case study learning (The teachers together with the researcher to use the developed case study to facilitate students' participative learning. This was observed during the implementation of the interventions).

1) A very common occurrence in the lecture-based learning in all four different classes was that the students seldom raised their heads to look at the teacher or the screen with PowerPoint presentation. They were talking, playing games on their mobile phones, watching videos on their laptops, or just keep sleeping (e.g. more than half the part-time students in class C did nothing but sleep). This exposed the problem that in lecture-based learning, the students hardly engaged in any learning activities. Very few students (two out of 24 full-time students in class B) with good learning habits, were observed to take notes or respond to the teacher's questions. When teachers keep talking but students have nothing to do both the engagement rate and engagement level were observed to be very low although the situation in full-time classes was a bit better than part-time classes.

2) Compared to the situation described above, the behavioral engagement in case study learning was observed improve immediately. Particularly in relation to reading materials attentively, listening to each other carefully, asking questions and conversing with the teacher during the group presentation preparation. Obvious improvements were identified in both the full-time and part-time student groups. The results from the two full-time classes were very similar; they were more active in group work compared with part-time students. However, since Teacher A tried to stimulate more interactive conversations with students, students in Class A were observed to have more interactions with teachers and peers. The results between the two part-time classes (Class C & D) were slightly different. Students in Class D were observed to have a higher level of engagement in listening and discussion and they were more task-focused and well- organized in group work. This could be related to Teacher D's classroom management, which directed more attention to students' learning behaviors and always reminded students to stay focused. While the learning attitude of students in class C tended to be focused on "coordinating with the researcher" to finish the assignment and get the marks. Nevertheless, during this process, more of the students were observed to "be pushed" into becoming involved by their peers (e.g. group presentation) and the design of the activity (e.g. every group mate needed to list at least two green technologies used in campus or your workplaces). Since more students were engaged in the classroom learning, the learning environment started to change into becoming more engaging and interactive.

In addition, compared to the listening lecture without specific tasks, the task-oriented lesson was observed to be conductive to retaining students' concentration and engagement. For example, at the beginning of the lesson the researcher asked students to draw a concept map to describe what green technology is in order to attract students' attention and stimulate their curiosity. When the researcher started to introduce the concept of green technology, she asked students to keep writing down more key words to

demonstrate their understanding of the concept in their concept maps. During the lesson, the students were observed to look at the PowerPoint presentation more frequently and take notes in their concept maps.

Overall, this "keep students busy" strategy helped to keep them on task with attention and concentration, while the group work stimulated the interaction with peers and teachers. However, the high effort and high task persistence were observed to remain quite limited especially among part-time students. The students hardly did any preparation for the lesson, or pre-reading for the case study, which resulted in the less effective use of class time and influenced the quality of discussion.

2. Emotional engagement

For the rating of emotional engagement, the results were generated from the interview questions that revealed students' interest, values and attitudes (e.g. Do you think engaging in exploring the topics is interesting and important?) as well as conversations with students during their group activities. By joining in with the students' activities, the researcher could "hear" both the negative and positive emotions towards what they were learning. For example, the researcher asked, "What green technology has been used in your workplace?" A part-time student in class C just simply replied that "no, even there is, the so called professional guys in construction industry won't consider to use it, they just too much get used to and rely on what they are using." The response reflected students' obstacles to knowing more about, or engaging in the discussion of, green technology in the workplace.

1) The results in Table 19 showed that the full-time students' emotional engagement was much higher than part-time students. They showed an interest in the case study and appreciated the real-world examples in the resources that helped them to connect the concept understanding to its application. They had relatively high levels of learning motivation and believed they could learn more and develop generic green skills through case study learning. For instance, here are two responses to the interview question, "Do you think the learning resources are helpful in developing your generic green skills?"

> I think it can, because the learning resources are very related to green technology and the environmental issues, which provides some new ideas for us to think about greening. (Full-time student in class A)
>
> Of course, it did. For instance, it inspired me to compare the waste management policy in Hong Kong and Japan, and think about how to adapt the one proved to be effective in Japan to be used in Hong Kong or how to modify the one used in Hong Kong based on Japan's. (Full-time student in class B)

They also showed higher self-efficiency in doing online research to understand a problem and thinking about how to apply what they learnt in their future careers and daily lives.

2) Emotional engagement observed in part-time students was quite limited, particularly in class C. It seemed they participated in group work just for the marks so they would not easily fail the course. Although a few students mentioned the resources could broaden their minds and they wanted to learn more too, it always came with conditions, such as

"if we have more time" or "but we are very tired after work".

> It is good to learn more, but sometimes, we are just too tired after work, not really energetic for that. (Part-time student in class D)

Part-time students also showed lower self-efficiency in problem-solving and felt discouraged about trying to apply the greener solutions in their workplaces. For instance, one response to the interview question, *"Do you think you can apply what you learnt to green the workplace?"* was

> When you suggest to buy the greening products, they will say we don't have enough money. So even you learnt it, you knew it, but you can't apply it. (Part-time student in class C)

When the researcher asked, "Do you think this would influence your motivation to learn more about greening?" The student replied, "Yes, it did. We are not motivated to learn it. Knowing more is ok, but we could not apply it. For us, it is more like that what materials you are given, then you just use it." (Part-time student in class C)

The teacher in Class C explained further:

> I can understand that. I would say if they are the students like those I taught before, which was majoring in environmental engineering, they will pay more attention in how to apply the greening strategies. Because they know for sure, they will work in greening related fields after graduated, and what they are learning now might be part of their future job. But for the students in my class now, they are not involved in making decision for any change such as electricity consumption. For them, learning is only for knowing, they won't know when they can/will apply in their jobs. (Teacher C)

All of these factors influenced part-time students' emotional engagement, particularly in their attitudes and values towards a willingness to learn more about greening. It also indicated that students' emotional engagement is very much influenced by their learning motivation.

3. Cognitive engagement

The cognitive engagement rating was based on a comprehensive consideration of different data sources, including the students' group discussion memos, group presentations and assignments, the discussions with the teacher and researcher during the lessons, as well as the observation checklists and field notes, which revealed the use of learning strategies and the learning process between knowledge acquisition and application that demonstrated students' cognitive engagement.

1) Compared with emotional engagement, the students were observed to have a higher level of cognitive engagement. In particular, full-time students in class A (who were more interested in the case study) and part-time students in class D (who devoted more effort to the assignments since the teacher highlighted their percentage of the final mark) were found to have higher level of cognitive engagement. They had more discussions/

consultations with teachers in class, and their assignments were better quality. For instance, in the assignment about the closed-loop economy, students were required to draw the closed-loops to describe the greening of a restaurant (a case study) and design a closed-loop to reflect waste management in their workplaces (for part-time students) or in their daily life/campus (for full-time students). The submitted assignments showed that on average, the closed-loops drawn by students in class A and class D revealed a more comprehensive consideration of different elements. Teacher D reflected on the students' engagement and explained:

> I tried to facilitate the assignment in two ways. The first time, I explained it with inspiring examples in class and the students did it at home, it was not bad. But the second time, we implemented it together in classroom, as you can see, students were much active, and their discussions and presentations were interesting too. Because the students have similar working backgrounds, their discussions were quite practical which looked like experience sharing. (Teacher D)

In addition, students in class D were observed to consult with their teacher after every lesson with detailed ideas regarding their final project. The researcher found that their final project reports reflected deeper thinking and understanding about the identified issues and they were able to analyze solutions from different perspectives in relation to different stakeholders such as the government, citizen and industry sectors in Hong Kong.

2) Furthermore, both the researcher and the teachers were quite surprised by the students' group presentations. Both the full-time and part-time students were observed to engage in group presentations and share their ideas according to the discussion questions listed in the worksheet, although full-time students were observed to do online research for the discussion much more frequently. As some of the students mentioned in the interviews, they considered that doing online research could facilitate a deeper understanding and they could learn about what they were really interested in. The researcher's reflective journal described students' engagement in a case study learning:

> During the discussion session, the students tried to apply the concept "closed-loop economy" to identify and analyze the food waste problems from different perspectives. Their ideas are interesting, and some of the students also searched information online when they were stuck at the questions. When I asked them to explain their ideas to me, they can clearly say it. When I challenged some of their ideas, they came back and did online search further. In students' group presentation, I found that they can explain the identified problems referring to the information and data searched online. When demonstrated the solutions, students can clarify how they work and what are the limitations. (Researcher journal, 14 June 2019 in class A)

In addition, the part-time students were observed to be more actively engaged when they started to talk about what happened in their workplaces. They were observed to write down some key words or draw a diagram to help organize or illustrate their ideas. For instance, a group of students in class C, who were majoring in construction, designed a model for reducing the waste of rebar based on their understanding of closed-loop

economy. This waste reducing model was designed to start from better measuring and end with more proper recycling.

3) Finally, the analysis of the contents and topics of the students' presentations revealed that the full-time students' ideas were more innovative, and they tried to connect and apply what they learnt to think about the issues and solutions in Hong Kong. For example, in the second lesson the researcher introduced the concept of green technology with some inspiring examples, in which she showed the students different kinds of green walls built in Singapore and explained that some of the angles of the plants on the walls could be adjusted to follow the sunlight to absorb more heat and produce more energy. In their group presentation, a group of students in class A immediately applied this idea to their design for improving the efficiency of household solar panels. Compared to the full-time students who generated ideas based on what they learnt or what they found through online research, part-time students tended to analyze the issues and solutions based on their work experiences and devise more practical ideas that considered the procedures, resources and constraints towards implementing/adapting a solution to solve a real-world problem.

Overall, the students' engagement in classroom learning was improved to a great extent, particularly in cognitive engagement. The "keep the student busy" strategy and the push from "peer learning" effectively facilitated students' engagement although the engagement level of part-time students was lower than that for full-time students. The result also showed that part-time students were more willing to engage in discussion if the discussion was designed as "work experience sharing". However, their motivation to engage in different learning activities was mostly driven by the need to get the required marks to pass the module.

5.2.2 Teachers' engagement

As with the students' engagement, the identified elements of teachers' engagement have been categorized and are listed in Table 20.

Table 20

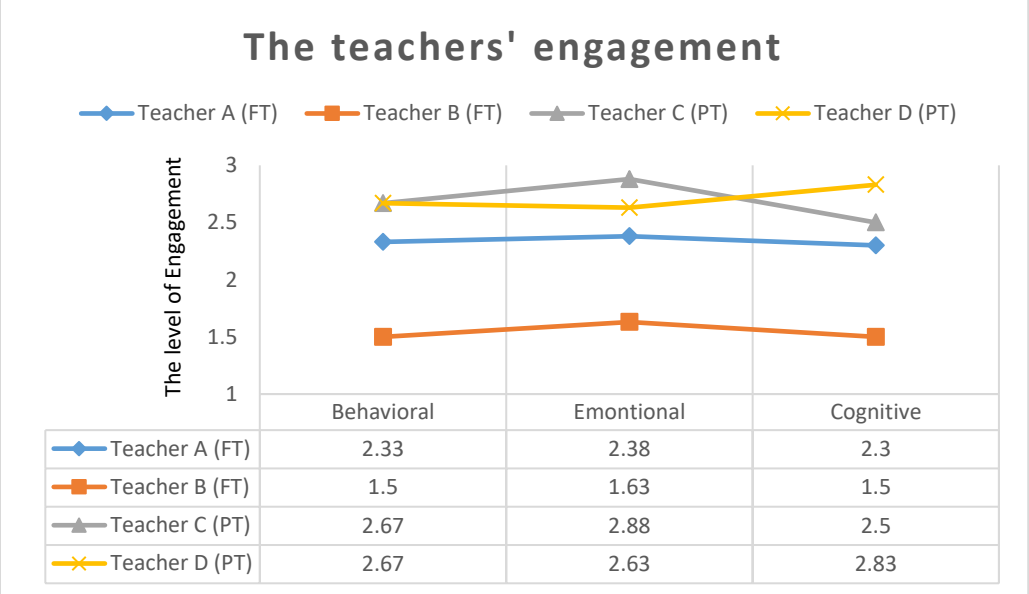
The results of teachers' engagement in three dimensions

Engagement dimensions	**List of the observable and quantifiable elements that demonstrate students' engagement**	**Teacher A (FT)**	**Teacher B (FT)**	**Teacher C (PT)**	**Teacher D (PT)**
Behavioral engagement ✓ Interaction with students ✓ Teaching involvement	Teachers are well-prepared for the lesson.	2	1	2	3
	Teachers engage in students' group discussion randomly.	3	1	3	2
	Teachers facilitate students' discussion actively.	2	1	3	3
	Teachers give comments about students' presentations.	2	1	3	2
	Teachers pay attention to students' questions and provide their understanding and opinions on the questions.	2	2	3	3
	Teachers provide guidelines for student assignments.	2	2	2	3
	Average	**2.33**	**1.50**	**2.67**	**2.67**
Emotional engagement: ✓ Affective reactions to teaching	Teachers are passionate in implementing the resources.	2	1	3	3
	Teachers think they will keep using the resources.	3	2	3	3
	Teachers feel encouraged to use the case study to teach.	2	2	2	2
	Teachers feel confident to teach in a student-centered approach.	2	1	3	2

✓ Passionate about and committed to implement the resources	Teachers did not feel pressure to change their teaching methods.	2	2	3	3
	Teachers believe it is important to equip students with generic green skills.	**3**	**3**	**3**	**3**
	Teachers show enjoyment of teaching in a more interactive way.	3	1	3	2
	Teachers want to use more integrative pedagogical strategies.	2	1	3	3
	Average	**2.38**	**1.63**	**2.88**	**2.63**
Cognitive engagement: ✓ Use of teaching approaches & pedagogical strategies ✓ How teachers learn to implement the resources	Teachers inspire students with specific examples.	3	2	3	3
	Teachers facilitate students' discussion with guiding questions.	2	2	3	3
	Teachers design the lessons based on a student-centered approach.	2	1	2	2
	Teachers reflect on their teaching and think about how to further improve it from different perspectives.	2	1	3	3
	Teachers consider the resource implementation expands their sustainability knowledge and competencies.	2	2	1	3
	Teachers think about how to implement the resources under the guidance of the researcher.	3	1	3	3
	Average	**2.3**	**1.5**	**2.5**	**2.83**

Figure 19

Four teachers' engagement



	Behavioral	Emontional	Cognitive
Teacher A (FT)	2.33	2.38	2.3
Teacher B (FT)	1.5	1.63	1.5
Teacher C (PT)	2.67	2.88	2.5
Teacher D (PT)	2.67	2.63	2.83

Overall, the results showed that two part-time teachers (teachers C and D) reported higher levels of engagement in all three dimensions. They put an effort into interacting with students by actively facilitating discussions and sharing their experience or understanding of an issue to inspire students. They were passionate about using the developed resources to teach this generic green module and indicated a more positive reaction to case study teaching. They also showed deeper reflection about their teaching practice and students' learning.

In addition, Figure 19 shows that, Teacher A, Teacher B and Teacher C all showed higher engagement in the emotional dimension compared to the behavioral and cognitive dimensions. While Teacher D indicated lower engagement in the emotional dimension than the other two dimensions, although he still ranked higher than Teacher A and B in this dimension. Below are descriptions of the four teachers' backgrounds and a demonstration of their engagement in the three dimensions that supplement the results showed in Figure 19.

Teacher A is a full-time teacher working in the engineering department. He does not have much work experience related to sustainability, but he is familiar with some important sustainability issues that related to his teaching subject content, such as renewable energy. He engaged in designing the lessons based on the resources and actively co-taught with the researcher. He believes that the inclusion of more interactive classroom activities can increase students' classroom engagement. In his class, he tried to use some daily life examples to stimulate students' discussion, such as how to reduce the electricity consumption of the elevators in campus. He considered lecture-based teaching should be changed, but also worried that the

knowledge-based assessment could not encourage teachers and students to make the change. He engaged in the activities relevant to the resource implementation actively, such as attending the module team meeting for the introduction of the resources and discussion about lesson design. However, he did not indicate a high motivation to make changes in the current pedagogical practice and considered it hard to make changes if the educational system and environment did not support teachers' teaching autonomy. He reflected that

> It is hard to push the teachers to use the resources and change their current teaching. The module setting requires teachers to go through all the contents in the teaching package (includes lots of PPTs, notes prepared for teachers) in the limited teaching hours, so implementing everything outside the package actually requires extra time. If we didn't reduce the original contents and keep adding new things, it just increases teachers' workload. (Teacher A)

Teacher B is a full-time teacher who does not have any work experience related to sustainability. She did not care much about how students learn or the importance of including ESD in TVET sector. Before the intervention, she simply followed the teaching content provided by the module coordinator in the form of PowerPoint presentations, and did not attempt to make changes/improvements. She does not have sufficient motivation to engage in the introduction of new resources. In the co-teaching process, she seldom engaged with students in discussion and provide comments about the students' presentations. When the researcher was co-teaching with her to implement the resources, she tended to be an observer rather than engaging in the teaching and learning process (e.g. facilitating students' group discussion) although she also observed that the students' engagement in the case study learning was more active than it was with the lecturing.

> When I sit in the classroom and observe the lesson demonstration, I can see students become more active learners. The issues and case studies related to local context are really helpful to students' understanding too. (Teacher B)

Teacher C has rich work experience related to sustainability in the construction sector. He conducts research on developing materials and technologies for green buildings, and has more than 10 patents in this area such as green brick and solar panels. He always shared his insights about how to solve a sustainability problem in the construction sector and engaged with students in discussion randomly to inspire them (most of the students in his class are part-time students working in construction related companies). Teacher C indicated high emotional engagement in implementing the resources and, in particular, he feels confident teaching sustainability related subjects using project-based and problem-based approaches. He strongly believes in a more interactive learning setting, students can learn more and reflect further on what they have learned. During the reflective conversations after each lesson, he could always reflect on the issues in teaching and learning and propose solutions based on his prior teaching experiences.

> I have been using project-based and problem-based approach to organize teaching and learning when I worked in University. It did take a long time to change students' mindset and learning behaviors to get used to inquiry learning, however students finally indicated great appreciation for it. It is important to get teacher prepared for the change too, since

> they are the change makers in classroom. (Teacher C)

Teacher D is a full-time teacher teaching in mathematics-related subjects, and only works as part-time teacher for this generic green module. In his class, he always tried to use the examples provided in the resources to inspire students and facilitate whole-class discussions, although he has very little work experience related to sustainability. He mentioned that he needed to spend time to learn the resources and think about how to implement them before the lesson.

> Since I am not very familiar with the sustainability issues and the teaching content in the resources, I did need to spend time to prepare the lesson. Generally, I need to learn it first and then think about how to implement in a classroom. (Teacher D)

Teacher D was observed to provide more specific guidelines for student assignments and was more engaged in the students' final projects. He checked their project progress every week and provided suggestions to them. He did not indicate high emotional engagement in the resource implementation, particularly in the elements related to positive reactions to teaching, such as confidence in teaching. However, he showed great passion in making change to the teaching methods and considered the resources could help to expand his sustainability knowledge and competencies.

> I think the resources are very useful. Usually, I learn the new concepts based on the concept information sheets. If the examples provided there didn't match most of the students' working backgrounds, I will further search online. I am happy I can keep learning by teaching this module. (Teacher D)

Furthermore, although the four teachers had different backgrounds and engaged differently in the three dimensions, they showed similarities too. They all strongly believed it is important to equip students with generic green skills.

> Students need to have the green knowledge, awareness and understand regarding I should/I could do things in a more environment-friendly way. (Teacher D)

> Greening is becoming more and more important in different industry sectors, students need to understand this and improve their competences in greening. (Teacher A)

> I have been working on and teaching sustainability for a long time, maybe the terminology was different, but developing students' innovation ability in relation to environment-friendly design and green economy development has always been the vital part in education. (Teacher C)

In terms of feeling encouraged when using case study to teach, the four teachers all displayed moderate engagement. They did believe the case study had benefits for students' learning, however they did not feel encouraged by the students' engagement or the assessment format.

> I like using case study to teach, however it is quite hard to push part-time students to engage in group discussion or group works. They just come and listen, and I can understand they are tired from work. (Teacher C)

> The assessment did not design to match with case study. We can't teach students using case study but assess them using knowledge-based multiple tests. (Teacher A)

To sum up, this section has reported the four teachers' engagement with the resource implementation in three dimensions. The results revealed that the four teachers' behavioral, emotional and cognitive engagement towards using the resources in their classroom teaching were very different. The elements identified that influenced their engagement include motivation to make pedagogical change, professionalization of sustainability, students' learning engagement and teachers' teaching autonomy. How the identified elements influenced teachers' engagement in resource implementation were further discussed in chapter 6.

5.3 The impact of the implementation of the ESD resources on students' generic green skills development and the enhancement of teachers' competency in greening the curriculum

This section reports the impact of resource implementation on students' generic green skills development as well as the enhancement of teachers' competency in greening the curriculum. The results of the impact on students were generated mainly from observation checklists (with field notes) and the students' final group project reports. Supplementary data was derived from the teachers' and students' reflections obtained from interviews. Results of the impact on teachers were generated from a self-evaluation survey, which required the teachers to self-evaluate their competency enhancement in the areas of professional knowledge, practice and engagement towards greening curriculum. In addition, some results were generated from in-depth interviews and participant observations to complement the interpretation of the survey results.

5.3.1 The impact on students' generic green skills development

1. The teachers' and students' reflections

Both the teachers and students were asked, "Do you think the resources help to develop students' generic green skills? How?" in the interviews. The results from both the teachers and different types of students were highly consistent. They all focused the reflection on Cognitive Competency development (The classification of generic green skills includes: Cognitive competencies, interpersonal skills, intrapersonal competencies and technological skills), particularly in relation to how the resources increased students' awareness and mindset transformation towards greening, as well as problem solving skills (See Table 21); although the part-time students tended to be less positive compared to the full-time students. For example, some of the part-time students used the term "more or less" to describe the level of impact.

> More or less, at least we did two case study, and know more innovative ideas about doing greening. (Part-time student in class D)

> More or less, if we know something which is more environmentally friendly and we are able to do it, then we will do it too such as using Eco-friendly paper. (Part-time student in class C)

Table 21

The teachers' and students' reflections that reflect specific aspects of cognitive competencies

Specific items in Cognitive competencies	**Students' and Teachers' responses** (Examples)
• Environmental awareness and a willingness to learn about sustainable development • Awareness of the habits in what you do and think	Our environmental awareness has been increased. I start to think more about the solutions for the 'waste' we get used to such as the plastic bottle recycling. (Full-time student in class B) I think for sure, the students' awareness of the importance of sustainability has increased... (Teacher D) I think the resources are useful in increasing my awareness. I started to think about how to reduce the materials waste in my work. (Part-time student in class D)
• Ability to think about things differently	The resources provide some new ideas for us the think about greening. (Full-time student in class A) Since the case not that related to their workplace, …… But it can open their minds, give them some new ideas. (Teacher C)
• Innovation skills to identify opportunities and create new strategies to respond to green challenges.	I think it helps to develop my creative problem-solving competence. The solutions provided in the case study (SMOG Free Project) are something I never thought about, and I was quite impressed to know that we can solve air pollution problem in such a creative way (Full-time student in class B). It is good to use case study to develop students' problem solving skills. I found some innovative ideas in students' sharing. (Teacher A)

In addition, the teachers and the students also shared similar opinions regarding limitations in developing the other kinds of generic green skills. The constraints that existed in the workplace and the case studies, which were unrelated to work, were still the critical elements mentioned by part-time students. This limited the opportunities for them to "apply what they learnt" which in turn helps to develop generic green skills, particularly interpersonal competencies and technological skills.

> I don't think it influences a lot, we can't apply. What can't decide what to do. (Part-time student in class D)

Two teachers teaching in part-time classes also expressed the same opinions:

> The problem is not the teaching materials, is their practical work. From the students' feedback, I can say their awareness have been increased but other skills related to adaption or application are still hard to address. (Teacher D)

> The learning had an impact on raising students' awareness however there is not much space for students to make changes due to the constraints in their work. (Teacher C)

Some of the full-time students were also concerned about the applied learning; they believed competencies are developed when you are using them.

> I don't think it is very helpful. Because after the end of the semester, if you didn't use it [what your learnt], you will just forget. But of course, it can influence our mindset, how we think about environment issues. (Full-time student in class A)

In brief, the interview results revealed that both the teachers and students considered the resource implementation to have a considerable impact on their cognitive competencies development, while improvements in the other three categories were very limited. The interview results were highly consistent with the results of participant observation , which are reported below.

2. Classroom observation checklists

As explained previously about the data collection and analysis, the researcher used the scale of "**Limited=1, Moderate=2, Fully present=3"** to describe the development of each examined skill in the observation checklists. Table 22 presents the results generated from the observation checklists used in classes A, B, C and D. The items in ***italic and bold*** are the targeted generic green skills listed in the concept learning, "Activity on closed-loop economy", while the items in plain are the targeted generic green skills listed in the case study, "How much energy do data centers use?".

Table 22

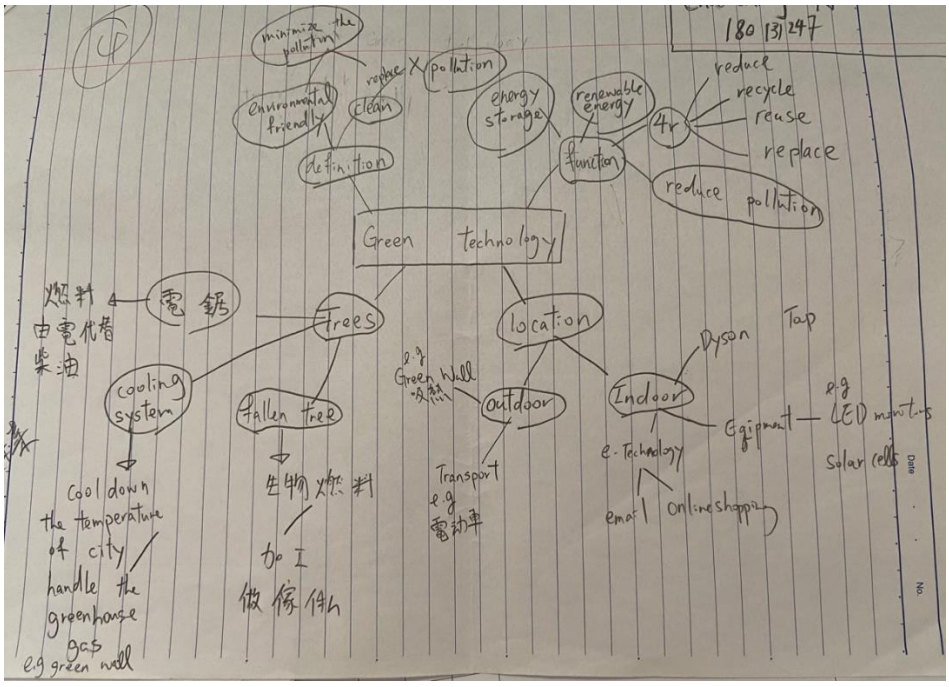
The results of students' generic green skills development generated from participant observations

Generic Green Skills	**Examined Items**	**Class A**	**Class B**	**Class C**	**Class D**
Cognitive competencies	Environmental awareness and a willingness to learn about sustainable development	3	3	2	3
	Systems and risk analysis, skills to assess, interpret and understand both the need for change and the measures required	2	2	3	2
	Innovation skills to identify opportunities and create new strategies to respond to green challenges	3	2	1	1
	Ability to make judgments based on both evidence and sustainability values	2	1	2	1
Interpersonal skills	Strategic and leadership skills to enable policymakers and business executives to set the right incentives and create conditions conducive to cleaner production, cleaner transportation, etc.	1	1	1	1
	Coordination, management and business skills to facilitate holistic and interdisciplinary approaches that encompass economic, social and ecological objectives	2	2	1	1
Intrapersonal competencies	*Adaptability and transferable skills that help workers learn and apply the new technologies and processes required to green their jobs*	2	3	1	1
Technological skills	Quantification and monitoring (waste, energy, water)	1	1	1	1

The scores in Table 22 were based on classroom activities designed for two workshops, such as drawing a concept map, group discussion and presentations. All the students' mind maps (see picture 1 as an example) and their discussion and presentation memos (see picture 2 as an example) were collected after each lesson. They were collected as part of the assignments that provided data for further analysis. The researcher also assisted the teachers to facilitate (or facilitated herself) the students' group discussions and presentations. Since the researcher was not allowed to video record the students' learning, the main ideas from students' presentations were written down as field notes. Therefore, each score in Table 22 was based on the data collected from different kinds of learning activities. For example, in terms of "innovation skills to identify opportunities and create new strategies to respond to green challenges", both the full-time students' classroom presentations and assignments showed that they can generate innovative ideas to respond to green challenges, however, in comparing Class A and Class B, the students in Class A indicated a higher level of competence towards including innovative design in their solutions. The part-time students (Class C and D), seldom considered how to adapt the new/innovative strategies to solving sustainability problems. In their assignments, innovative ideas for a new design (e.g. design a closed-loop for solving a waste problem in their workplaces) were also rarely found. Therefore, the rating for this item is: Class A fully present=3, Class B moderate=2, Class C & D limited=1. A specific explanation for each examined items in this table is provided below.

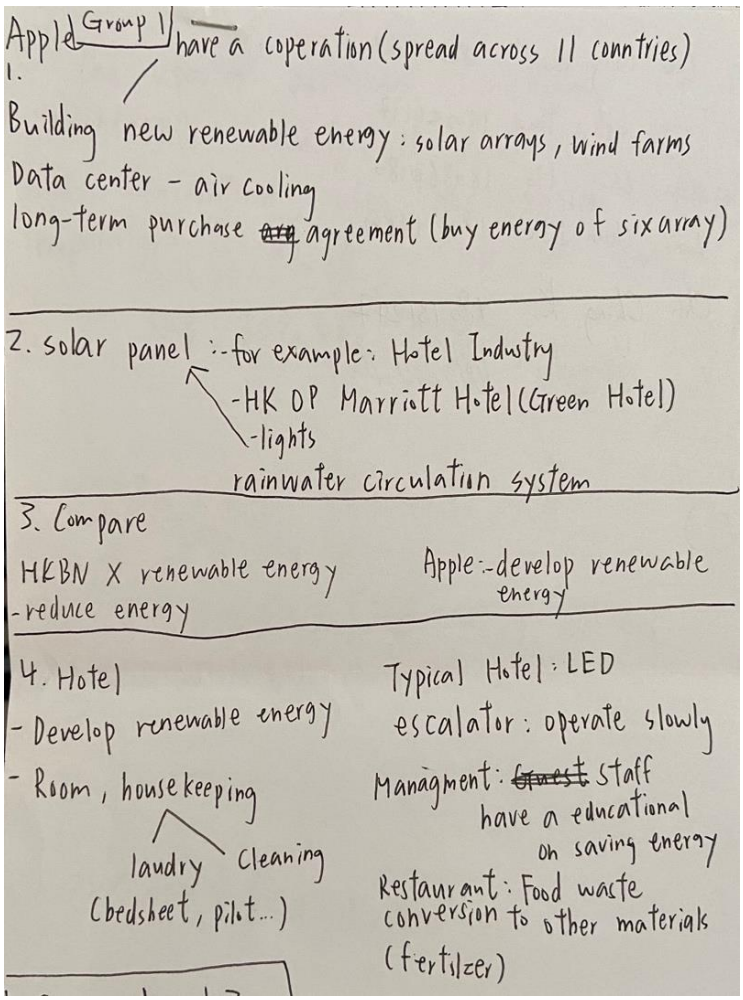
Picture 1

A concept map that illustrated the understanding of green technology drawn by a full-time student



Picture 2

Group discussion memos (class B)



Overall, the results revealed that, the resource implementation had a higher level of impact on full-time students' generic green skills development, although some of the skills were observed to have limited improvement among both full-time and part-time students. More specifically:

1) In terms of cognitive competencies, the concept maps indicated full-time students were able to connect the green concepts to a broader understanding and they showed more willingness to learn about sustainable development. Their assignments and group presentations also included more innovative ideas in response to green challenges. However, it is worth noting that, the part-time students in class C revealed higher "Systems and risk analysis" ability in their group presentations. They used their projects (most were working in the construction inspection area) as an example to analyze the

materials waste problem and devise solutions based on the concept of closed-loop economy. However most of them believed it is hard to implement in practice. In addition, class A (full-time students) and class C (part-time students) were observed to perform better in "Ability to make judgments based on both evidence and sustainability values". The field notes which briefly noted the teachers' teaching processes and contents revealed that Teacher A and Teacher C, who had more sustainability work experience, were more used to providing real-world information or sharing their own experiences related to the problems to inspire students. For example, when the students were discussing the effectiveness of solar energy in Hong Kong for electricity generation, Teacher C shared his experience of working on some solar energy projects to explain the main issues that needed to be considered, such as the payback period and the maturity of different technologies. He also shared his experience as a homeowner and pointed out that the solar panel on his roof could provide more than enough electricity to power his house so he was able to sell the extra electricity back to the electrical grid to balance the installation cost. However, he also noted that most people in Hong Kong live in high-rise buildings, so the promotion of solar energy becomes more complicated. After that, the students who analyzed the installation of solar panels or other renewable energy facilities in different places, such as on campus and the public library were observed to be able to make more comprehensive judgments. It could be argued that this teacher's sharing of his experience contributed to the students' judgment skills development to some extent.

2) In terms of interpersonal skills, all the students were observed to have limited increase in "strategic and leadership skills". In the role plays and simulations activities designed for the case study about the data center, the students were asked to take on the role of the owner of Hong Kong Broadband Network (HKBN) and to think about what could be done to improve the company's electricity consumption and reduce the cost of it. However, in the students' presentation, there was hardly any discussion related to policy formation for promoting renewable energy or influencing policymakers about improving energy issues in Hong Kong. In particular, the part-time students tended to believe they do not require leadership skills since they can only do what they are "told" to do. In relation to "coordination, management and business skills", the full-time students who had broader mindset and majored in different subjects were observed to perform better. More than half of these students connected the case study to their major learning area and/or daily life and proposed solutions for solving the energy issue from different perspectives. For instance, a group of students in class A used public libraries in Hong Kong as an example to illustrate how to save energy by improving the efficiency of energy use in different facilities such as the air-conditioning. They considered the use of more renewable energy that could replace traditional electricity production by installing solar panel at the top of library. They also suggested the library use its facility to develop activities to encourage/educate the public to do the same at home or office.

3) With respect to the "adaptability and transferable skills" in intrapersonal competencies, the full-time students were observed to outperform the part-time students, particularly the full-time students in class B. Most of these students were majoring in subjects related to those industries that have started including different kinds of green technologies in their operations, such as the hotel industry. Two of three groups of students in class B used the hotels in Hong Kong (e.g. Hong Kong Ocean Park Marriott Hotel) as examples to discuss

the application of a closed-loop economy in all aspects of greening hotels, such as waste management, manufacturing and distribution. While the part-time students, as previously mentioned, were working in construction related sectors and considered they did not have autonomy to initiate changes. During these students' group discussion and presentations, there was hardly any reflection focused on the adaption or application of new technologies and processes required to green their jobs. They pointed out that, in the construction sector, the site worker seldom received any training related to greening and their bosses were more concerned about convenience and efficiency than greening. From this perspective, it appears that, the effectiveness of the resources in developing students' generic green skills was influenced not only by the students' learning backgrounds and work experiences, but also by the development of industry greening within the local context.

4) Regarding the development of "quantification and monitoring (waste, energy, water)" in technological skills, an activity requiring students to calculate the energy bill for running a data center in Hong Kong was included in the student worksheet to draw students' attention to the energy problem. Before the group discussion, the students were asked to read some sample company cases that included different monitoring strategies. However, during the group discussion and presentations, neither the full-time nor the part-time students mentioned any strategies related to energy monitoring or used any data or quantification results to support their management strategies for electricity consumption. Nevertheless, some of the students reported that their awareness towards the other technology skills, such as material use and waste management, had improved.

In summary, the results generated from participant observations are consistent with both the students and teachers' reflections of the impact of the resource implementation on generic green skills development. The analysis of observation checklists has provided more detailed information to demonstrate the development of each of the examined items and how students responded to them. It is worth noting that the development of each item was an interrelated process and that each of the learning activities not only facilitated the development of specific items but also influenced the others even though the impact assessment of all the examined items was illustrated separately.

3. The analysis of the students' final project report

All the students were engaged in the mini project, "**Urban innovation for reducing the greenhouse gas (GHS) in Hong Kong**". In this project, the students were required to

1) Identify problems related to climate change and global warming in Hong Kong.
2) Explore the identified problems and the solutions to deal with it.
3) Adapt the solutions provided in case studies for solving the identified problems.

More specific information of the project is presented in Appendix J.

Regarding the analysis of the final project reports, only three reports in Class B were accessible to the researcher (the teacher of Class B invited the researcher to mark together, therefore the original reports in his class were all sent to the researcher). Although the researcher had a chance to have a quick look of Class D's reports in the teacher' office, she was not allowed to collect any documents for further analysis. The

researcher also involved in the students in Class C's final project presentation, but again, she could not access to the documents of their final group reports. Thus, since the researcher can only keep Class B' group reports for detailed analysis, three reports of Class B were used as a small sample that complement the evaluation of the impact on students' generic green skills development. Even so, they still played an important role on the impact evaluation, as Class B represented most of the situations happened in this generic green module, such as the students were majoring in different subjects who did not have working or learning experience related to sustainability subjects, the teachers hardly had any training related to teaching sustainability subjects and did not have much working experience in this area, and the use of typical content-based and lecture-dominated pedagogical approach.

Accordingly, three group reports in class B were marked and analyzed based on the "Rubric for mini-project report assessment (specifically focusing on generic green skills) (see Appendix K), which was developed by the researcher and reviewed by Dr. Pavlova. The researcher carefully read all three reports and highlighted the key words, sentences and paragraphs that reflected the description of the examined items. She also wrote specific comments based on these for further analysis and marking. For instance, the paragraph below shows that the researcher highlighted the following key words: "the government", "incentive-cum-regulatory approach" and "monitoring data". She also highlighted the description regarding the change of the annual monitoring data and wrote a comment based on the conclusion: "Make judgment based on data". This paragraph reveals that the students had considered what the government, as one of the main stakeholders, has done to solve air pollution problems. They also used data to demonstrate the effectiveness of those solutions and formulate a judgment based on it.

> In 2018, the government addressed the air pollution problems by Tightening the sulfur content of gasoline, replacing Liquefied Petroleum Gas taxis and minibuses. Also, they adopt an incentive-cum-regulatory approach to phase out some 82,000 pre-Euro IV diesel commercial vehicles (DCVs). According to Yang (2019), the air quality monitoring data reflects the slight improvement in the annual average of pollution that felt from a high level of more than 120 micrograms per cubic meter in 2011 to 80 micrograms in 2016, a drop of more than 30%, however, this still exceed the Hong Kong air quality level indicator. In 2017, there are signs of a rebound and increase in air pollution indicator to 90 micrograms.
>
> This shows that the air pollution problem has not been effectively improved whereas the situation is still in a serious state. Hence, the demand for air pollution problems needs to solve is high. (Make judgment based on data) (Report from group 1)

Table 23 below presents the marking of the students' mini-project group reports. The first row lists the skills to be assessed in the mini project. Each of the items accounts for 10 points, and five items added up to 50 points. The second row specifies the rubrics for assessing each of the skills, which were developed based on the module learning objectives and the implication of each skill in conducting a project. All reports in class B

(six students in a group, and a total of three group in class B) were marked, based on the detailed analysis of the whole reports. The marking for three reports was sent to Teacher B for her reference and moderation.

Table 23

The results of the students' mini-project group reports

Assessed Items	**Description of the rubrics**	**Group 1**	**Group 2**	**Group 3**
1) Environmental awareness and a willingness to learn about sustainable development (10)	*Students reflect on the identified sustainability problems referring to their industrial experience /individual life*	7	7	8
2) Innovation skills to identify opportunities and create new strategies to respond to green challenges (10)	*Students proposed innovative solutions/ strategies to respond to the sustainability issues.*	5	7	7
3) Strategic and leadership skills to enable policymakers and business executives to set the right incentives and create conditions conducive to cleaner production, cleaner transportation, etc. (10)	*Students analyzed the cause and effect of the identified sustainability problems in relation to different stakeholders and proposed effective strategies to enable them to response to the green challenges.*	4	5	5
4) Adaptability and transferable skills to enable workers to learn and apply the new technologies and processes required to green their jobs (10)	*Students specify clearly how to adjust and promote/implement the solutions (e.g. greening concepts and technologies) based on the local context.*	8	4	6
5) Technological competencies-Impact and use minimization (10)	*Students propose technological solutions to real-world problems and justify how the proposed technologies help to solve the identified problems with evidences.*	7	6	5
	Total	**31/50**	**29/50**	**31/50**

Group 1: Report 1 indicates that the students in group 1 did reflect on air pollution problems in Hong Kong and provided a comprehensive analysis of the cause and effect based on specific data and reports. A specific adaptation plan that enables the SMOG FREE project to effectively work in the Hong Kong context was provided, and it included recruiting different technicians, finding suppliers of product materials and machines, conducting project pilots, organizing training modules and building the promotion team. The limitation of the local context was considered too.

> Besides, we have to consider the location and size of the tower and selling market of product, as it is not suitable to occupy a large area in Hong Kong. (Report 1)

In addition, the students tried to justify how the proposed innovative technologies helped to solve the air pollution issue within the local context, and they also specified the environmental impact assessment for the whole project. A one-year air quality monitoring plan that was developed according to the Annual Air Quality Index data will be conducted by the air surveyors in Hong Kong to examine the change of outdoor air quality. Research will be conducted to identify the number of deaths from air pollution, cardiovascular and respiratory causes to ascertain whether the trend declines.

> In order to be able to know the effectiveness of the plan, we will evaluate it in around 1 year after the project is completed through the Annual Air Quality Index data. (Report 1)

However, there was limited discussion about involving different stakeholders, such as government, energy sector and environmental organizations in the project to respond to green challenges.

Group 2: Report 2 indicated the students in group 2 analyzed the cause and effect of the air pollution issue from the perspectives of economic development and human well-being. They also proposed innovative solutions to adapt green technology to solve the air pollution issue in Hong Kong, and suggested involving “ofo” (a shared bicycle company) to introduce the SMOG FREE BICYCLE to the citizens.

> The project is being developed with ofo…… The SMOG FREE BICYCLE inhale contaminated air, clean the air, and provide clean air to both the rider and the city. (Report 2)

In addition, the report pointed out the importance of obtaining support from government for land use and policy formulation, as well as some environmentally friendly businesses, to collectively facilitate the project implementation. However, there was limited discussion about developing effective strategies to enable them to respond to the green challenges, which is similar to report 1.

> We need support from the government's land support and policies, and we hope that there will be environmentally friendly businesses that can help us, such as sponsoring SMOG Free Bicycle. (Report 2)

Moreover, there is relatively unclear discussion on how to adjust, promote and implement the SMOG FREE BICYCLE project based on the Hong Kong context, such as the lack of bike lanes in most of the districts. Nonetheless, the strategies for evaluating the objectives outlined in the proposal were clearly specified.

> Objective 1……
>
> Objective 2……
>
> Objective 3: Upward trend of the NO. of SMOG FREE BICYCLEs
>
> Result: Increase 300 bicycles every year
>
> How to conduct monitoring and evaluation: Recording to the incoming receipt
>
> Who will carry out the project evaluation: Environment and Conservation Fund (ECF)" (Report 2)

Group 3: Report 3 indicated the students in group 3 had reflected on the air pollution issue with reference to local problems - the heal island effect in Hong Kong, and more particularly the influence on the hotel industry and those districts with very high density buildings, such as Kowloon. In response to the identified issues, they proposed installing the SMOKE-FREE Tower and they analyzed its utilization from different perspectives.

> Refer to the second generation of the tower, the appearance has also changed a lot. This giant air cleaner, not only environmentally friendly features, but also add a lot of commercial value. It is very design-oriented, and the exterior wall can increase the LED display advertisement, which becomes the economic benefit of the tower. (Report 3)

The problems regarding building a SMOKE-FREE Tower in Hong Kong were also discussed in this report. The students considered a pilot study was needed that would determine the effectiveness of the tower in Hong Kong and a public consultation that would help to understand citizens' different opinions.

> The cost of the tower is high, the space is large, and the land in Hong Kong is seriously not enough. According to Scientific India Magazine, a smog-free tower costs $54000. If the Hong Kong government need to produce a lot of towers, the payment will be large and it will affect other costs of social policies. (Report 3)

A brief illustration regarding the implementation and promotion of the SMOKE-FREE Tower in Hong Kong was found in the report too. For example,

> About the place of Smog free tower, it is suitable in Hong Kong. According to Studio Roosegaarde, the height of the tower is about 7 m. And the width of the tower is about 20-25m. Then, it can be distributed in any parks and living area. (Report 3)

However, as was found in report 1 and report 2, the students included very limited discussion about what different stakeholders need to do to response to the green

challenges. In addition, there is a lack of an evaluation plan that would include an impact assessment of the proposed technologies, however the students did try to justify how the SMOKE-FREE Tower might help solve the air pollution issue by referring to specific data and reports. For instance,

> According to the Daan Roosegaarde and his team of experts, it is learned that one Smog free tower can reproduce 30,000m^3 clean air per hour and contain more than 75% of PM2.5 and PM 10 by using a small amount of green electricity. If we build Smog free towers, the air pollutants in that area will be decreased. (Report 3)

Overall, the marking showed that the differences between the three groups are not obvious, although Group 2 indicated less development in terms of adaptability and transferable skills. Three groups of students reflected on the air pollution issue based on specific data and discussed its impact on health problems to reveal the need to make changes; this indicated they performed well in environmental awareness development. They also performed better in innovation skills development by creating different strategies to respond to the air pollution issue, which is consistent with the findings for classroom observations: the full-time students were observed to propose more innovative solutions to respond to green challenges. In addition, all three groups of students recognized the important role of government and other environmental organizations in solving sustainability issues, although they did not propose effective strategies to enable them to respond to the green challenges collectively. This indicated the students' strategic and leadership skills development were relatively underdeveloped. This is also consistent with the results generated from classroom observations. In terms of technological competencies, the group reports showed that the students focused more on impact monitoring and evaluation in doing real-world projects compared to doing the case study in classroom learning.

To summarize, the impact on the students' generic green skills development has been examined through the teachers' and students' interviews, classroom observations and the students' group project reports. As discussed in section 3.5, triangulation that involves using a variety of methods for data collection can verify the results and strengthen a conclusion. Different methods have provided insights into the skills assessment from different perspectives which, when combined, created a more comprehensive picture of the impact of the resource implementation on students' generic green skills development. The interviews revealed the impact on the development of cognitive competencies from the teachers' perception and the students' self-evaluations; the classroom observations provided an objective angle for the researcher to understand how different generic green skills were developed through different learning activities; while the analysis of the group project reports helped complement the results of the interviews and classroom observations to provide a more complete understanding of how real-world problem-oriented (air pollution in Hong Kong) and project-based learning (group project) facilitates students' generic green skills development. Although the information gained from different methods has different strengths and limitations, the results generated from different data sources were highly consistent.

First, the full-time students preferred to learn with the case study and they engaged more actively in classroom learning. They outperformed the part-time students in almost all the assessed skills, but particularly the innovation skills needed to respond to green challenges. The part-time students who have more work experience and more connections to different industry sectors, could have been expected to perform better in terms of adaptability and transferable skills and strategies and leadership skills since they had opportunities to reflect on what they learnt and connect it to their daily work. However, the results revealed that they were limited by their lack of autonomy at work, as well as their negative experiences related to making changes.

Second, the learning activities were found to be effective in cognitive competencies development, such as environmental awareness. The development of some skills in cognitive competencies, such as the ability to make judgments, was found to be highly related to the teachers' professional knowledge and experience and how the teachers inspired students based on their experience. While the development of other kinds of generic green skills, such as strategic and leaderships skills (interpersonal skills) and quantification and monitoring (technological competencies), which were also facilitated only through classroom learning activities without real-world practice, was less effective.

Third, the locally relevant learning content, especially the case studies based on the local context, were designed to help students to make connections to real-world learning and make emotional connections to the place they lived and be a part of the local solutions. In other words, this kind of learning was designed to contribute to the development of generic green skills that leads to green practice in the local context, such as strategies and leadership skills. However, the results indicated that although the students' mindset transformation and awareness development towards "what I should do" were improved to a certain extent, their competencies in relation to "How to do" were still far from being well-developed since there was a limited time available and the intervention only included two workshops and a mini project. More precise discussion about how to improve the impact of the resource implementation on students' generic green skills development was provided in the discussion chapter.

5.3.2 The impact on teachers' professional competencies development

The data gathered from the questionnaire were organized in Table 24, which listed all the evaluated competency items in three domains and the four teachers' responses on all the items. The number formatted in *italics* refers to "*Before*", the number formatted in **Bold** refers to "**After**". Organizing the data in this way clearly reveals the teachers' competency enhancement on each item, and also clearly indicates the differences between the four teachers. The results presented below were generated by:

1. Comparing each of the "*Before*" and "**After**" ratings to identify the impact on the four teachers' competency enhancement individually.
2. Comparing the four teachers' ratings in three competency domains (examining the similarity and differences between the four teachers' self-evaluation results) to gain a deeper understanding of how the process of resource implementation

influenced the teachers differently and to further explore what caused the differences.

3. Comparing the mean values in both "*Before*" and "**After**" categories of all competency items in order to understand the general impact on the teachers' competency enhancement and to identify the most effective and less effective itmes influenced by the process of resource implementation. The comparison aimed to further generalize some suggestions for facilitating the effectiveness of teacher training for the purposes of greening the curriculum (See the discussion chapter).

Table 24

The results of the teachers' self-evaluation

Section 1: Professional knowledge				
1. In terms of the content and teaching strategies, I can demonstrate knowledge and understanding of:	**A**	**B**	**C**	**D**
1) The sustainable development concepts that form the basis of greening the curriculum.	*2*	*2*	*3*	*3*
	4	**4**	**4**	**4**
2) Generic green skills and their role in developing students' green mindset and their generic competencies in the context of greening.	*2*	*1*	*3*	*3*
	5	**4**	**4**	**4**
3) Student-centered strategies that can support students' active engagement in terms of learning about greening.	*1*	*2*	*2*	*3*
	4	**4**	**4**	**4**
2. In terms of content selection and organization, I can:	**A**	**B**	**C**	**D**
1) Organize SD related concepts into themes or modules that can be taught across different subjects, or as a separate subject.	*1*	*2*	*3*	*3*
	4	**5**	**4**	**3**
2) Organize content in a logical sequence to achieve effective learning and teaching.	*1*	*1*	*4*	*3*
	4	**5**	**4**	**4**
3. In terms of curriculum assessment and reporting, I can:	**A**	**B**	**C**	**D**
1) Effectively design and implement teaching related to greening.	*2*	*2*	*3*	*3*
	4	**4**	**4**	**3**
2) Use assessment as a tool and means of providing feedback to students about their generic green skills development.	*1*	*2*	*3*	*3*
	3	**4**	**4**	**4**
3) Implement assessment that is aimed to evaluate students' competencies (knowledge, values and attitudes) about finding innovative solutions to problems, exploration, debate, etc.	*2*	*1*	*4*	*3*
	3	**4**	**4**	**3**

Section 2: Professional practice	**A**	**B**	**C**	**D**
1. I can set clear learning goals (that are challenging, but achievable) for all students, for each learning activity that explores SD concepts, industry-based case studies and others.	*2*	*2*	*3*	*2*
	4	**5**	**4**	**4**
2. I can plan each activity within, or across, several lessons, at a workplace-based or real-world problem-based or extra-curricular setting in a coherent and structured way to effectively engage students.	*1*	*2*	*4*	*3*
	3	**5**	**5**	**4**
3. I can choose and apply a variety of teaching strategies based on a student-centered approach to engage students in critical thinking, problem solving and innovation in the context of greening.	*1*	*1*	*3*	*2*
	3	**5**	**5**	**5**
4. I can select and design resources that are appropriate for my institutional context, including the practices of greening industry in my region/country.	*1*	*1*	*3*	*3*
	3	**5**	**4**	**3**
Section 3: Professional engagement	**A**	**B**	**C**	**D**
1. I can demonstrate an understanding of the areas in relation to the SD concepts that needed to be addressed in my professional development.	*2*	*1*	*4*	*3*
	4	**5**	**4**	**4**
2. I can understand and identify sources for professional learning in relation to greening the curriculum.	*1*	*1*	*4*	*3*
	3	**5**	**5**	**4**
3. I can understand the importance of external professional networks and actively participate in networks and forums to broaden my knowledge in relation to greening the curriculum and improving my practice.	*1*	*2*	*3*	*3*
	2	**5**	**5**	**5**

1. The individual impact on the four teachers

1) Teacher A

Figure 20

Teacher A's ratings of the competency items (before versus after)

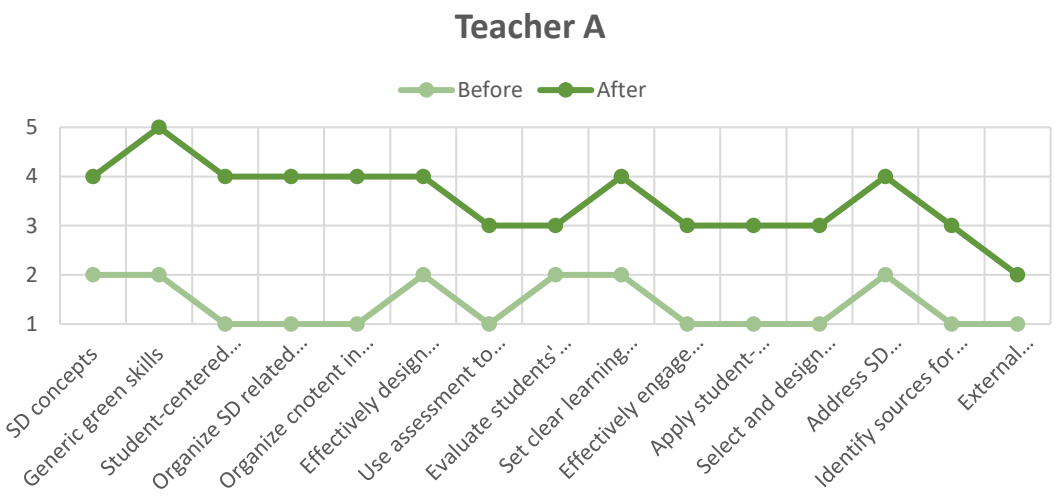


Figure 20 highlights the obvious impact of the resource implementation on Teacher A's competency enhancement. In the "Before" category, he rated himself either less proficient or not at all proficient for all the items, while in the "After" category, most increased at least two levels except "*Implement assessment that is aimed to evaluate students' competencies…"* (which increased from 2 to 3) and *"I can understand the importance of external professional networks…"* (which increased from 1 to 2). In addition, the figure also shows that Teacher A reported higher improvement in the domains of professional knowledge compared to professional practice and engagement, where half the items increased from level 1 or 2 to level 4 or 5, particularly in the areas of understanding the content and teacher strategies related to greening, as well as selecting and organizing content to achieve effective learning and teaching.

As mentioned earlier, Teacher A is a full-time teacher in the engineering department, and the students in class A were majoring in different subjects. Both Teacher A and the students in class A were not familiar with the concept of sustainability and did not have much work experience related to industry greening. So Teacher A followed the PowerPoint to deliver the content in this module, like most of the other teacher in this module, and this is regarded as "standardized teaching". This type of content-based lecturing was observed in the first classroom observation in Teacher A's lesson and the students were observed to be inactively engaged. After this observation, the researcher implemented the first workshop with him to see how the students responded to it. The teacher did see a different picture. More than half of the students became

attracted to the new concepts and the examples used to explain it. When they were working in the group task, Teacher A could see the students were engaged more actively. In the reflective conversation after the first workshop, the teacher mentioned,

> I like to have more interaction with students in my lesson, and teaching and learning in activity-based lesson design is not that boring too. (Teacher A)

In the second workshop, Teacher A tried to introduce the concept of green technology by himself in a more interactive way. He used sustainability issues identified on campus, such the elevator's electricity consumption, to stimulate the students' problem awareness and understanding of why green technology is important in solving environmental problems. After presenting some examples from the resources, he asked the students to work in a group to discuss and identify how the green technologies worked in their daily lives. Subsequently, the students continued to work on the case study, "How much energy do data centers use?". During the case study learning, more discussion in groups as well as interactive conversations between the teacher and the students were observed. It was found that in this particular workshop, Teacher A tried to design the classroom learning in a more interactive way based on student-centered approach. The enhancement in terms of Teacher A's understanding and practice of content organization and teaching strategies related to greening were identified in the classroom observations and reflective conversations.

Furthermore, in the domain of professional practice, the item "*I can set clear learning goals for all students, for each learning activity…"* was reported to increase from less proficient to proficient, which means Teacher A considered he became more proficient in this competency after using the resources. Another three items were reported to increase from 1 to 3, which means Teacher A considered himself not at all proficient in these items at the start, however after trying to implement the resources himself and observing how the students responded to the student-centered pedagogical strategies, he believed his teaching practice in planning activities, engaging students in problem-solving learning and designing resources in the context of greening was improved to a certain level but had not reached the "proficient" level. This could be related to his limited working and teaching experience in the context of greening. Additionally, it was a bit challenging for Teacher A to design a lesson and organize the content that could satisfy the students' different learning needs since they were majoring in different subjects. However, the students' performance in case study learning was still impressive for Teacher A.

> I need to think about how to use the same case study to inspire the students which major in different subjects. However, I was quite impressed by students' innovative ideas in the group presentations, and I think the case study learning can help to improve their problem-solving ability. (Teacher A)

It could be argued that the students' learning engagement could contribute to the improvement of teacher's self-efficacy in teaching practice to some extent. When Teacher A observed that his students engaged more actively in the learning activities and achieved better learning outcomes, he tended to be more confident about his teaching.

Moreover, in terms of professional engagement, this teacher's understanding of a need to address the areas in relation to the SD concepts in professional development was identified as having

improved to a "proficient" level, although the competency of identifying sources for this kind of professional learning only increased to level 3 (neutral). This finding revealed that more support for providing sources for teachers' professional learning towards greening of curriculum is needed.

Lastly, two items were reported to have increased only partially. One is "*Implement assessment that is aimed to evaluate students' competencies…"* (increased from 2 to 3) in the domain of professional knowledge. The limited enhancement of Teacher A's assessment competence was found to be related to a lack of guidelines and autonomy with which to implement assessment aimed at evaluating students' competencies.

> The assessment was too much knowledge-based particularly the test which covers all the rigid knowledge listed in the lecture notes. The module syllabus also did not provide specific guidelines that introduce the implementation of competency assessment for us to reference. (Teacher A)

Another item is *"I can understand the importance of external professional networks…"* in the domain of professional engagement*, and for Teacher A this only* increased from 1 to 2 although the other three teachers all considered they had improved to the level of "very proficient". This was probably due to Teacher A's concern about it being too much extra work if they participated in external professional networks, since the teaching workload was already quite heavy. This issue was mentioned in both the reflective conversations and the in-depth interview.

> The module setting requires teachers to, so implementing everything outside the package actually requires extra time. If we didn't reduce the original contents and keep adding new things, it just increases teachers' workload. (Teacher A)

In short, both the self-evaluation and classroom observations, as well as the interviews, all indicated that the impact of resource implementation on Teacher A's enhancement of profession knowledge was noticeable compared to the other two domains where most of competency items only improved to level 3.

2) Teacher B

Figure 21

Teacher B's ratings of the competency items (before versus after)

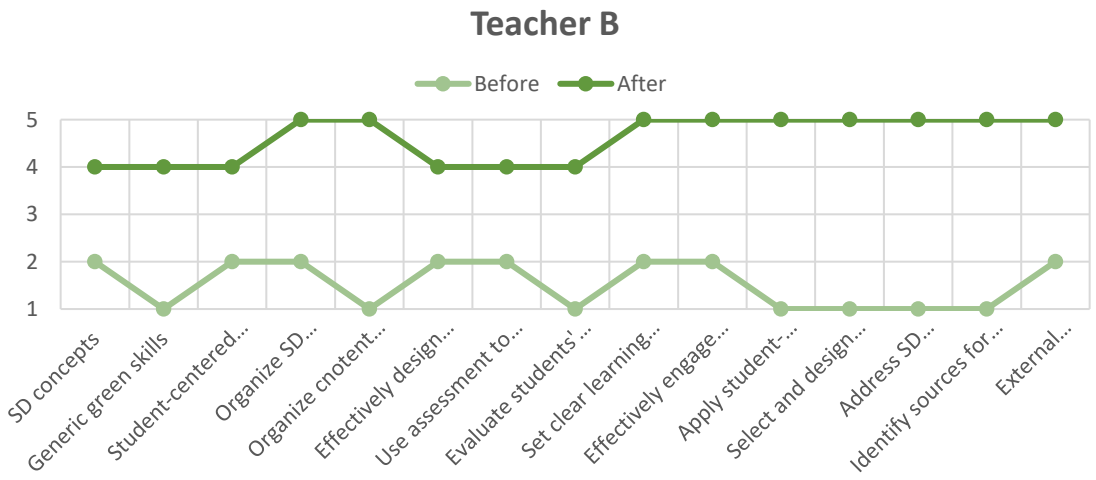


Figure 21 indicates a significant impact of the resource implementation on Teacher B's competency enhancement compared to the other three teachers. In the "Before" category, she rated herself either less proficient or not at all proficient in all the items like Teacher A, however in the "After" category, all competency items increased at least two levels to proficient level. In fact, more than half the items (9 out of 15) increased to very proficient level. The figure also reveals that Teacher B reported an obvious improvement in the domains of professional practice and engagement compared to professional knowledge, where all items increased from not at all or less proficient to very proficient. In the domain of professional knowledge, content selection and organization also saw a higher improvement compared to the other items.

The results seem not that consistent with the findings from classroom observations. Compared to the other three teachers, Teacher B was less active in implementing the resources. During the workshops, he also preferred to be a classroom observer rather than co-teaching with the researcher. When the students were doing presentations, he seldom provided any comments either. The researcher found it hard to identify teacher B's improvement during classroom observations since, most of the time, he sat to the side and observed the researcher's teaching and how the researcher organized learning activities and interacted with the students. For example, in the first workshop, the researcher introduced the concept of green technology and asked students to draw a concept map that demonstrated their understanding of the new concept from different perspectives. The students were interested in green technology and the examples related to it, and they kept adding new ideas to their concept maps. After that, the students were divided into three groups, as suggested in the teacher guidelines for the case study, "How much energy do data centers use?". The students engaged more actively in group learning. They asked questions, did

online research and had discussions with their peers during the preparation of the group presentations. Their group presentations were interesting; they introduced ideas about how hotels could include more renewable energy. During that whole workshop, Teacher B remained seated at the side without becoming involved in teaching or facilitating the students' discussion or providing comments on the students' presentations. However, in the reflective conversations, she expressed high appreciation for the resources and noted the students' active engagement.

> The students were attracted by the new concept and the case study is very interesting. I never saw the students engaged that actively. It was impressive. It is good that the students can engage more in the learning but the teacher talk less. (Teacher B)

In the in-depth interview, when the researcher asked, "What do you find the resources is useful or helpful to you?", Teacher B responded,

> I think, generally, the resources are well-designed, and they are easy to use too. I used the learning and teaching package of closed-loop economy in my class. I just followed the teaching instructions and explained to the students what they are required to do as suggested in the teacher guidelines. (Teacher B)

It could be said that Teacher B appreciated the student-centered strategies after she had observed changes in the students during the workshop (conducted based on the case study). She also learnt how to organize the teaching and learning effectively by implementing the resources following the teacher guidelines. This kind of improvement in awareness and knowledge was revealed in her self-evaluation survey although the researcher considered that to some extent the evaluation was overrated. For example, Teacher B considered the competency related to curriculum assessment, "Use assessment as a tool and means of providing feedback to students about their generic green skills development." had improved to proficient level, however the researcher could not identify this kind of improvement in her classroom practice nor in her guidance during the students' mini projects.

Furthermore, in the domain of professional practice, Teacher B considered she was very proficient in all the listed items that focused on setting learning goals, planning activities, applying student-centered teaching strategies and designing resources for developing students' different competencies in the context of greening. However, similar to the observation above, the researcher could not identify improvements in Teacher B's teaching practice since she engaged very little in the co-teaching process. In addition, the researcher understood that Teacher B did not have rich teaching and industry experience in relation to greening, which meant it was more challenging for her to plan, design and organize the learning resources and activities in relation to greening industries.

Moreover, regarding professional engagement, all the competency items were self-evaluated as very proficient too. This was acknowledged to be related to the improvement of teacher B's awareness and willingness to learn more about, and participate in, professional learning in relation to greening. She observed,

> I don't know much about sustainability, but I am quite interested in it, and will be happy to learn more about it. If I still teach this module in the coming semester, I will be more than happy to try out the resources in my class with your assistance. (Teacher B)

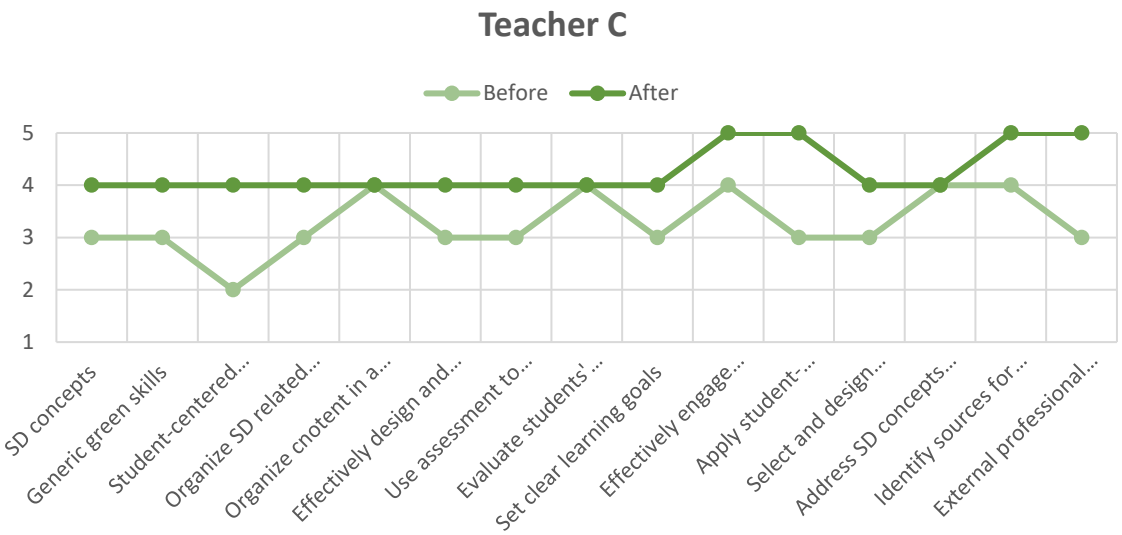
This indicates that Teacher B understood and recognized the need to broaden her knowledge in relation to the SD concepts and greening of curriculum through continued professional learning.

In short, the self-evaluation revealed the resource implementation had a significant impact on Teacher B's competency enhancement in all three domains, however the researcher considered that some of the competency items were overrated by Teacher B herself, since the results were not consistent with what the researcher found in the classroom observations.

3) Teacher C

Figure 22

Teacher C's ratings of the competency items (before versus after)



In terms of Teacher C, who has rich work experience in sustainability and rich teaching experience in using project-based and problem-based learning in higher education, the impact on his competency enhancement was identified to be relatively limited compared to Teacher A and Teacher B. Most of the items (12 out of 15) only increased one level or did not increase at all. Figure 22 shows that seven items increased from 3 to 4, two items increased from 4 to 5, and three items remained at level 4 in both the categories of "Before" and "After". This indicates that implementing the resources had a relatively limited impact on Teacher C's competency enhancement. It also revealed that generally Teacher C have relatively high self-efficacy in most of the examined items, but particularly in those items which were rated 4 at the "Before" category, such as "organizing content in a logical sequence to achieve effective learning and teaching". In one of the reflective conversations, the researcher tried to understand how he prepared the lesson based on the resource by asking, "Do you need to spend time to read the materials and do research for preparing the lesson?". Teacher C replied,

> No really. I just needed to have a quick look at the activity part to know what students are required to do in classroom. Because most of the concepts, examples and cases have already in my mind, I can explain them based on my understanding and experience as needed. When students come up with problems, I can give examples to help them to understand easily too.

In the participant observations, the researcher found that Teacher C responded to the students' questions and engaged in their discussion more actively. He only used the PowerPoint provided in the teaching package as a lesson outline and included more living examples in his professional area to inspire the students.

In addition, although the overall competency enhancement was not significant, the figure above shows that Teacher C reported higher improvement in the domains of professional practice and engagement compared to professional knowledge. This means the resources were useful in supporting Teacher C's classroom practice in terms of "choose and apply a variety of teaching strategies based on a student-centered approach to engage students in critical thinking, problem solving and innovation in the context of greening" (rated from 3 to 5), as well as facilitating his professional engagement towards greening the curriculum: "*actively participate in external professional networks and forums to broaden knowledge and improve practice in relation to greening the curriculum*" (rated from 3 to 5). While the only item that increased relatively obviously in the domain of professional knowledge was "I can demonstrate knowledge and understanding of student-centered strategies that can support students' active engagement in terms of learning about greening", which improved from 2 to 4. This improvement could be identified in the classroom observations too. In the first half of the class (the first classroom observation), for example, the researcher was allowed to sit and observe how the students engaged in learning and how the teacher interacted with the students. As described in the earlier section about students' engagement, very few of the students (4 out of 30) engaged in lecture-based learning, most were sleeping, talking or playing games and the teacher continued talking based on the PowerPoint; this method is very content-based classroom learning. In the second half of the class, the researcher conducted the first workshop alongside the teacher. This part of the class was designed based on student-centered strategies that included interactive learning activities with the teacher and students. Not all the students engaged actively in the interactive learning activities, but an obvious change occurred immediately. Most of the students were guided to read the case study and participate in the group discussion. At the end of the workshop, all the students gave a group presentation as required in the student worksheet. They introduced the models or strategies that proposed to reduce waste and pollution in their workplaces based on the concept of the closed-loop economy. Both the researcher and Teacher C were quite excited and surprised by the changes and they had a reflective conversation immediately after that first workshop. Teacher C shared his experience in implementing project-based learning before he worked as a part-time teacher for this module and pointed out the difficulties and time needed for achieving desired outcomes. However, he found that in this workshop, the students engaged more actively in classroom learning and he believed student-centered learning is helpful for engaging students in interactive activities and is more beneficial for students' competency development.

> The activity-based classroom learning is more interesting, and we can see students' engagement has been improved. It is good to have something for them to do in

> classroom, though I know it is hard for part-time students to be active leaners since they are tired from working almost every day. (Teacher C)

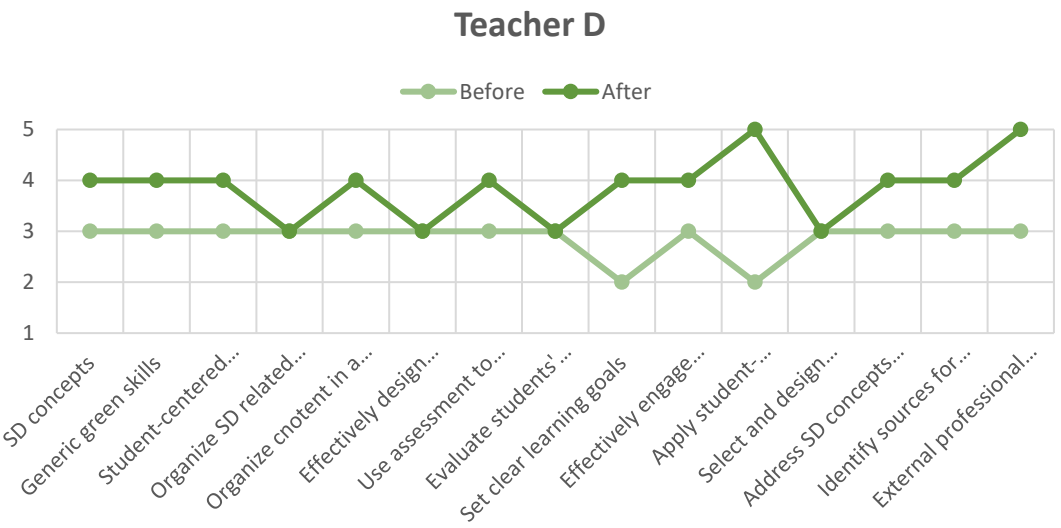
It could be argued that Teacher C's awareness and understanding of the importance of student-centered strategies in supporting students' active engagement in learning about greening had improved.

In short, all the competency items in Teacher C's self-evaluation were enhanced to at least proficient level after being involved in the resource implementation. However, the enhancement was relatively limited compared to the other three teachers since Teacher C was reported to have a higher baseline in the "Before" category.

4) Teacher D

Figure 23

Teacher D's ratings of the competence items (before versus after)



Teacher D is a part-time teacher teaching in this green module, but is full-time in a mathematics related subject, and has rich teaching experience in TVET institutions. He rated most of the competency items (13 out of 15) as 3 (neutral) in the "Before" category, which means he regarded himself not less proficient, but also not proficient, at these competencies. However, the figure showed that after the resource implementation, most of the competency items (12 out of 15) only increased one level (8 items increased from 3 to 4) or even had no increase (4 items were kept rating at level 3). Only three items increased more than one level (one from 2 to 4, one from 3 to 5 and one from 2 to 5). This revealed that the resource implementation only had a relatively limited impact on Teacher D's competency enhancement, particularly for those items

(listed below) which remained at level 3. This indicated Teacher D still considered he was not proficient at all.

Specifically, in terms of the items that remained at level 3, two were relevant to content selection and organization in the domain of professional knowledge.

- Organize SD related concepts into themes or modules that can be taught across different subjects, or as a separate subject.
- Effectively design and implement teaching related to greening.

One was under the domain of professional practice.

- I can select and design resources that are appropriate for my institutional context, including the practices of greening industry in my region/country.

It was found that these items are highly related to the teachers' knowledge and teaching experience of greening the curriculum in the TVET sector as well as industry experience on green practice. The development of these competencies was identified to be relatively difficult for Teacher D since he had kept teaching mathematics-related subjects after graduating from university and only had very limited industry experience. When he worked as a part-time teacher for this module, the TVET institution did not provide any training for teachers like him. However, some evidence as to how Teacher D effectively selected resources, designed and implemented teaching related to greening can be found in his reflection. He said,

> I need to take time to learn the teaching contents myself before I can teach the students. It is not bad and I can learn something too. The cases and solutions are very innovative, some of them I had never heard about, so I use these examples to stimulate discussion and explain to students how to solve an environmental problem from different perspectives and how we can think about it. It is not only about the '3R' which focus on reducing, but the way how to transform the pollutants to something useful. (Teacher D)

In the reflection, Teacher D shared the use of innovative examples to inspire students' thinking regarding solving environmental problems in a more transformative way. In addition, more substantial evidence regarding Teacher D's competency enhancement on "content selection and organization" could be identified in the interviews and reflective conversations too. For instance, the first question for Teacher D in the in-depth interview was "How you prepared the lessons based on the developed resources?"

Teacher D introduced the way he prepared lessons and further explained it using an example:

> I carefully read the materials and try to find out how those contents are relevant to the given lecture notes. For those that are very related, I pay more attention and integrate more in my lecture. For instance, there is an example introducing H&M joins the circular economy with 'Close the Loop' Recycled Denim Line to achieve zero waster for the old cloths. I used this example to stimulate the discussion of how to design a closed loop for building refurbishment with demolition and reconstruction, since all the students were worked at construction related sectors. Particularly, how to bring the construction waste such as the steel bar and timber back to a closed-loop to reduce the waste. (Teacher D)

The example in Teacher D's description demonstrated how he organized SD related concepts into

themes that could be taught in his class and how he selected resources, designed and implemented teaching that was related to greening industry.

One more item, which remained at level 3 related to curriculum assessment in the domain of professional knowledge.

- Implement assessment that is aimed to evaluate students' competencies (knowledge, values and attitudes) about finding innovative solutions to problems, exploration, debate, etc.

Although the targeted generic green skills, expected learning outcomes and assessment for the learning activities were specified in both the student worksheets and teacher guidelines (see Table 25 as an example), it seemed, they did not help enhance Teacher D's proficiency towards implementing assessment that aimed to evaluate students' competencies about finding innovative solutions to problems. This was found to be related to a lack of autonomy for teachers to decide the assessment of students' performance since the module assessment scheme had already been specified: a knowledge-based test (30%), assignments based on two workshops (20%) and a mini project report (50%). Three types of the assessment tended to focus on knowledge but less on values and attitudes. Although the assessment of two assignments was designed to measure students' formative performance that focused on competency development (see Table 25 as an example), it did not provide enough guidelines for teachers about how to do it or suggest some assessment tools that could help teachers to conduct assessments that focused on competencies. This is similar to Teacher A's reflection towards assessment.

Table 25

Part of the teacher guidelines for the case study of "How much energy do data centers use?"

Teacher guidelines for case study: How much energy do data centers use?	
Sustainable development goals (SDGs)	Goal 9: Industry, innovation and infrastructure Goal 11: Sustainable cities and communities Goal 7: Affordable and clean energy
Generic green skills	**Cognitive competencies:** Environmental awareness and a willingness to learn about sustainable development Ability to make judgments based on both evidence and sustainability values Innovation skills to identify opportunities and create new strategies to respond to green challenges **Interpersonal competencies:** Communication and negotiation skills to discuss conflicting interests in complex contexts Strategic and leadership skills to enable policymakers and business executives to set the right incentives and create conditions conducive to cleaner production, cleaner transportation, etc. **Technological competencies:** Quantification and monitoring (waste, energy, water)
Expected learning outcomes	**Student are excepted to:** Recognize how much energy data centers use and what solutions there are for this issue. Find out how Hong Kong responds to data center energy consumption issues and how it can be further improved.
Assessment	The assessment is based on students' presentation, according to the clarity and accuracy of their arguments.

Note. The example of how learning outcomes and assessment are listed in the teacher guidelines (How much energy do data centers use?) is from "Generic Green Skill for TVET: Teaching and Learning Resource" by M. Pavlova, S. C. Chen & A. Saral, 2019 (https://greenskillsresources.com/).

Furthermore, in terms of the items (listed below) that increased more than one level for Teacher D, each was focused on the domains of professional practice and engagement, which was similar for Teacher C.

- I can set clear learning goals (that are challenging, but achievable) for all students, for each learning activity that explores SD concepts, industry-based case studies and others (increased from 2 to 4, in professional practice).
- I can choose and apply a variety of teaching strategies based on a student-centered approach to engage students in critical thinking, problem solving and innovation in the context of greening (increased from 2 to 5, in professional practice).
- I can understand the importance of external professional networks and actively participate in networks and forums to broaden my knowledge in relation to greening the curriculum and improving my practice (increased from 3 to 5, in professional engagement).

After having a close look at the increased items, it could be found that Teacher D believed he was more proficient in setting learning goals and very proficient at applying student-centered teaching strategies after engaging in the resource implementation. He also better understood the importance of broadening knowledge towards greening the curriculum by participating in external professional networks and forums. As discussed earlier, he was willing to take time to learn the resources and think about the impact on both himself and the students' competency development.

In the classroom observations, Teacher D was observed to include more student-centered teaching strategies and interact more with the students in his classroom practice. An obvious example was, at the end of each lesson he always left time for the students to ask questions and to ask for comments about their mini projects. During the in-depth interview, he also reflected on how the teacher guidelines helped him with pedagogical design.

> The teacher guidelines are very clear and properly designed. I can follow the instructions that specified the teaching and learning sequences to organize all the learning activities. I can also learn from it. (Teacher D)

He also suggested adjusting the learning goals for different students, to effectively encourage them all to engage in the project learning and derive more benefit from doing the project.

> The mini project might be a bit difficult for some students since they don't have any experience on writing a proposal for solving environmental problems such as they may don't know how to set a budget for the proposed solution. So, it will be better, if we can set the base part for most of the student to finish, and encourage those students which have higher ability or are more passionate in doing it to do the advanced part. (Teacher D)

Thus, the increase of the items listed above was also found in the classroom observations and the in-depth interviews with Teacher D.

In short, both the classroom observations and the interviews indicated the resource implementation had an obvious impact on Teacher D's competency enhancement in all three domains although several competency items only improved to a limited extent. However,

Teacher D reported a relatively low improvement in self-evaluation, the researcher believed he underrated his improvement to some extent.

To conclude, the professional learning designed, based on the resource implementation, was found to have different levels of impact on the four teachers. More specific discussion about the differences, and how to meet the teachers' different professional learning needs, were provided in the discussion section. Furthermore, it is worth noting that the possibility of information bias caused by underrating and overrating in self-evaluation was improved by using multiple data sources to provide the mutual corroboration.

2. The differences and similarity between the four teachers' self-evaluation across three domains

Figure 24 shows that the "Before" level rated by the two part-time teachers were higher than the two full-time teachers in most of the items (13 out of 15), which means the two part-time teachers have higher self-efficacy in most of the examined competency items, particularly Teacher C which rated 14 out of the 15 competency items at or above level 3, and five of them were rated proficient. While two full-time teachers rated all the items at only level 1 or 2, they considered they were less or not at all proficient in all the competency items. In addition, in both professional knowledge and practice, the four teachers' self-evaluations from highest to lowest were as follows: Teacher C, D, B, then A (C>D>B>A). Similarly, in professional engagement, the rating from highest to lowest was as follows: Teacher C, D then B, and A was equal to B (C>D>B=A). This revealed that two full-time teachers, particularly Teacher A, needed more support in competency enhancement towards greening of curriculum in all three competency domains.

Figure 24

Four teachers' self-evaluation regarding "Before Implementation"

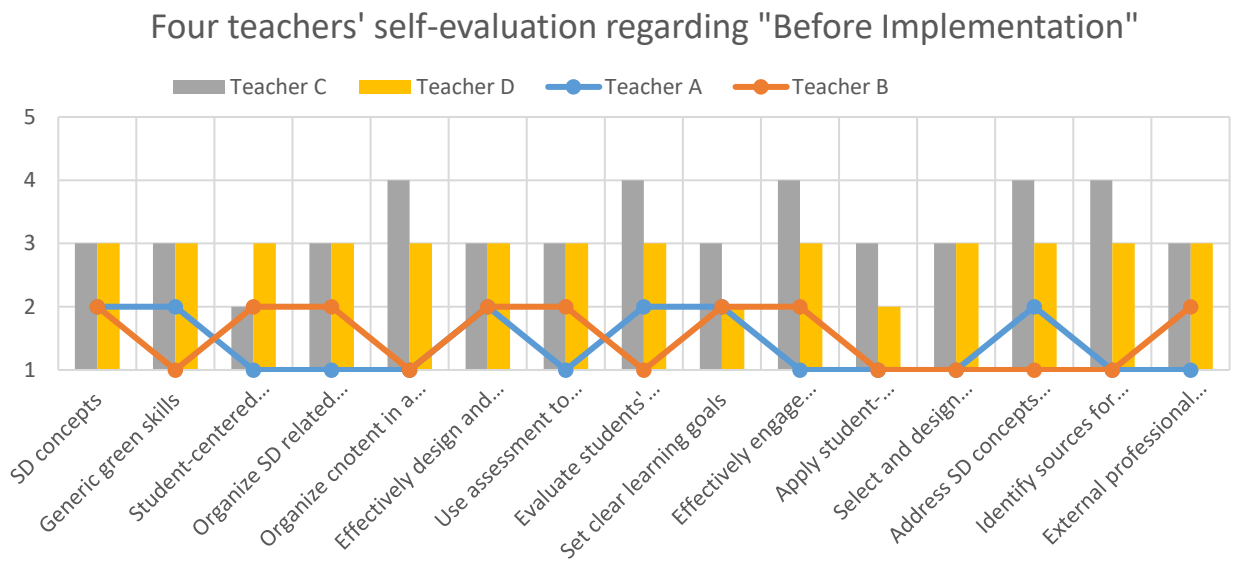
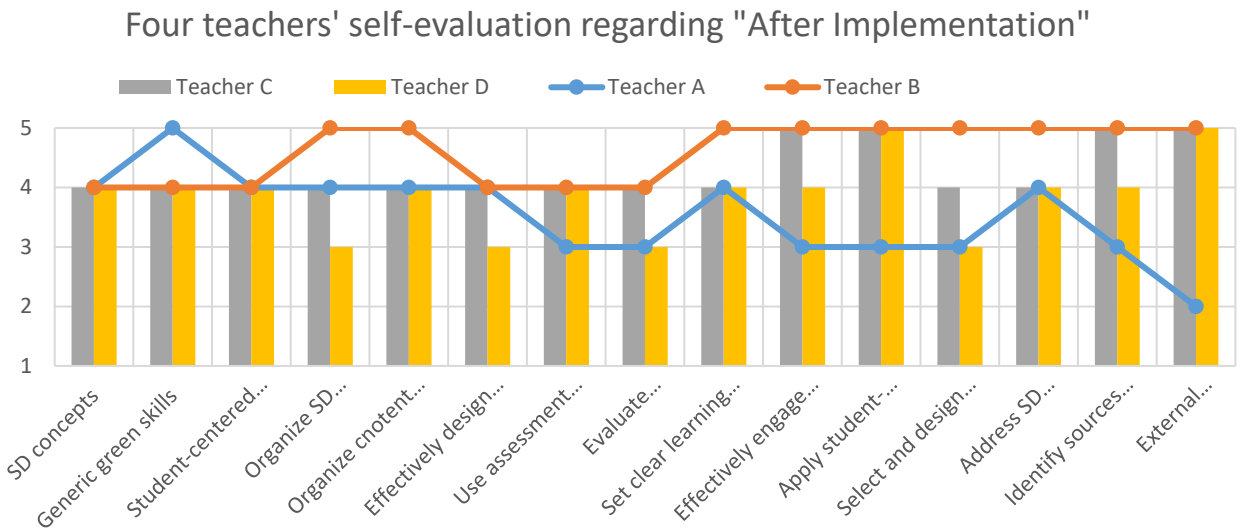


Figure 25

Four teachers' self-evaluation regarding "After Implementation"



However, Figure 25 indicated that after the resource implementation, the increase was obvious. More than half the items rated by the two full-time teachers were higher than, or at least equal to, the two part-time teachers. Specifically, in terms of professional knowledge, the rating from highest to lowest is as follows: Teacher B higher than A, A was equal to C but higher than D (B>A=C >D). Overall, the two full-time teachers' competencies related to professional knowledge were improved to a higher level. While in professional practice and engagement, the rating from highest to lowest is as follows: Teacher B, C, D, then A (B>C>D>A), so the two part-time teachers' competencies related to professional practice and engagement were improved to a higher level than Teacher A, but lower than Teacher B. However, as explained earlier, the researcher believed that to some extent Teacher B overrated herself in these two domains, therefore it could still be argued that the two part-time teachers' competencies related to professional practice and engagement were improved to a higher level than the two full-time teachers. In the final analysis, the resource implementation was effective in enhancing the full-time teachers' professional knowledge and the part-time teachers' professional practice and engagement.

In addition, Figure 25 also shows that, following the resource implementation, two-fifths of the items were increased to at least proficient across all four teachers, which indicates a general impact on the teachers' competency enhancement. However, some items were still rated "not yet proficient" by both the full-time and part-time teachers, which revealed different challenges for the teachers to improve their competency in greening of curriculum. For instance, both Teacher A and Teacher D rated themselves not yet proficient at "Implement assessment that is aimed to

evaluate students' competencies…" and "I can select and design resources …, including the practices of greening industry in my region/country". These items revealed common challenges for different types of teachers in terms of competencies enhancement towards greening the curriculum. The former revealed the challenging of changing the knowledge-based assessment to competency-based assessment that aims to evaluate students' problem solving and innovation competency towards greening. As discussed earlier, the fixed assessment scheme in the generic green module that focused on knowledge assessment appears to be the constraints for the teacher to make changes in assessment. This is an example of how an institutional problem (which was defined as external influential factors in the discussion chapter) can influence teachers' competency development. In addition, the latter indicated that the lack of professional experience and practice in greening industry also increases the teachers' difficulty in selecting and designing resources in the context of greening for TVET students. This is an example of how teachers' professionalization (which was defined as internal influential factors in the discussion chapter) influences the impact on their continued professional learning. Moreover, Teacher A also rated himself "less proficient" at "I can understand the importance of external professional networks and actively participate in networks and forums to...", while the other three teachers all rated themselves "very proficient" at this item. This could be related to personal factors, as discussed earlier: Teacher A was concerned that participation in external professional network would increase their already heavy workloads.

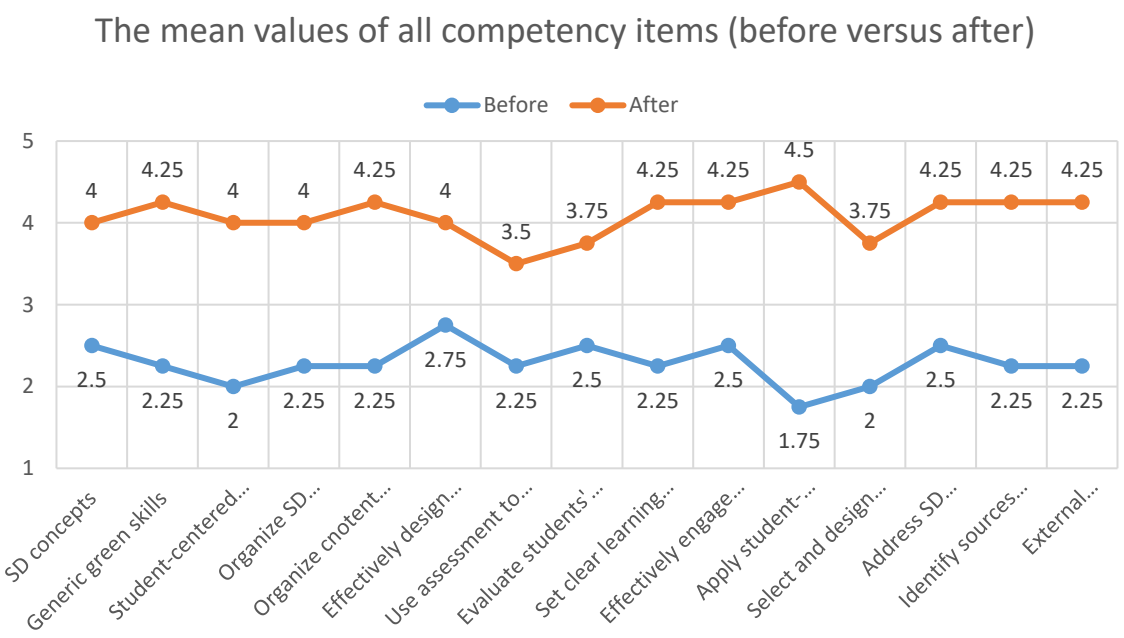
Finally, by comparing Figure 24 and Figure 25, it was found that the full-time teachers had higher increases than part-time teachers in a clear majority of the competency items (12 out of 15), which means that overall the resource implementation had more impact on the two full-time teachers who has less experiences on both sustainability and student-centred learning.

3. The general impact on the four teachers' competency enhancement

Figure 26 shows that after resource implementation, the mean values of four-fifths of the competence items were increased to greater than, or equal to, level 4. This means a clear majority of competencies were enhanced to at least proficient level, which reveals generally the resource implementation had a positive impact on the teachers' competency enhancement. Among the examined items, some were reported to have higher increase (≥2 level), while others were reported to increase less (≤1.25) or to still not yet achieve proficiency. This suggests the resource implementation had more impact on enhancement of certain kinds of competencies, but less on the others.

Figure 26

The mean values of all competency items (before versus after)



The items listed below were identified to have increased by at least two levels.

First, in the domain of professional practice are:

- I can demonstrate knowledge and understanding of generic green skills and their role in developing students' green mindset…. (increased from 2.25 to 4.25)
- I can demonstrate knowledge and understanding of student-centered strategies that can support students' active engagement…. (increased from 2 to 4)
- I can organize content in a logical sequence to achieve effective learning and teaching. (Increased from 2.25 to 4.25)

It was found that three items all increased from less proficient to proficient. The enhancement of the listed competencies demonstrated that implementing the resources helped teachers to improve their knowledge and understanding of generic green skills, student-centered strategies and ways of achieving effective learning and teaching. It could be argued that the resources that were designed and developed based on, but not limited to, the key elements listed below played an important role in providing appropriate learning resources for the teachers' professional learning.

✓ Set clear generic green skills development targets for each learning activity.

- ✓ Design and organize the learning content and activities based on student-centered strategies.
- ✓ Provide specific teaching and learning sequences in both the student worksheet and teacher guidelines to help teachers and students to achieve effective learning and teaching.

Before the teachers implemented the resources, they needed to learn and think about how to organize and implement the designed learning content and activities in their classroom practice. In addition, the researcher also demonstrated how the student-centered strategies and the case study helped facilitate students' engagement through co-teaching with the teachers. These have become effective ways to help the teachers to develop teaching competency (knowledge, values and attitudes) in the context of greening.

Second, in the domain of professional practice are:

- I can set clear learning goals (that are challenging, but achievable) for all students, for each learning activity…. (increased from 2.25 to 4.25).
- I can choose and apply a variety of teaching strategies based on a student-centered approach …. (increased from 1.75 to 4.5).

The first item was reported to increase to proficient level. As mentioned earlier, this could be related to the design of the developed resources, in which both the student worksheets and teacher guidelines all listed clear expected learning outcomes and generic green skills development targets (see Table 25 above as an example), which helped the teachers understand how to set clear learning goals and assess students' achievements based on them.

Regarding the second item: it was reported to have lowest rating in "Before" but the highest rating in "After", which means the teachers considered themselves to be less proficient in adopting student-centered strategies to engage students in problem solving and innovation in the context of greening; however, after the resource implementation they believed they were more than proficient in it. It could be argued the significant change related to the obvious changes in students' engagement in classroom learning. This is an example of how students' responses influence the teachers' teaching behavior and self-evaluation, which was discussed in the discussion chapter. In addition, the resources, which included different kinds of activities that were student-centered and which encouraged more interactive learning, also provided examples for the teachers to think about how to choose and apply a variety of student-centered teaching strategies to facilitate students' engagement.

Third, in the domain of professional engagement are:

- I can understand and identify sources for professional learning. (increased from 2.25 to 4.25).
- I can understand the importance of external professional networks and actively participate in networks and forums …. (increased from 2.25 to 4.25).

It was found that two items all increased from less proficient to proficient. As indicated in the analysis of the four teachers in the section earlier, Teachers B, C and D all considered the resources to be useful sources for professional learning in relation to greening of curriculum, and they all regarded the cooperation with the researcher was a kind of professional network that

helped broaden knowledge and improve practice in the context of greening.

In short, the general impact of the resource implementation on the teachers' competency enhancement was consistent with the findings generated from individual analysis and the parallel comparison across four teachers within the three competency domains. It revealed that, both the developed resources (as useful learning sources) and the process of resource implementation (as an effective means of practical learning) all played an important role in the teachers' professional learning and competency enhancement towards greening of curriculum.

However, the items listed below had a relatively limited increase (≤1.25) or did not achieve proficiency.

First, in the domain of professional knowledge are:

- Effectively design and implement teaching related to greening (increased from 2.75 to 4).
- Use assessment as a tool and means of providing feedback to students …. (increased from 2.25 to 3.5).
- Implement assessment that is aimed to evaluate students' …. (increased from 2.5 to 3.75).

These three identified items all belong to the category of "curriculum assessment and reporting" in the domains of professional knowledge. Although the first item was reported to achieve proficiency, its increase was identified as being limited. This suggests that the resource implementation had less impact on enhancing the teachers' competencies related to curriculum assessment. This finding was consistent with the analysis earlier, which revealed the constraints of a fixed assessment scheme in institutional systems and a lack of appropriate guidelines to help teachers implement competency-based assessment. More professional learning, that helps teachers understand the importance of and, helps them develop their competency on implementing competence-based assessment, is needed.

Second, in the domain of professional practice is:

- I can select and design resources that are appropriate for my institutional context, including the practices of greening industry in my region/country (increased from 2 to 3.75).

In order to include more real-world learning opportunities that are relevant to TVET students' learning and working backgrounds into classroom learning, all the case studies developed in the resources were focused on specific industry sectors (See Appendix I). The implementation of resources that were designed on this industry-specific principle should be useful in terms of broadening teachers' knowledge about greening industry. However, results indicated the teachers considered they had not yet achieved proficiency in this competency item after the resource implementation and this is understandable as the implementation phase was not long enough. In addition, with reference to the four teachers' ratings, it was found that the teachers who lack industry experience and/or knowledge related to sustainability tended to rate themselves lower in this item. As mentioned by the teachers in interviews, it was less difficult for them to implement the resources provided by the researcher following the suggested teaching sequences, which mainly required general teaching skills. However, it was still challenging for them to select and design resources by themselves, particularly for those teachers who did not have much industry experience or resource development experience. Thus, a researcher-assisted

professional learning model or program that helps to develop teachers' competency in resource selection and design in the context of greening is needed.

In short, the analysis of the competency items that the teachers were less proficient in revealed the limitations of supporting teachers' professional learning through resource implementation. It also highlighted a need to improve the teachers' competency in implementing competency-based assessment and developing resources in the context of greening.

CHAPTER 6

DISCUSSION AND FINDINGS

This chapter interprets the results of the study with the reference to the following two research questions:

What is an ESD pedagogical model that can specifically support pedagogical innovation for the purposes of improving the implementation of generic green modules in TVET?

How effective is the proposed ESD pedagogical model in terms of improving teaching and learning for generic green skills development?

In response to these questions, this chapter refers to some additional literature that was examined after the data for this study had been collected to enable further interpretation of results. This chapter is in three sections; two discuss issues directly related to the research questions, and the final section addresses the limitations of the study and future directions for research.

6.1 POPBL+ model as an effective pedagogical framework for greening TVET curriculum for generic green skills development

This study started with a theoretically designed POPBL+ pedagogical model, which was adopted to develop students' generic green skills through effective teaching and learning that leads to real-world problem solving. Throughout this study this model was applied for resource development, which bring concepts and practices of greening industry in the local context in order to support the teaching and learning of the generic green module, "Green knowledge and practice". Results indicated the development of students' generic green skills was focused on cognitive competencies, however the desired outcomes in relation to knowledge application were achieved to a limited degree, particularly for part-time students. In addition, although the full-time students indicated high levels of acceptability and engagement with the case study learning and the teachers all perceived case study to be an effective approach for integrating pedagogical strategies and learning content that support real-world based learning, there were still some challenges related to effective teaching and learning that were identified during the study and which need to be addressed. The development of appropriate pedagogical strategies that facilitate the development of other kinds of generic green skills (in addition to cognitive skills) is the most important aspect. In other words, the results of the study revealed a need to further develop the POPBL+ model in order to improve its effectiveness in greening the TVET curriculum for students' generic green skills development. In order to explore the problematic areas in more detail, indicators suggested by UNESCO-UNEVOC's (2017) *"A greening TVET monitoring and assessment framework*" were used. Fourteen indicators, and the relevant desired outcomes for assessing the integration of sustainability into the existing curriculum and training for TVET students' competency development towards green transitions were suggested in the framework (see the first two columns in Table 26). These provide a framework for the assessment of actual progress in "greening the curriculum and training". Therefore the following section examines the effectiveness of the proposed POPBL+ model on greening TVET curriculum for students' generic green skills development, based on this UNESCO assessment framework; and also proposes some suggestions for greening TVET curriculum based on this.

The first two columns in Table 26 list the indicators and desired outcomes proposed in the

assessment framework for greening curriculum and training (UNESCO-UNEVOC, 2017, p. 74-77). The third column presents the findings of the assessment with respect to the effectiveness of the POPBL+ model, based on examples from the redesigned generic green module, "Green Practice and Knowledge" involved in this study (see Table 14). The POPBL+ model has also been applied to improve the pedagogical practice when implementing this generic green module at a TVET institution in Hong Kong.

Table 26

The analysis of the effectiveness of POPBL+ model in greening TVET curriculum

Greening the curriculum and training	***Desired outcomes***	**The effectiveness of the POPBL+ model on greening TVET curriculum: Examples from the redesigned generic green module, "Green Practice and Knowledge"** (see Table 14)
1) The importance of greening	*The cross-curricula focus of greening is addressed through the study of topics across all subjects and levels, and through integrated course of study.*	The selected topics for the generic green module have included generic sustainability issues across different industry sectors (subjects) and community-based development. All learning related to the topics was designed as case studies that facilitate integrated learning (see the learning content in Table 14 above), which are reflected in the learning process related to knowledge application in the POPBL+ model.
2) Greening in all aspects of curricula	*Curricula and training for institution-based teaching or as part of work-based learning adequately reflect a greening focus or related topics in subjects.*	As a generic green module that was available to students in all subjects, it was designed to reflect a greening focus on topics in different subjects. For instance, the concept learning of "sustainable consumption" could be related to any subject that required a reduction in material consumption such as construction and fashion design. Thus, the POPBL+ model maintains that applied learning should play an important role in facilitating students from different subject areas to understand the sustainability concepts based on their working context.
3) Valuing and recognition of greening	*Greening the curriculum is motivated by internal and external factors that are highly valued by the entire institution.*	The re-designing of this module was mainly motivated by the requirement to revise the module to include more up-to-date content (internal factor), combined the driving force from the resource development team (external factor) that aimed to accelerate the progress of greening TVET in Hong Kong. Although these identified motivations are not directly relevant to the POPBL+ model, the model was endorsed highly by the module team since the first time the researcher introduced the resources developed based on it. In addition, the POPBL+ model proposed for greening TVET curriculum for students' generic

		green skills development also helped improve teachers' appreciation and recognition of greening.
4) Linking curricula to community/ business sustainability needs	*The institution has an important role to play in developing a green work culture and society within the local community.*	The POPBL+ model emphasizes the importance of developing learning content that reflects different kinds of local issues to students. Thus, the case studies, as learning content designed for this module, were developed based on local sustainability issues and local solutions. Some of them are more relevant to business sustainability needs, such *as "Wood-based fibers could lead sustainable fashion out of the woods"*; others are more relevant to greening the community such as *"Sludge treatment in T. Park"*. However, the learning was still focused more on knowledge acquisition rather than engaging and extending its influence in community-based development. This revealed the need for further exploration of learning approaches that could facilitate knowledge application, particularly in the ways students could apply what they learnt to solve local sustainability problems in the workplace and the broader community.
5) Greening is inclusive	*The curriculum encourages local entrepreneurship and the engagement of disadvantaged groups (e.g. young people, women, persons with disabilities, rural communities and other vulnerable groups).*	This indicator was not considered in re-designing this generic green module since it is more relevant to the domains of society and economy in sustainable development. However, the resources also included case studies related to the concepts of corporate social responsibility and social enterprise, which helped enrich students' understanding of sustainability.
6) Innovative design of course delivery	*Curricula are aligned with community needs regarding both content and delivery.*	Since one of the aims of re-designing this module based on the POPBL+ model is to connect students' learning to local community needs and workplace greening, all the content (including sustainability concepts and relevant case studies) and the student-centered learning activities were designed to facilitate the achievement of this objective. The POPBL+ model was proposed to bring real-world learning opportunities into classroom learning through a progressive learning process, and this is consistent with the desired outcome that

		emphasizes aligning teaching and learning with community needs.
7) Curricula recognize traditional sustainability	*All curriculum documents are inclusive of different disciplines, cultures and perspectives, including indigenous/ traditional knowledge and worldviews.*	All the selected concepts were generally relevant to different disciplines, while the developed case studies were focused on local issues and provided solutions from both the local and international perspectives as shown in the POPBL+ model. In addition, the case studies focused more on innovating solutions rather than traditional knowledge, although some of the solutions were innovated based on traditional knowledge as well. For instance, the design of SMOG FREE BICYCLE was inspired by the manta ray, a fish that filters water for food. The innovative bicycle inhales polluted air, cleans it, and provides the cyclist with clean air.
8) Green curricula resources and readily available	*ESD resources are provided for teachers including a variety of media, sample units of study, course profiles, teaching guides, electronic and text-based resources.*	The developed ESD resources included both concept learning packages and its relevant case study learning packages. Each package includes an information sheet for introducing a new concepts or a case study, a student worksheet and a teacher guidelines that support classroom practice. Each of these was provided as electronic and text-based resources and was supplemented by pictures, videos and PPT presentations. The developed ESD resources were identified to play an important role in teachers' lesson preparation and their professional learning.
9) Teaching/ pedagogy reflects greening	*Pedagogical approaches involve systems thinking, inquiry, discovery, active learning, problem-solving and futures thinking emphasizing both a local and a global approach adaptable for teaching in the classroom or learning at the workplace.*	The POPBL+ model proposed the use of problem-oriented and project-based learning that leads to real-world problem solving as the core pedagogical approach to implementing the generic green module. The selected real-world problems were focused on issues in greening the community and industry, and the proposed solutions were focused on the local context with reflections on international contexts. It could be argued that this pedagogical approach is flexible enough to be used for teaching in the classroom or learning at the workplace in relation to greening. Different kinds of pedagogical strategies, that related to the proposed pedagogical approach, were also used to facilitate learning activities for different learning objectives.
10) Greening	*Natural and human-built*	The POPBL+ model indicated that learning in a real-world setting is more

reflected through the use of local examples	*environments are utilized as sites of discovery and active learning.*	beneficial to students' generic green skills development, however constraints such as a lack of field trips limited the real-world learning opportunities outside the classroom. An alternative approach, although perhaps not the best, is to include real-world cases in classroom learning to help students understand what is happening in the real-world and to develop problem-solving abilities through solution exploration. This is what the POPBL+ model was proposed to address. Therefore, the resources included local case studies that reflected industry greening, such as Greening building in Hong Kong and Sludge treatment in T. Park. Some learning activities were also designed based on the campus and the local community as sites, for example the identification of green technology on campus and a focus on the food waste problem in canteens.
11) Students learn greening from institutional practice	*Institutions provide a safe and supportive learning environment in which students are engaged in decisions about their institution and their learning of greening perspectives.*	Students' engagement in decisions about their institution and learning in relation to greening perspectives can help to create a supportive learning and teaching environment, however this did not attract enough attention in the TVET institution. Both the teachers and students involved in this generic green module had little autonomy in terms of deciding what to learn and how to learn. The POPBL+ model emphasized the importance of collaboration between TVET institutions, industry sectors and the community to create real-world learning opportunities for students.
12) Greening as part of core assessment strategies	*Transparent assessment mechanisms monitor student achievement in greening, including action-learning approaches.*	The POPBL+ model suggested developing assessment that focused on evaluating students' competencies about finding innovative solutions to the real-world problems. However, as discussed in the results section, more guidance and appropriate assessment tools that focus on competence-based assessment needed to be further developed.
13)Workplace-based learning	*Cooperative, workplace-based, experiential and other forms of learning styles support greening partnerships*	The POPBL+ model proposed the use of project-based learning to facilitate learning by implementing projects that aim to solve sustainability issues in workplaces (part-time students) or projects that help to solve problems in relation to greening community (full-time students). This kind of learning

	with the community and potential employers.	includes different learning approaches, such as workplace-based and experiential learning that support greening partnerships between the community and potential employers.
14) Learning through community/ workplace engagement	*Opportunities exist to engage parents, the community, and businesses in the practice of greening principles.*	The POPBL+ model proposed to create real-world learning opportunities through a progressive learning process. In the process of learning, by visiting the world and engaging with the world, different stakeholders are encouraged to engage in students' projects that focus on the practice of greening principles for the purposes of problem solving in sustainability.

The assessment of the effectiveness of the POPBL+ model for greening TVET curriculum revealed that the proposed POPBL+ pedagogical model (see Figure 9 below) can be used as a comprehensive pedagogical framework for greening the curriculum in the TVET context for three reasons.

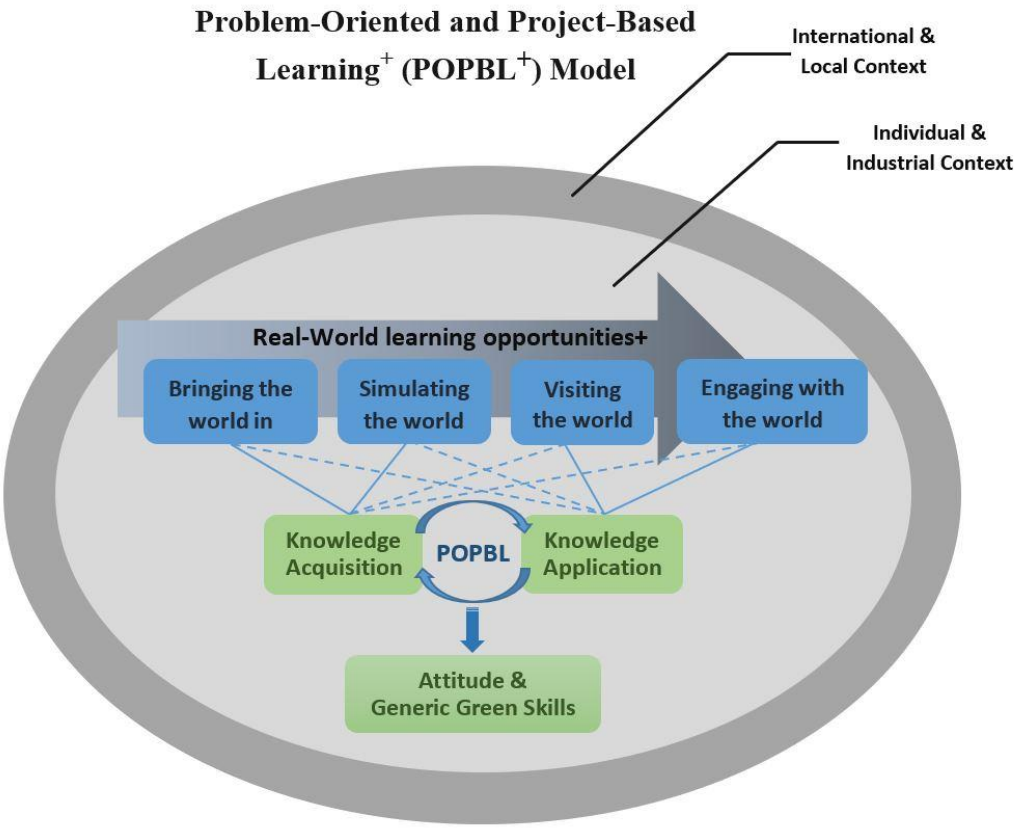
First, the principle of including real-world learning opportunities in classroom learning is consistent with students' primary learning needs in the TVET context, namely that learning in workplace-based and practice-oriented settings contributes to the development of different competencies. It also conduces to integrating sustainability issues, which are cross-curricular and link to community-based development and business sustainability needs, into the TVET curriculum. From this perspective, greening the curriculum in the TVET context can innovate the whole system in accordance with this principle, as it provides resources that support real-world learning for both teachers and students, improves assessment to motivate students' engagement in greening and develops training programs to support teachers' professional development in the context of greening.

Second, the progressive learning process, that is based on problem-oriented and project-based learning, can be regarded as an integrated pedagogical approach for content and pedagogical design in relation to greening industry and community as well as the approach for assessment that focuses on students' generic green skills development. The progressive approach provides a framework with which to set clear learning goals, to organize and design learning content and activities that facilitate learning in relation to real-world problem solving in sustainability. Different pedagogical approaches, such as inquiry-based learning and systems thinking, can also be integrated into the progressive learning process through different kinds of learning activities such as developing a closed-loop to minimize waste in an industry sector or a specific company. These kinds of activities require students to consider sustainability issues using system thinking and to explore solutions through further research.

Finally, contextual issues always play a critical role in understanding and solving sustainability problems. The assessment framework also included the following three indicators: 1) linking curricula to local community; 2) pedagogical approaches that can be adapted to classroom and workplace learning within both the local and global contexts; and 3) the use of local examples in greening the curricula. Each of these emphasizes the importance of developing content and pedagogical approaches that can be adapted to the local context to generate impacts on that local community. The implementation of these indicators has also been considered in this pedagogical model. It suggests the curriculum should include learning content that addresses greening in the individual context (what an individual should do) and the industrial context (what an industry sector should do) and should also examine the impact on both the local and international contexts.

Figure 9

Problem-Oriented and Project- Based Learning+ (POPBL+) Model



Note. This POPBL+ pedagogical model was adjusted based on "Facilitating the development of students' generic green skills in TVET: an ESD pedagogical model" by M. Pavlova and S. C. Chen, 2019, TVET@Asia, issue 12, p. 15 (http://www.tvet-online.asia/issue12/pavlova_etal_issue12.pdf).

Although the assessment of the POPBL+ model indicates that many aspects of greening the curriculum have been achieved through re-designing a pedagogical approach based on this model, additional adjustments can be made for a number of elements (e.g. community engagement in the practice of greening) to improve the effectiveness of the model in developing the competencies related to the "how to do" dimension. The following three issues were identified in the results and need to be further addressed.

First, there needs to be an improvement in students' engagement in learning processes related to knowledge application, in particular how students can visit and engage with the world, based on case study learning.

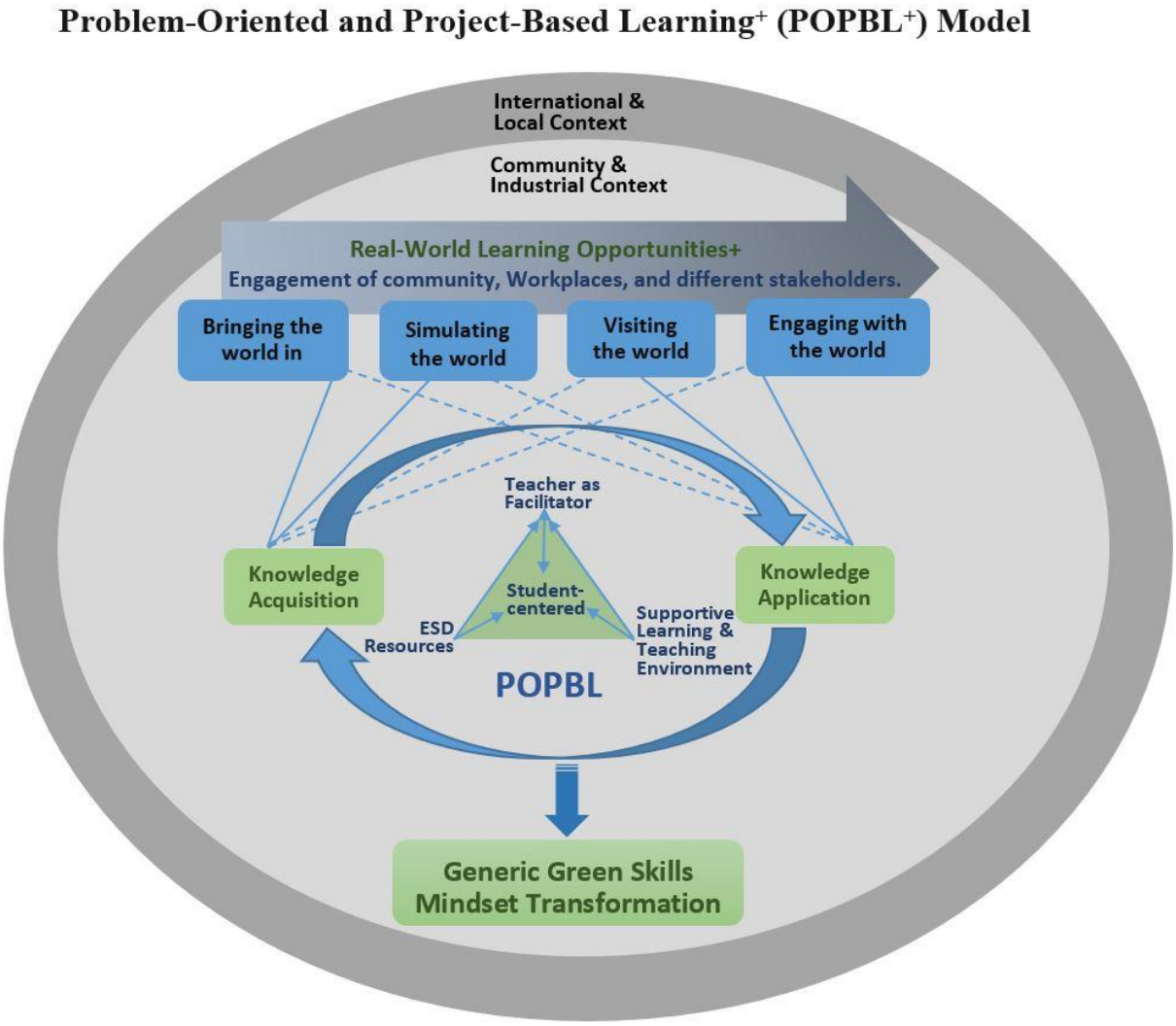
Second, there should be a reduction in the constraints that exist for the effective implementation of problem-oriented and project-based learning, such as the lack of supportive learning and teaching environment.

Third, there needs to be greater facilitation of students' mindset transformation towards sustainability as well as further developing their generic green skills through real-world problem solving.

These individual issues should be addressed holistically however as they are interrelated within the pedagogical framework. Improvements in each issue can contribute to the desired outcomes in the whole system. Accordingly, the POPBL+ model has been modified as illustrated in Figure 27, which provides a more systematic approach for greening the curriculum in the TVET context.

Figure 27

The updated POPBL+ model for greening the TVET curriculum



For the purposes of clarification, the adjustments included the following:

First, the importance of "Engagement of community, workplaces and different stakeholders" should be further emphasized to address the challenges of development of generic green competencies related to "how to do" dimension. It emphasizes the importance of creating real-world learning opportunities for students to engage in real-world problem solving situations to broaden a perspective to the outside classroom to practice 'how to do' skills in the context of greening. The part-time students' negative mindset towards an opportunity to make change has become the main constraint in terms of encouraging them to apply "what they learnt" to solve

real-world problems. This was related to prior work experience: “I can just do what the manager ask me to do and use the materials provided by the company”.,. For the full-time students main concern is related to the need to apply what they learnt: “if you do not use it [what your learnt), you will just forget”. This highlights the importance of knowledge application in competency development. However, it is difficult to overcome these limitations without engaging with the community, workplaces as well as different stakeholders in creating real-world learning opportunities for students, particularly in terms of supporting students’ project-based learning that will facilitate knowledge exploration and application for solving real-world sustainability problems. This kind of cooperative engagement in greening the TVET curriculum does not only provide a supportive real-world learning environment for students, but it also helps to connect the learning processes between knowledge acquisition and knowledge application and help students recognize that sustainability issues can be addressed through projects (e.g. green technology; eco-design) (Pavlova, 2015). Cooperative engagement can be integrated into greening curriculum as well as the progressive learning process in different ways. For example, industries can contribute to resource development by providing innovative greening examples that demonstrate how sustainability issues can be addressed in their contexts. With respect to the learning process of “Bring the world in”, these examples could be introduced to students to help them understand what is happening in the industries. For the process, “Simulating the world”, controversial issues that reflect different opinions in industries (e.g. the carbon trading scheme) and in the community (e.g. the plastic bag charge scheme in Hong Kong) could be included in simulative activities that help students understand how sustainability issues influence each of us in the community as well as to learn how to deal with various perspectives and conflicts. In terms of “Visiting the world” and “Engaging with the world”, relevant stakeholders could cooperatively engage with student projects to explore potential solutions for identified issues or provide opportunities for students to apply “what they learnt” in a real-world setting. For example, public libraries could engage in students’ projects that explore and implement solutions for a reduction in electricity consumption.

Second, a student-centered pedagogical approach, as the foundation for implementing problem-oriented and projected-based learning, has been further emphasized in the updated model. This revised approach includes three critical components: 1) teacher as facilitator; 2) appropriate ESD resources; 3) a supportive learning and teaching environment, which jointly support students’ learning for mindset transformation towards sustainability as well as generic green skills development throughout the whole progressive learning process. Appropriate ESD resources in this model are defined as teaching and learning resources that can support students’ learning needs as well as teachers’ teaching practice in generic green modules within the TVET context, such as case studies that relate to greening industry. A supportive learning and teaching environment should be developed based on a system mainly composed of TVET institutions, community, industries and universities. Each of these provides different kinds of support to ensure the effective implementation of generic green modules, such as resources needed for field trip learning, teachers’ teaching autonomy and professional learning, along with community and workplace engagement in students’ project learning. It also refers to the supportive environment created by active interactions between student-peers and teachers. Furthermore, the inclusion of “teacher as facilitator” also plays a critical role in implementing the student-centered approach, whereby teachers use different pedagogical strategies to facilitate learning activities designed according to the problem-oriented and project-based learning approach. Smith and Blake (2005)

pointed out eight characteristics of facilitative teaching in the context of TVET:

> An emphasis on the workplace as a meaningful learning context; interactive approaches to cognitive and performative aspects of learning; work-ready learning outcomes; learner collaboration in determining learning and assessment processes; learners as co-producers of knowledge; recognition of prior learning; flexible teaching strategies for different learning styles; and social interaction as integral to the learning process. (Cited in Bedi & Germein, 2016, p. 125)

It is worth noting that the availability of appropriate ESD resources that can be used in facilitative teaching (e.g. case studies that focus on greening workplaces and interactive learning activities), as well as relevant training that supports the use of these resources both play crucial roles in supporting the teacher as facilitator when implementing the student-centered approach.

Third, "mindset transformation" was identified as the key learning outcome that can help to bridge the gap between knowledge acquisition and knowledge application, which have a critical impact on students' understanding of greening. The results of the study indicated that both the teachers and the students perceived changes in the way of thinking (specifically, how we think about environment issues and respond to them) are important in terms of solving sustainability issues. They also believed exploring sustainability issues from different perspectives and innovating solutions for problem solving can facilitate generic green skills development. A more systematic discussion regarding the importance of mindset transformation in sustainability education is presented in section 6.2.2 below. In addition, there is considerable evidence which indicates that behavior does not change directly in relation to attitude change, and so sustainability education needs to go further than simply fostering value and attitude change (Arbuthnott, 2009). Thus, particular emphasis on "mindset transformation" was placed on learning outcomes generated through the learning cycle, between knowledge acquisition and knowledge application, in this model. The objective here is to transform students' mindset from "this is none of my business" to "I should/can be part of it", and finally involving in solutions for greening their community and workplaces.

Last, the context of community has been added in the inner circle of the updated model to indicate the importance of community context for enriching teaching and learning in TVET.

In conclusion, the preliminary POPBL+ model has been modified and improved for the purposes of greening the curriculum in the TVET context based on the findings of the effectiveness assessment (from a theoretical perspective) and the results of the study (from a practical perspective). The findings of this study strongly suggest TVET institutions use this pedagogical model as a framework to systematically green their TVET curriculum, particularly in terms of developing resources and reconstructing a supportive learning and teaching environment to support student-centered learning that grounded in the approach of problem-oriented and project-based learning towards real-world problem solving. In addition, the findings also suggest the generic green module (e.g. the one involved in this study) be set as a fundamental course for all students in TVET, since it can enable students' mindset transformation towards sustainability and equip students in different training disciplines with generic green skills (including knowledge and practice in greening). It could be argued that this could contribute further to students' specific green skills development (task-oriented competencies required for a specific occupation) that is needed for greening the community and industry.

6.2 Conditions for the effective application of the POPBL+ model for improving teaching and learning for generic green skills development

It is acknowledged that a number of conditions should be in place to ensure the effective application of this model, however this section specifically focus on discussing the conditions that are particularly evident from the results of the study. They are mainly related to the inclusion of real-world learning opportunities for TVET students in the context of greening (e.g. Creating learning opportunities for students to engage with community, workplace and different stakeholders) and the enhancement of TVET teachers' professional competencies for teaching in the context of greening (e.g. Providing appropriate training to support TVET teachers to transform their teaching role into facilitators).

6.2.1 Inclusion of real-world learning opportunities for TVET students in the context of greening

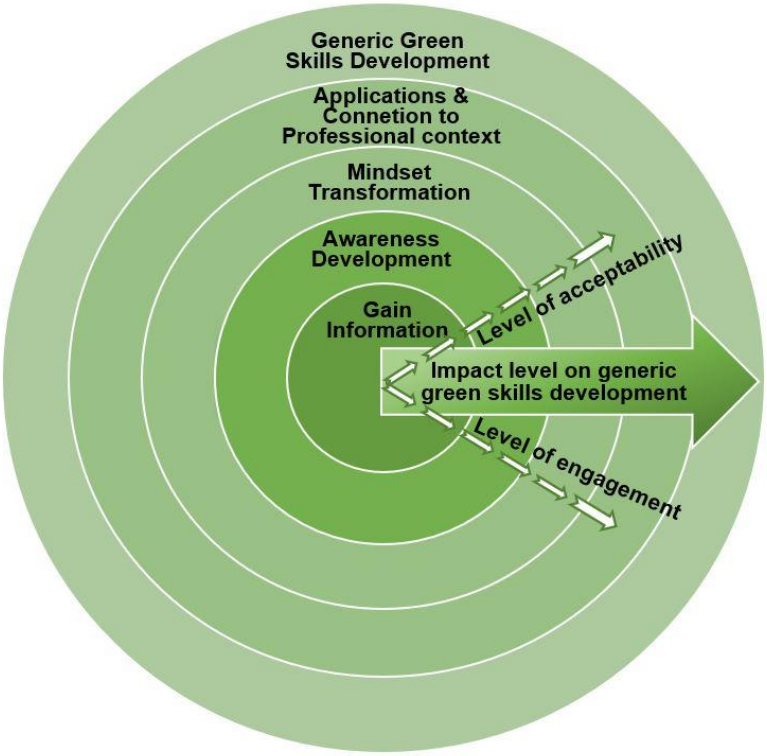
This section discusses the conditions related to the inclusion of real-world learning opportunities for TVET students in the context of greening. It suggests, the learning outcomes, as determined by students' acceptability of, and engagement with, resource implementation based on a new pedagogy (POPBL+), should contribute to students' generic green skills development at different levels. It also highlights the critical role of mindset transformation for facilitating a higher level of learning towards knowledge application. Finally, a connectivity-based learning approach (CBL approach) is introduced, which is designed to help students connect different learning processes with their professional contexts.

Condition 1: The learning outcomes should contribute to students' generic green sills development at different levels

The examination of students' acceptability of, and engagement with, the resource implementation revealed, levels of acceptability (to what extent students believed the resources are helpful to generic green skills development) and engagement (to what extent students engage in the learning activities designed based on the resources), which together determine the impact level on students' generic green skills development. Figure 28 presents the progressive development of students' generic green skills. It reveals the higher level of acceptability and engagement (which determines the radius), the higher impact level on generic green skills development (which determines the area of the circle).

Figure 28

A conditional matrix indicating the progressive development of students' generic green skills



As shown in the figure, the higher level of acceptability and engagement has a higher impact on students' generic green skills development. To facilitate the development of generic green skills, teaching and learning activities need to target the learning outcomes listed in each layer of the matrix. Five learning outcomes, representing different levels of impact on generic green skills development, are:

1) Gain Information: Students focus their learning on getting information from the resources. The learning purpose of this theme is just "knowing". At this level, students only consider the resources to be helpful for gaining more information about sustainability and they are observed to have certain kinds of behavioral engagement. However, they are hardly observed to have any emotional or cognitive engagement in the learning activities.

2) Awareness Development: Students reflect on the sustainability issues and recognize their impact on the community and different industry sectors. They also become aware of the importance of making changes, however they have not yet considered acting on the issue and being part of the solution. At this level, students consider the resources increase their environmental awareness and are interested in knowing more about the solutions for solving the identified sustainability issues. They are observed to have a higher level of emotional

engagement in the learning activities. For example, they feel discouraged in proposing the use of green technology to improve the energy issue in their companies and consider their suggestions will not be approved.

3) Mindset Transformation: Students are not only aware of the complexity of sustainable development issues and challenges but they also consider they should be a part of the solution and actively engage in exploring solutions. They are observed to engage more in learning activities that are relevant to solution analysis and exploration for solving the identified problems, such as analyzing how Google and Microsoft use renewable energy to support electricity generation for data centers. They also indicate higher cognitive engagement in different learning activities, and are observed to have deeper discussions with their peers and teachers as well as deeper thinking and understanding of the identified issues. At this stage they can develop a more comprehensive closed loop for reducing the food waste, for example, after analyzing the issues from different perspectives.

4) Applications & Connection to Professional Context: Students apply what they learnt by conducting projects that aim to solve real-world sustainability problems. They also connect the generic green module to their professional development and practice. Full-time students might focus more on thinking about how the transformation towards "green industry" influences their future career development and what they should do now. While part-time students who already work in different industry sectors should reflect on the discussed issues and solutions in their workplaces and green those workplaces by working practically on the identified issues. They are observed to have a high level of engagement in project learning and believe they can make changes by implementing the projects collaboratively with different stakeholders. They also exhibit a deeper understanding about the sustainability issues they were working on and achieve greater improvements in competency development in the context of greening.

5) Generic Green Skills Development: Students' generic green skills are advanced by engaging in learning activities that generate the learning outcomes listed in the different layers of the circle. In the layer, "Gain information", a few cognitive competencies such as the "Ability to make judgments based on evidences and sustainability values" will increase slightly after students understand some of the key concepts. This was observed in both class A (full-time students) and class C (part-time students) in this study. In "Awareness Development", more cognitive competencies, such as "*Awareness of the habits in what you do and think*", will be improved to a certain extent after students are engaged in the learning activities designed to stimulate environmental awareness. However, the results of the study revealed that most of the students remained in the layer "Awareness development". The development of a certain number of generic green skills in different categories was shown to require a higher level of learning engagement, in particular emotional engagement (that encourages students to be change makers) and cognitive engagement (that facilitates deep learning, for example, inquiry learning and system thinking) in terms of the development of different competencies. Therefore, the learning outcome, "mindset transformation" in the next layer plays a significant role in transforming students' mindset from recognizing "This is important" to deciding "I should do something". In this layer, more items in interpersonal skills and intrapersonal competencies will be developed a little more, but at the basic level. The development of the more "practice-based" competency items like, "Coordination, management and business skills to facilitate holistic and interdisciplinary approaches that encompass economic, social and ecological objects", need to be

addressed through the learning process that relate to "knowledge application" and through learning activities that facilitate students' deep reflection on real-world problem solving. However, the results of the study indicated there are different kinds of constraints that limit students' real-world learning towards knowledge application and professional development.

In brief, it was found that generic green skills are developed through learning processes and learning activities designed for facilitating the achievement of the identified learning outcomes listed in the conditional matrix. In the progressive development of different learning outcomes, mindset transformation towards sustainability was identified as the key learning outcome that helps bridge the gap between knowledge acquisition to knowledge application and to transform the developed awareness into specific actions (see more discussion in section 6.2.2 below). In addition, a learning model that proposed to connect the progressive learning process to students' professional application and development is introduced in section 6.2.3.

Condition 2: Transformative learning plays a critical role in transforming students' mindset towards sustainability

To better understand the concept of mindset, additional literature was examined after the data had been analyzed. In this study, "mindset for sustainability" and "sustainability mindset" are the desired outcomes of "mindset transformation", and the terms are used interchangeably. Mindset transformation is the foundation for any **sustainability initiatives** as it represents a new way of looking at the world, interpreting data, analyzing problems, and exploring alternative solutions (Rimanoczy, 2017).

Generally, mindset for sustainability is understood as translating ways of thinking into actions from a sustainability perspective and for the purposes of achieving sustainability. For instance, Kassel, Rimanoczy & Mitchell (2016) defined it as

> a way of thinking and being that results from a broad understanding of the ecosystem's manifestations as well as an introspective focus on one's personal values and higher self, and finds its expression in actions for the greater good of the whole. (p. 8)

Fairfield (2018) also emphasized the importance of ways of thinking based on the conception of the self and its relationship with the whole system for making real change.

> As Senge et al. (2008) said, "All real change is grounded in new ways of thinking and perceiving" (p. 10). Change needs to be rooted in one's deep conception of self and relationship with others, community, and the world. (p. 30)

The dimensions for these new/different ways of thinking were summarized in Rimanoczy (2013) who drew on earlier work by Adams (2004; 2008). These dimensions include

1) Time orientation—from short-term to long-term;
2) Scope of attention—from local to global;
3) Prevailing logic—from either/or to both/and;
4) Focus of response—from reactive to creative;
5) Problem or error consideration—from accountability and blame to learning; and
6) Life orientation—from doing and having to being.

(Cited in Fairfield, 2018, p. 33-34)

More specific explanations of the six dimensions can be found in Rimanoczy's (2019) later work. These dimensions explain directions in thinking for addressing sustainability issues. After reconsidering the ESD resources used in this study, it was found that to some extent the resource development integrated the six dimensions of sustainability thinking, particularly in the case studies. Table 27 below lists examples that demonstrate the integration of the six dimensions in sustainability thinking. The case studies that predominantly related to the six dimensions in sustainability thinking were provided as examples by both the students and teachers to answer different interview questions, such as "in what way do you think the resources help to develop generic green skills?". For example,

> For the energy problem, we get used to guide students to think about how to reduce electricity consumption and/or develop renewable energy to reduce the greenhouse gas. However, the case study that shows us how to transform CO_2 into plastic provides a new way of thinking, which means we don't have to control CO_2 emission and it can be transformed to something useful too. I can use the example like this to explain solution is not always about reducing but more importantly, transforming the negative influence into something useful. (Teacher D)

> I think it helps to develop my creative problem-solving competence. The solutions provided in the case study (SMOG Free Project) are something I never thought about, and I was quite impressed to know that we can solve air pollution problem in such a creative way. (Full-time student in class B)

Similarly, the interview question: "Do you think the case study can help you to connect your learning experience with real-world problem solving?" received the following responses:

> Of course, it can. Such as the example that introduces transform CO2 into plastic, this is something I never heard about. I can learn something new from that. (Full-time student in class A)

> Yes, it is useful, such as the concept of closed-loop economy make me feel guilty and consider if the thing could be reuse, should not be wasted. (Part-time student in class D)

This revealed that both the teachers and students were impressed by the examples or case studies that provide new/creative ways of thinking, and this helps transform students' mindset towards sustainability and to facilitate their generic green skills development. However, the results of the study revealed students' mindset development in these six dimensions was far from sufficient, so more effort needs to go into improving the resources that focus on facilitating students' mindset transformation towards sustainability, particularly in the dimension of "Being", which plays a key role in creating a new mindset.

Table 27

The integration of the six dimensions of the sustainability mindset in resource development

Dimensions of sustainability thinking	**Examples that demonstrate how the identified dimensions were integrated into case study learning**
Time orientation—from short-term to long-term	The solutions introduced in different case studies are proposed from a long-term perspective. For example, in the case study "*How much energy do data centers use?*" the students are required to consider both the short- and long-term consequences of using renewable energy in Hong Kong.
Scope of attention—from local to global	As emphasized in the POPBL+ model, the resources were focused on local issues in the community and industries and provide solutions from both the local and global perspectives. For example, cases introduced in the case study of data centers include the global companies Apple, Microsoft and Google as well as the local Hong Kong Broadband Network (HKBN). The purpose here was to develop a global perspective for students in order to solve local issues and also to consider the impact from both the local and global perspectives.
Prevailing logic—from either/or to both/and	This dimension was addressed in some of the case studies that included "both/and" solutions, which helps to inspire students to think in a both/and mindset. For example, the case study "*Over packaging in retail sector: Can "AirCarbon" help?*" introduces the AirCarbon technology that can convert methane emissions and carbon dioxide emissions into a naturally occurring bioplastic material. This can achieve the desired outcome of transforming air pollution into something useful instead of solving the air pollution issue based on the traditional idea of reducing CO_2 (otherwise the air pollution issue will be more serious).
Focus of response—from reactive to creative	In the ESD resource, the introduced solutions for the case studies play an important role in providing innovative ideas for students, while the learning activities are designed to facilitate students' competency development by creating innovating solutions for solving sustainability issues. For example, the learning activity in "Closed-loop economy" was designed as follows: "Based on the example design criteria below, you are encouraged to redesign the suburban house (see diagram 3) by substituting more 'closed-loops'". This activity aims to help students understand that the achievement of sustainability is always through design that

	minimizes waste and maximizes the recovery proportion of the original resource at the outset.
Problem or error consideration—from accountability and blame to learning	Provide solutions and examples in different contexts for students to learn from other companies, industries and countries, and translate the experiences into locally adaptable problem-solving strategies through the learning activities that are designed to facilitate applied learning. For example, the group discussion in the case study about the data center included the following problem: "If you are the owner of Hong Kong Broadband Network (HKBN) and you want to further improve the energy issue of this data center, what solutions do you think could be applied, based on the experience from the data centers introduced in this case study and why?".
Life orientation—from doing and having to being. Being here specifically refers to exploring and identifying the value in action, revisiting the personal contribution to the problems and how the individual behaviors shape the world (Rimanoczy, 2017).	The ultimate goal of resource development in this study is to create real-world learning opportunities for students to apply what they learnt to solve the real-world sustainability problems and to enhance their generic green skills during the problem-solving process. The learning activities in the resources were therefore deigned to help students reflect on sustainability issues and solutions in greening community and industry and encourage them to also think about how to adapt the solutions to green their workplaces and local community. For example, the learning objectives set in the group project include "1) Identify problems related to climate change & global warming in Hong Kong; 2) Explore the identified problems and the solutions to deal with it; and 3) Adapt the solutions provided in case studies for solving the identified problems."

Furthermore, a certain number of studies that assess competency development in sustainability education in different fields have identified the critical role of developing sustainability mindset through transformative learning for facilitating the change of perception and action towards sustainability (e.g. Arbuthnott, 2009; Sterling, 2011; Pavlova, 2011; 2015; Bell, 2016; Rimanoczy, 2017; Fairfield, 2018). Referring to the "Levels of learning" in transformative learning reviewed in section 2.3.1, which indicates students can learn at different levels of knowing and meaning, it was found that the learning processes listed in the progressive learning circle (see Figure 28) can be reflected in the three orders of learning and change in transformative learning. More specifically, most students perceived the learning in the generic green module was to "Gain Information", which can correspond with first order learning, "information transfer"-learning about things. A certain number of students perceived the learning could lead to "Awareness Development", which corresponds to second order learning, in which meaning is recognized and negotiated between learner's beliefs, values and assumptions. Only a few students perceived the learning could facilitate their "Mindset Transformation", which enables them to think differently. Learning that leads to thinking differently corresponds to third order learning, whereby "an expansion of consciousness and a more relational or ecological way

of seeing arises, inspiring different sets of values and practices" (Sterling, 2011, p. 23).

This revealed that, from information transfer (first order) to examining beliefs, values and assumptions (second order), and finally to seeing things differently (third order**)**, learning outcomes shift to a higher level of change that in turn leads to inspiring different sets of values and practices. Based on the reflection of the three orders of learning and the changes discussed above, the researcher is arguing that seeing things differently (values) can lead to responding to a problem differently that in turn further influences the actions on solving the problem (practices). Accordingly, if students' mindsets are transformed to "I should be a part of the solutions for the sustainability issue", their perception and engagement to "Knowledge Application and Connection to Professional Context" (the higher level of learning in the progressive learning circle, see Figure 28) will be improved, which will further influence their actions on greening workplaces (industries) and the local community. Therefore, generic green skills which, it has been argued, are effectively developed through the cyclic learning process (between "knowledge acquisition" and "knowledge application"), therefore will be developed too. Some evidence that demonstrated the validity of the assumption found in this study. It was found that, full-time students considered the case study learning helped to change their mind and they were observed to engage in the learning activities relevant to "knowledge application" more actively. These students also tried to connect the generic module learning with their main subject learning (professional learning). The full-time students also cared more about community-based development and reflected more on what they could do to green the local community. According to the results from classroom observation checklists, they were reported to have higher achievements in generic green skills development. In addition, the teachers who believed case study learning could facilitate students' mindset transformation, were observed to place more emphasis on developing students' thinking abilities (how to think differently/from different perspective) in their teaching practice and to provide more guidance on students' project learning that focused on "knowledge application" (for example, applying the solutions provided in the case studies to solve the air pollution issue in Hong Kong). Generally, their students tended to engage more and put more effort into the group projects, which also indicated higher levels of achievement in generic green skills development (based on the results generated from the group presentations for the projects and the final project reports).

Therefore, transformative learning, as a critical approach in sustainability education, leads to "seeing things differently" and can facilitate mindset transformation towards sustainability. This also contributes to developing generic green skills through the learning process of "knowledge application" for real-world problem solving in relation to greening. However, as indicated in Sterling (2011), "transformative learning arises from the interaction between the state of readiness of the learner and the quality of the learning environment to yield a particular learning experience" (p.27). So, in order to facilitate transformative learning in the generic green module, the constraints identified in providing a supportive learning and teaching environment for real-world learning, particularly in creating learning opportunities for students to learn through "knowledge application" that connect to their professional context, need to be adequately addressed. A learning approach that integrates transformative learning to facilitate students to make connections between different learning processes and their professional contexts is proposed in the next section.

Condition 3: Facilitate transformative learning through the connectivity-based learning approach

As discussed in the results section, the constraints that limited the effectiveness of the resource implementation in facilitating students to learn in the "knowledge application" part of the POPBL+ model includes:

External factors (e.g. institutional inertia, the learning resources)

1) A supportive learning environment that encourages real-world learning for problem solving is needed to enable "knowledge application", however neither the institution, nor industry and community were engaged in students' greening projects and provided relevant resources to support the project implementation.
2) Some external factors were challenging in terms of implementing the developed ESD resources. In particular, the case studies were developed around specific industry contexts/sectors/companies in order to meet different students' learning needs and for connecting to their professional contexts. However, since one case study mainly focused on a single industry context, whereas students' learning and working backgrounds were so diverse, it became more challenging for the students, whose professional backgrounds differed from the case study, to reflect on the learning towards "knowledge application".
3) The teachers' lack of professional experience and practice in greening industry, as well as pedagogical competency in facilitating real-world learning, also limits the realization of desired learning outcomes.

Internal factors (e.g. students' self-efficacy, practical experience in professional contexts)

1) The part-time students limited themselves to "we cannot make changes" due to their lack of autonomy at work and negative experiences of trying to make changes in the workplace. This resulted in students responding passively to learning activities that required them to analyze the issues and solutions from the position of "I can be part of the solutions". This was identified as *"perceived control"* in Arbuthnott (2009), which suggested *"we are less likely to make behavior changes when we believe that our efforts will not make a difference"* (p.155).
2) The full-time students who do not have/have limited work experience also face the challenge of connecting the generic module with their professional context since they do not have practical ideas about "what is happening in my workplace", particularly for those who are majoring in music composition or IT engineering. These students tended to be confused about what they could do in the context of greening.
3) The students who were used to being passive learners and had low learning motivation, also created a challenge in terms of the implementation of real-world learning as it requires students to be active problem solvers and change makers.

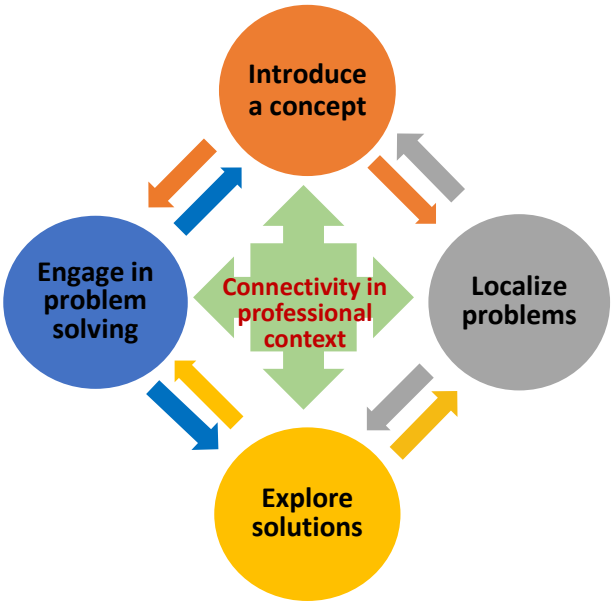
It could be argued that the external and internal factors combined made the issue of addressing the constraints more complicated. The researcher also understands that in order to address all the constraints, the whole system requires change that could jointly drive, or even reinforce, change in each of the single factors. However, the focus of this study is on pedagogy and how it can be changed to improve students' learning about greening and to develop their generic green skills. Thus, connecting students' learning to a real-world context, particularly to their professional contexts, which simultaneously facilitates students' mindset transformation towards

sustainability, is important from the pedagogical perspective presented by the POPBL+ model.

The connections between students' professional learning/majors (full-time students) and professional development/working contexts (part-time students) have been subsequently analyzed. Four learning processes included in POPBL+ model: "Bringing the world in", "Simulating the world", "Visiting the world" and "Engaging with the world" need to be further interpreted for the purpose of designing learning activities. Table 12 in Chapter 4 presents the original thinking at the beginning of this study for applying POPBL+ model in practice. Following the data analysis, a more focused approach has been suggested. It highlights the need to address the issue of creating unique real-world learning opportunities for students who study for different occupational/ professional contexts. The suggested approach, the connectivity-based learning approach (CBL approach) (see Figure 29), is focused on the following learning processes: "Introduce a concept", "Localize the problems", "Explore the solutions" and "Engage in problem solving". The cyclical pattern is used to represent the interconnection between the four continuous learning processes. Most importantly, each learning process needs to include learning activities that facilitate students to reflect on the connections with their professional contexts, for the purpose of achieving the desired outcome of "seeing things differently" which is foundational to transformative learning.

Figure 29

The connectivity-based learning approach (CBL approach)



It can be argued that when students start to make connections between their learning and different professional contexts, the ways and spaces for them to see things differently are created; in other words, transformative learning has occurred. This kind of connectivity, which "breaks

through the barriers created by overly defined and differing contexts in which work experience and, arguably, any form of learning in any organization takes place." (Griffiths & Guile, 2003, p. 57), can happen in any of the four learning processes by capturing "the essence of an issue", which is independent of the specific context of the issue. The term "the essence of an issue", which acts as an agent for facilitating the connectivity towards "seeing things differently", can be further illustrated by comparing students' different perceptions of connecting the learning to their work. Specifically, the researcher implemented the case study, "*How much energy do data centers use?*" in both the part-time and full-time classes. When the students were asked "In what ways do you think the case study can help you to connect your learning experience with real-world problem solving?", the part-time students tended to focus the connectivity on "Whether the object (data center) introduced in the case study is relevant to my work?" instead of "Whether the sustainability issue (energy generation for electricity supply) discussed in the case study is relevant to my work/workplaces?".

> The case study such as data center, it is something totally won't be considered in my work. There won't be data center in construction industry. (Part-time student in class D)

They can "see" data center, as the object of the case study, is not related to their work but they cannot "see" the energy issue in the data center is actually relevant to their work. This is not "the essence of an issue" that the researcher is trying to illustrate. Neither is it the desired outcome of "seeing things differently" that is emphasized in transformative learning. Conversely, the full-time students were found to be able to reflect on the issue and the solutions discussed in the case study and relate these to their professional contexts. They were also able to further think about how to apply these to solve a specific problem.

> It helps to break my old mind, and facilitates me to think more about how to apply the solutions into engineering design such as using what replacement can reduce the energy consumption. (Full-time student in class A)

In this student's response, "Reducing energy consumption" is an example of what the researcher is referring to as "the essence of an issue", while thinking about "how to apply the solutions into engineering design" reflects the desired outcome of "seeing things differently" emphasized in transformative learning.

In addition, how students connect the identified "essence of an issue" to their work also reflects the ways of knowing and thinking that frames their perception of, and interaction with, the world. When students were asked "Do you think you will/can apply the more environmental-friendly solutions at your work /to green your workplaces (for part-time students) or in your future work (for full-time students)?", the part-time students tended to "see" the connectivity based on the external objective world such as "data centers were hardly related to us", which reflects the "first-order learning" that is illustrated in Bateson's learning model, concerning "*learning about things*" (Sterling, 2011, p. 22). This can only result in superficial connectivity that is far from the desired "dramatic shift of consciousness" (Sterling, 2011, p. 23) in transformative learning.

> The cases were hardly related to us. We can't apply. Thinking about how to save electricity is managers' stuff. (Part-time student in class D)

Full-time students, on the other hand, were able to "see" the connectivity between the inner or subjective perspective that reflects the interaction they perceive between their own sense of self and the world. They considered "knowledge can be shared and integrated".

> I think so, although I am majoring in early childhood education, I can share what I have learnt with the teachers or even think about how to integrate the green knowledge into children's course design. (Full-time student in class B)

The students' different responses revealed two totally opposite perceptions about connectivity: one of which leads to the negative idea that "This is none of my business", while the other brings out a positive response: "We can contribute to green practice in different ways". The latter, which develops connectivity by making deep connections between the "the essence of an issue" and their professional contexts from the inner or subjective perspective, achieves the desired outcome of mindset transformation towards sustainability.

The CBL approach proposed in this section is aimed at helping students to identify "the essence of an issue" and make deep connections with the issues and relevant solutions in their workplace, to generate the outcome that involves a shift of epistemology, namely "seeing our worldview rather than seeing with our worldview so that we can be more open to and draw upon other views and possibilities" (Sterling, 2011, p.23). In order to translate the CBL approach into pedagogical strategies that support practical teaching and learning, the researcher then developed a pedagogical framework (see Table 28) that specifies the learning objectives and provides suggested learning activities for the four learning processes (illustrated in Figure 29 above). The main purpose of the framework is to inspire teachers by providing ideas about how to design learning activities based on specific learning objectives, to help students make deep connections between their learning and their professional contexts. More exploration about pedagogical design that facilitates connectivity learning is needed by teachers in their daily teaching practice.

Table 28

The pedagogical framework translated from CBL approach

Four phases progressive learning	**Learning processes**	**Learning objectives that focus on connectivity**	**Sample learning activities that help students "see" things differently**
Bringing the world	**Introduce a concept**	• Reflect on the understanding of a new concept in relation to a specific professional context. • Explore the application of a new concept based on a	1) Use a mind map to illustrate: What do you think closed-loop economy means in your industry? (e.g. material recycling) 2) Draw a closed loop that already exists in your company or develop a closed loop for your company to solve a specific problem. Explain how the

		specific professional context.	closed loop is working/will work in your company/industry.
Simulating the world	**Localize problems**	• Localize the problems relevant to the new concepts. • Connect the localized problems to a specific professional context.	1) Group work: Analyze the waste problem in Hong Kong. Each group mate is required to focus on one specific issue, such as how Hong Kong deals with different kinds of waste or how the recycling industry works in Hong Kong? 2) Individual report: Analyze the waste problem in your company/industry from different perspectives (e.g. electricity consumption, use of raw materials).
Visiting the world	**Explore solutions**	• Understand how the solutions in the case studies solve the identified problems. • Think out of the box: the case studies that provide solutions based on specific industries/companies. • Consider how to adapt the solutions/ ideas to address the problems in other industry sectors.	1) Field trip: Visit the T. Park (a waste treatment facility that offers an alternative solution for sludge disposal in Hong Kong) and identify at least two ideas or good designs related to "waste-to-energy" or "waste-to-usableness" that you think could be applied in the industry sector of your choice. 2) Group discussion: Discuss how ideas identified during your visit could be applied in the industry sector of your choice, and then illustrate what changes could be made in order to transfer waste into something useable to close a loop.
Engaging with the world	**Engage in problem solving**	• Apply the proposed solutions to solve the problems identified within a specific professional context. • Reflect on the effectiveness of the proposed solutions with reference to a specific professional context.	1) Develop a project/proposal (could be designed as group work if students are majoring in interrelated disciplines) for addressing the identified waste problems in your workplaces. 2) Cooperative learning: Engage different stakeholders to evaluate the effectiveness of the proposal and the changes made after implementing the project.

The sample learning activities included in Table 28 are based on the concept of, and the issues and case studies relevant to, the closed-loop economy. The "closed-loop economy" topic is simply used as an example to show teachers the whole picture with respect to designing learning activities for a specific sustainability topic throughout the four continuous learning processes. For part-time students, the learning activities could be designed to focus on facilitating students to make connections to different industrial context (e.g. inspiring students working in the construction sector to make connections with their construction work). While for full-time students who do not have/have limited working experience, the learning activities designed to facilitate making connections might need to be adjusted to focus on local community or their future workplaces (such as, encouraging students majoring in hotel management to make connections to a specific hotel in Hong Kong). It could be argued that transformative learning will still occur during a learning process that facilitates the connection of "knowledge application" to the contexts students are familiar with, so they will be involved in more reflection on it.

Moreover, the CBL pedagogical framework also revealed the importance of engaging institutions, industry and community in supporting students' real-world learning towards problem solving, such as the field trip and project learning designed for the closed-loop economy outlined in Table 28. For part-time students, support and incentive provided in workplaces (e.g. resources and autonomy) can encourage them to make changes by implementing the projects that focused on greening industry/workplaces. For example, in order to encourage students to integrate what they learnt in the generic green module to improve their companies' competitiveness in sustainable development, the final project could ask students to "Summarize the sustainability challenges identified in your company and write a proposal that specifies the sustainable development strategies for addressing the challenges. You are required to focus on at least three dimensions (e.g. electricity consumption, waste management and corporate social responsibility) to identify the issues and propose solutions to improve them." Since students' working contexts might be different, it could be designed as an individual project, or if students' working experiences are interrelated, it could involve small group work that facilitates a more comprehensive understanding and cooperation between different industry sectors. In order to further improve the quality of students' engagement in the project implementation, their companies should be encouraged to engage in the project and set up incentives to motivate students, which in turn will also help improve the sustainable development of the companies. While for full-time students, as discussed above, the project learning needs to be designed to connect to the contexts they are more familiar with, such as the local community (e.g. public libraries) or relevant industry sectors (e.g. the hotel industry) that can provide opportunities for them to explore the problems and solutions in a real-world setting. This can also provide more flexibility for full-time students to make connections to their professional learning.

Moreover, although disciplinary barriers and institutional inertia were identified as rendering the integration of sustainability in higher education more challenging, additional studies have been completed to overcome these dilemmas. For instance, the book "*Sustainability education: Perspectives and practice across higher education*" edited by Jones, Selby & Sterling (2010), introduces case studies from teachers and lecturers in diverse disciplines that present the infusion of sustainability concepts, issues and case studies into learning and teaching, and which covered the disciplines of geography, environmental and earth sciences, nursing/health, law, dance, drama, music, engineering, media and cultural studies, art and design, theology, social work,

economics, languages, education, business and built environment, and several others which are not traditional academic disciplines. These studies lay the foundation for developing different kinds of learning resources and activities for generic green modules that involve students from diverse learning and working backgrounds.

In brief, this subsection summarized the constraints on facilitating students' real-world learning towards problem solving, and proposed utilizing the CBL approach to combat the constraints from a pedagogical perspective. This approach draws on transformative learning theory to argue that: facilitating students to develop connectivity between different learning processes and their professional contexts can help to achieve the desired outcome of "seeing things differently". This kind of mindset transformation can expedite the higher level of learning in "knowledge application" that contributes to the development of generic green skills. Last, it also developed a pedagogical framework to demonstrate how to design learning activities based on the CBL approach.

6.2.2 Enhancement of TVET teachers' professional competencies in the context of greening

This section discusses the conditions related to the enhancement of TVET teachers' professional competencies in the context of greening. It analyzes the factors that influence teachers' engagement in the resource implementation, and argues that the challenges related to these factors need to be address through the training and support provided to teachers. Particularly, teachers' motivation for engaging in educational change, which was identified as the most influential factor, needs to be improved through professional learning. Accordingly, a work-based learning and training model that reveals the mechanism of how teachers learn about implementing the resources is proposed, which sheds light on improving the effectiveness of teachers' professional learning and development.

Condition 1: Challenges related to the influential factors on teachers' professional engagement needed to be addressed through the training and support provided to teachers

Based on the examination of teachers' engagement in the teaching practice for the resources, four influential factors that influence their engagement in implementing the resources were identified. These include: motivation and professionalization, which are classified as internal factors that influence teachers' understanding and practice of "how to do" and "why to do" the resource implementation. The third and fourth are: students' engagement and teaching autonomy, which are classified as external factors that address "what to do". The identification of these factors was based on the data that revealed the four teachers' engagement with the resource implementation in this study (see 5.2.2 in the results chapter), although it is acknowledged that discussion of each of these factors can be found in literature too.

The researcher developed a figure (see Figure 30) to demonstrate how these four factors influence teachers' resource implementation, which in turn facilitates improvements in their competency in terms of reorienting the curriculum and innovating pedagogy in the context of greening. Three features in the figure are worth mentioning.

First, each gear in the figure represents an identified influential factor. The different sizes of the four gears represent the varying degrees of influence that each factor has on the teachers'

implementation of resources that further contributes to improvements in their competencies. The larger gear represents the greatest influence, while the smallest one represents the lowest influence. As the figure demonstrates the influence of the four factors on teachers' competency enhancement moving from highest to lowest is: motivation, professionalization, students' engagement, and finally teaching autonomy. The findings presented in the figure were drawn from the results of this study, which confirmed that internal factors play a more significant role in teachers' competency enhancement than external factors. "Motivation to make pedagogical changes" was found to have the greatest influence on the teachers.

Second, the motivation gear that represents "why to do" (e.g. goals and values) is the force that drives the motion of the other three gears. It plays a fundamental role in driving the professionalization gear that represents "how to do" (e.g. using a student-centered approach), while the professionalization gear sets the other two gears in motion that specifically address "what to do" (e.g. integrating real-world case studies into teaching). This representation of influences shows that motivation to make pedagogical change has a direct effect on teachers' professional learning and an indirect effect on improving students' learning engagement as well as reducing the negative effect of the lack of teaching autonomy. Meanwhile, improvements in students' engagement and teaching autonomy can also contribute to an increase in teachers' motivation for making changes, which is a reverse of the motion of the gears.

Third, the four gears are interrelated, whereby changes (e.g. in direction or speed) to any one of them will impact the others. The arrows in the figure indicate the direction of each gear, and if all the gears move according to the directions, the motion will begin and keep going. The acceleration or deceleration of any one of the gears will speed up or slow down the others. The researcher has created the gear diagram to highlight the mutual effect of the four influential factors in terms of engaging teachers in the resource implementation that helps with professional learning and competency enhancement towards greening of curriculum. The figure also signposts the importance of developing a whole-system approach to support teachers' professional development, while acknowledging that a single change can also make a difference to a certain extent.

Figure 30

The gear model

Note. This gear model reveals how four influential factors as a whole system that influence the teachers' engagement in resource implementation.

As shown in Figure 30, each influential factor plays a role just like a gear in a machine: in order to drive the motion of the machine, all the gears need to work in conjunction. In other words, in order to facilitate teachers' engagement in resource implementation (as professional learning), the challenges related to the four influential factors need to be considered and addressed through the training and support that is provided to teachers. The challenges related to the four influential factors in this study were identified as follows:

- **Motivation:** Teachers' low motivation for making pedagogical changes to improve the teaching and learning. They get used to giving lectures in the classroom based on the PowerPoints and the notes provided in the teaching packages, which cover all the content in this module. The importance of developing students' generic green skills also does not attract enough interest since the teachers consider this to be simply an elective course that will not have much influence on students.
- **Professionalization:** Teachers' lack of training, work and/or teaching experience related to sustainability. Some teachers are assigned to teach the generic green module, which are not sufficiently exposed to professional knowledge, practice and engagement in the context of greening. This raises a challenge for them in terms of facilitating students' real-world learning towards sustainability problem solving.

- **Student engagement:** Students' passive engagement becomes a challenge for teachers when attempting to implement a student-centered approach as well as more interactive pedagogical strategies, such as the case study and group discussion, which require students to be active learners. Passive engagement also lessens teachers' enthusiasm for using the resources to teach in a more interactive way and to be involved in more conversations with students.
- **Teaching autonomy:** The fixed teaching and learning content, combined with the ways students are assessed, raise challenges for teachers in terms of implementing the resources as they require teachers to decide "what to teach" (select and design learning content and activities according to students' learning needs) and "what to evaluate" (set clear learning goals and implement assessments that facilitate students' real-world learning, instead of content-based learning).

Moreover, the interactions of the four influential factors on the teachers' competency enhancement in greening the curriculum were further found through understanding how these challenges influenced teachers' engagement in the resource implementation.

For example, Teacher D had a higher motivation to initiate pedagogical change and Teacher C had rich experiences related to sustainability. Both of them indicated a higher acceptability and engagement with the resource implementation, although they faced higher challenges in terms of low student engagement than the two full-time teachers and they also had the same constraints in terms of the lack of teaching autonomy. Compared with Teacher C, Teacher D (who taught mathematics related subjects in the TVET institution) had relatively limited experience in working and teaching sustainability, however his higher motivation to make pedagogical changes effectively facilitated his professional learning during the implementation of the ESD resources. He was willing to spend more time learning the ESD-related resources, thinking about how to integrate the resources into his lessons and designing learning activities that encourage students' engagement. As a result, he was able to share deep reflections about how to use the resources to teach and inspire students to think differently during the reflective conversations. The data from the classroom observations and interviews also revealed that Teacher D had clearly experienced competency enhancement in the domains of professional knowledge, practice and engagement in greening of curriculum.

In relation to Figure 30, this can be understood as a speed up in the motivation gear which in turn accelerates the professionalization gear. In addition, although Teacher D was not able to make changes to the teaching content and needed to follow the fixed assessment structure (which applied to the other teachers too), he nonetheless attempted to integrate the learning materials he considered to be beneficial to students' real-world learning into current teaching (therefore the negative influence of a lack of teaching autonomy was reduced to some extent). The students in his class were observed to engage more in project learning and have more interactions with Teacher D (therefore students' engagement was improved). From this perspective, the speeding up of the motivation and professionalization gears helped accelerate the gears of students' engagement and teaching autonomy. Accordingly, Teacher D's example demonstrate that high motivation for making changes can drive teachers' engagement in professional learning and help equip them with necessary competencies to make those changes, while improvements in teachers' competencies can improve students' learning engagement and reduce the negative effect of the lack of teaching autonomy on teachers' teaching practice. Similar findings are

identified in different studies related teacher motivation. For example, Jesus & Lens (2005) revealed that the level of teachers' professional engagement has strong implications not only for their own professional development and the quality of teaching, but also for educational reforms and student motivation.

On the other hand, Teacher B, who showed relatively low motivation for making pedagogical change, was observed to have lower engagement in terms of co-teaching with the researcher when implementing the resources and seldom engaged in students' learning activities, although he had more work experience in sustainability than Teacher D. The pedagogical innovation designed to improve students' real-world learning and the importance of including ESD in the TVET sector did not attract his attention. However, after he had observed the students engaged in learning activities based on the resource when it was implemented by the researcher, he showed more interest in learning how to use the resources, particularly the use of the case study for engaging students in real-world learning. The same also occurred with Teacher A. Although his motivation to make changes was greater than Teacher B's, he stressed the lack of teaching autonomy as the major constraint in terms of making changes to his teaching practice. However, after he observed the students showing higher learning interest and motivation in the case study learning and engaging more actively in the learning activities based on it, he was much more willing to try to design and implement the lessons using the resources. However he was still concerned about the inconsistency between what he was teaching and what the assessment scheme evaluated. These two examples indicate that once teachers are convinced the changes can improve students' engagement, their motivation for embracing changes increases too. This is represented in the reverse process of the gear model, whereby improvements in students' engagement can have a positive influence on teachers' motivation to make changes. However, in the module team meeting, the researcher also found that the teachers who indicated very low motivation for making pedagogical changes tended to refuse to engage in the resource implementation because they considered it would increase their workload, despite the fact that they were more professional in teaching sustainability related subjects than Teacher D. This phenomenon can be assumed to be avoidance of stress, which Esteve (1992) explained: "Note that the teacher who exhibits the least engagement may become, paradoxically, the one at least risk of developing stress." (Cited in Jesus & Lens, 2005, p. 123).

Thus, it can be argued that motivation plays the most influential role in facilitating teachers' engagement with resource implementation and the professional learning that can enhance their competencies in addressing the identified challenges and constraints in greening the generic green module. However, improvements in the other factors can also help create a supportive environment for teachers' engagement, so an increase of teaching autonomy can create more space for teachers to explore their teaching practice and make pedagogical changes; an increase in student engagement can facilitate teachers' professional learning and teaching passion, since teaching and learning is an interactive process, and efforts to improve students' learning can also foster teachers' professional learning. Finally, the findings also revealed that factors which influence teachers' motivation, as well as how these factors influence the teachers' motivation, are different. This will be further discussed in the following section.

Condition 2: Professional learning plays a crucial role in improving teachers' motivation for engaging in educational change

The discussion regarding how different motivated factors influence teachers' motivation to engage in the resource implementation can further refer to the motivation research that explained how motivated factors influence motivated behavior. It aims to generate some suggestions that focus on providing support and appropriate training for teachers' professional learning, in order to improve their motivation for engaging in educational change.

The work by Thoonen, et al. (2011), examined the relative impact of motivational factors on teachers' professional learning and teaching practice, based on a considerable number of motivation studies (e.g. Bandura, 1986; Ford, 1992 & Geijsel et al., 2009) and found that motivated behavior, including professional learning and teaching behavior, is positively influenced by three motivational factors that are typically: expectancy, value, and affective components.

First, the expectancy component refers to teachers' self-efficacy, which is a future-oriented belief about the level of competency teachers expect they will display in a given situation (Thoonen, et al., 2011). In this study, this component specifically refers to the extent to which the teachers consider they are capable of implementing the developed resources in their teaching practice. Two factors were found to contribute to teachers' high self-efficacy in implementing the resources: a high involvement in professional learning and a high level of professionalism.

In the self-evaluation assessment, both Teacher C and Teacher D indicated high self-efficacy that led to a high level of competency in greening the curriculum. Although teacher D considered he lacked both work and teaching experience in sustainability, his high involvement in learning the resources, was found to significantly contribute to his high self-efficacy in implementing the resources. He considered learning and implementing the resources could expand his knowledge and experience in sustainability, and was willing to spend more time learning the resources and pedagogical design when he prepared lessons. In the classroom observations, the researcher found that he could clearly explain the new concepts based on the information (e.g. the definition, real-world examples and issues related to the concept) provided in the concept information sheets, and was also able to facilitate students' learning activities by referring to the provided teaching guidelines. Teacher C who had rich work and teaching experience related to sustainability was found to embrace the pedagogical changes more readily. He considered it is easy for him to integrate the resources and implement the case study teaching in the teaching practice. He could explain the sustainability concepts and relevant case studies based on his work experiences and responded to students' questions using examples that illustrate "what is happening" in different industry sectors/workplaces. It could be argued that his high level of professionalism in greening the curriculum contributed greatly to his high self-efficacy in implementing the resources.

Thus, the differences in teachers' behavior can be explained in terms of the level of self-efficacy. Additional literature has been reviewed to understand the concept better for the purposes of devising ways to improve teacher's competencies in greening the TVET curriculum. It can be argued that high self-efficacy, as a motivational factor, can facilitate teachers' motivated behavior for engaging in professional learning activities, which in this study is related to engagement in the resource implementation that facilitates the competency enhancement towards greening curriculum. This has been identified in different motivation studies (e.g. Jesus & Lens, 2005; Geijsel et al., 2009; Bruce et al., 2010 & Durksen, Klassen, & Daniels, 2017). In particular, Thoonen et al. (2011) stressed that teachers' self-efficacy appeared to be the most important

motivational factor for explaining teacher learning and teaching practices in terms of educational change. Therefore, in order to improve teachers' self-efficacy in making pedagogical changes, more support for improving their involvement in professional learning is needed, such as helping teachers to identify sources for professional learning and developing a professional learning community that provides opportunities for teachers with different backgrounds to work collaboratively and learn from each other. In addition, teachers' professionalism in teaching generic green modules in TVET also needs to be addressed through appropriate professional learning that aims to improve teachers' pedagogical competency in facilitating transformative learning in a transdisciplinary context and to equip teachers with industry knowledge and experience in greening.

Second, the value component of motivation concerns "teachers' goals for doing a task and the importance and interest attributed to the task". From this perspective, motivational processes are a function of teachers' personal goals and beliefs about their capacities and context (Thoonen et al., 2011, p. 505). In this study, the value component specifically refers to teachers' goals for implementing the resources that facilitate real-world learning, as well as their perception of the importance of, and their interest in, engaging in it. In addition, research has suggested a strong belief and internalization of the organization's goals and values is an element of teacher motivation (Geijsel et al., 2009). It reflects that, internalizing this study's goals of implementing resources, (including developing students' generic green skills and enhancing teachers' competencies in greening of curriculum), into teachers' teaching and learning goals plays an important role in teachers' motivation to engage in implementing the resources. Reflecting on the value component of motivation in the four teachers involved in this study, the researcher found that teachers "learn" the values underlying the resources that facilitate pedagogical changes (e.g. student-centered approach, project-based learning and real world case study learning) differently, and this influenced their goals, interest and perception of the importance of engaging in implementing the resources.

Specifically, Teacher C was found to learn the values from his previous experience of making educational changes; he had integrated project-based learning into a course in the environmental engineering program. As the program director, he played the role of teacher so he taught the reoriented course by himself, as well as the role of trainer as he trained the course teachers to use the new resources and change their pedagogical practice. Based on this experience, he reflected that

> With no doubt, project-based learning benefits both teachers and students a lot and a lot. Although the changes for that course were happened in a few years ago, I still keep receiving emails from the graduates for saying thank you and telling me how the project-based learning helps in their jobs. You need to keep paying effort and probably spend more times than teaching in the traditional way before the expected results coming out. (Teacher C)

Teacher C understood the importance of integrating project-based learning into the course design to produce the desired outcomes of teaching and learning and, because of this, he showed high interest and decided to take part in the project at the very beginning when the researcher introduced the project to all the module teachers. In his teaching practice, he was observed to engage more actively in student discussions and show more passion for case study teaching. In

addition, in terms of the goals for engaging in implementing the resources, instead of saying Teacher C had very clear goals regarding "why I want to use the resources in my teaching", the researcher would suggest Teacher C personally preferred, and was used to using, project-based learning in his teaching practice. However, it was also found that teachers' positive experience in making educational changes can have a positive influence on their understanding of the values for doing a task related to them.

Teacher D learned the values from his teaching experience as a mathematics teacher in TVET institutions. He shared his understanding of the challenges students experienced when learning mathematics, and some other academic subjects, to help the researcher understand the situation that happened in case study learning. For instance,

> A lot of students I taught/am teaching are lack of learning motivation and clear learning goals, which means they do not know "why I study here" and "what I want to do". Most of them are also lack of learning support, which show very low self-efficacy in learning. For instance, the students who do not feel confident in learning mathematics, tend to avoid putting efforts in their learning to avoid the sense of failure or the helplessness in learning, and this can also happen in case study learning. (Teacher D)

In this deep reflection on the resource implementation, he showed clear goals in using the resources to make pedagogical changes and improve his teaching competency to help the TVET students to learn better. Although he did not teach sustainability related subjects, he personally indicated a high appreciation of sustainability education and believed sustainability competencies are very important for TVET students' future development. In addition, he also showed a high interest in learning and implementing the resources. Although it was more challenging for him to teach the generic green module, since he did not have any teaching or work experience in greening, he tried to integrate what he considered to be useful for students into his teaching practice and placed more focus on using the resources to help the students to think out of the box and develop their innovative thinking. It was found that the experience of seeing students' learning challenges inspired Teacher D's personal goals of helping students to learn better, which combined with a belief in the importance of sustainability competencies for TVET students, made him learn the values of making pedagogical changes towards a student-centered approach and implementing the ESD resources. This reveals that internalizing a strong belief in the values of a task into teachers' personal goals (e.g. implementing the resource that was designed on student-centered approach can help students learn better) can help stimulate teachers' motivation for doing the task.

Teachers A and B learned the values from the researcher's lesson demonstration. As discussed in section 6.3.1, they indicated more interest in implementing the resources after they observed the students had higher engagement and achieved better learning outcomes in case study learning. This indicated that these two teachers understood the need to change their content-based teaching and focus more on students' competency development, however they did not know how to accomplish this and had been too used to delivering knowledge through lecturing. During the reflective conversations, it was found that after seeing "how to do it", Teacher A started to think about what was important for students rather than simply following the module syllabus. He said,

> It is important to develop students' problem-solving competence using case study

> learning, and also learning with more interactive activities will not be that boring. The learning contents which included too much conceptual knowledge should be redesigned to meet students' learning needs that help them to understand the local issues and solutions. (Teacher A)

Teacher B appreciated the changes in the students too, but he felt he needed more support or learning for implementing the resources. He also invited the researcher to keep working with him if the project was to continue into next semester. Thus, seeing the values of a task can also facilitate teachers' engagement in professional learning related to the task.

In brief, teachers can "learn" the values of a task in different ways. To help teachers see the value of making pedagogical change for greening the TVET curriculum, it is important to provide appropriate forms of support for teachers' work-based learning (e.g. lesson demonstration) and provide opportunities for teachers to learn "why sustainability education is important to TVET students" (a strong belief in ESD) through different ways of professional learning, such as an introduction session about the ESD resources, and lectures or field trips provided by different industry sectors that introduce their greening practice.

Third, the affective component of motivation refers to "teachers' feelings or emotional reactions to their task or the school in general" (Thoonen et al., 2011, p. 505). In this study, this component specifically refers to teachers' emotional reactions to engaging in implementing the resource that requires them to make pedagogical changes towards real-world learning. It includes negative emotional reactions such as feelings of uncertainty, as uncertain teachers tend to work in a routine way, avoid risks and maintain present attitudes; and positive emotional reactions such as feelings of excitement that occur when teachers experience a congruence between professional orientations and current changes. The processes that give rise to teachers' emotions examined in van Veen & Sleegers (2006) revealed that the congruence between teachers' orientations (which can be understood as how teachers think they should work) and situation demands (which refers to the demands, constraints and resources that a situation brings to teachers) can invoke teachers' positive emotional reactions to a task. The appraisal process concerns "the stakes one has in the outcomes of an encounter" (e.g. "goal relevance", which involves issues the teachers care about or have a personal stake in) and "the options and prospects for coping with the situation" (e.g. "future expectations": what a teacher thinks will happen in the way of change) (Lazarus, 1991, p. 827).

A reflection on the four teachers involved in this study, shows that Teachers C and D clearly indicated a high consistency in terms of how teachers think they should work (teachers' orientations) and what the resource implementation required them to do (situation demands). In particular, Teacher C believed project-based learning is more beneficial to students' learning, which is consistent with the pedagogical change proposed in implementing the resources. Since he had experienced the situation of integrating project learning into a course in his prior teaching practice, he tended to encounter less uncertainty in "what teacher think will happen in the way of change", such as constraints involved in changing students' learning behavior and was more confident in coping with the challenges brought about by the change. Teacher D's belief that he should improve his competencies in sustainability education to better facilitate students' learning is consistent with the goals set for the resource implementation that were designed to facilitate teachers' competency enhancement towards greening the curriculum. In other word's Teacher D's goals for engaging in the resource implementation are relevant to the project's goals.

Accordingly, positive emotional reactions were found in Teacher C's and Teacher D's engagement in the resource implementation and their teaching practice.

In contrast, Teachers A and B, indicated inconsistency between the pedagogical strategies (e.g. content-based teaching) they got used to when implementing the generic green module and the pedagogical change (e.g. student-centered teaching) required to implement the resources. They were observed to respond to change passively and have less engagement in the resource implementation. However, after observing or confirming the positive effect on students' engagement during the researcher's classroom demonstration, their negative emotional reactions became more positive to some extent. This suggests that a prospect that change will work out favorably can help to invoke teachers' positive emotional reactions to a task too. In addition, the teachers who considered the resource implementation would involve an extra workload tended to avoid engaging in it and indicated negative emotional reactions that were invoked by the avoidance of risk, stress and uncertainty. The teachers also stressed that the lack of teaching autonomy was the main constraint in coping with the pedagogical change. These situations reflect the notion that the person/environment relation can either harm or benefit the individual, whereby "If an appraisal is made that harm or threat has occurred, then the emotion will be negative; if the appraisal is that benefit has occurred, then the emotion will be positive." (Lazarus, 1991, p.827)

In brief, the level of consistency between teachers' orientations towards their work and the demands of educational change was found to influence teachers' emotional reactions to the task of resource implementation. High consistency invoked positive emotional experiences, while inconsistency invoked negative reactions that led to low motivation for making changes. In addition, the harmful person/environment relation that was caused by stress and uncertainty in making changes, as well as a feeling of helplessness embedded in a particular situation, also invoke teachers' negative emotional reactions. Thus, to improve teachers' motivation for engaging in educational change, it is important to transform the negative emotional reactions invoked by different tasks/in different situations to more positive emotional experiences that promote the availability of personal resources in supporting educational innovations. Professional learning is needed to help teachers connect their personal goals, beliefs and knowledge with educational change and to recognize the favorable prospects of making change. Moreover, at the institutional level, administrators and managers also need to consider the ways in which the person/environment relation can be improved in order to invoke teachers' positive emotional reactions and to recognize the need of providing ongoing support to teachers. For instance, this support might be encouraging teachers to become involved in the decision-making process about educational innovation, understanding teachers' concerns and the constraints involved in making changes and providing appropriate support for teachers to cope with them.

In conclusion, this section, discussed how the motivated factors of self-efficacy, value and emotional reactions influence teachers' motivation to engage in the resource implementation, and provided suggestions about how to improve teachers' motivation based on these factors. The findings revealed that the work-based professional learning that happens during the resource implementation process plays a crucial role in facilitating teachers' self-efficacy development, value judgment and positive emotional reactions for educational change. Research on teachers' engagement in professional learning also suggested teachers' engagement in professional learning within the education context can stimulate both their own professional development as

well as the institution's educational innovations that ultimately lead to better teaching and learning (e.g. Jesus & Lens, 2005; Bruce et al., 2010 & Thoonen et al., 2011). Based on these findings, a work-based learning model was developed to support teachers' different learning needs in terms of professional development. The model is clarified in the following section.

Condition 3: Facilitate teachers' professional learning through the work-based learning model

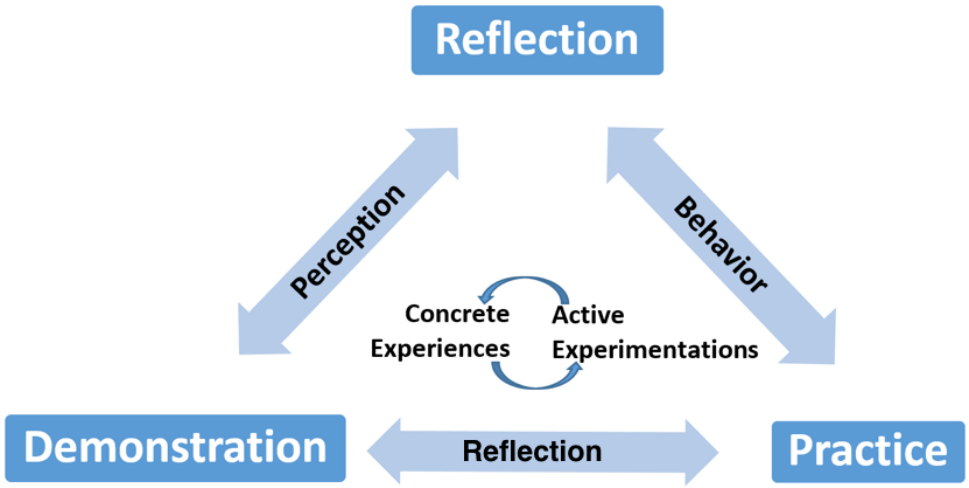
Work-based learning (WBL) refers to the formalization of learning at work, which could be described as "learning for and from work" (van Velzen et al., 2012, p. 230). It can also be briefly, and broadly, defined as "learning that takes place in a workplace whether as part of a course, while on placement, or independently while an employed worker" (Iredale et al., 2013, p.198). Opportunities for learning occur in the field, so learners can transform their conceptual knowledge into experimentation or practice. In this study, WBL that was developed for TVET teachers was focused on adjusting and implementing the ESD resources in their classrooms to gain ESD teaching and learning experiences through close collaboration with a researcher.

As has already been suggested, the resource implementation can be regarded as an effective way for teachers to experience work-based professional learning. Different forms of learning that happen in the implementation process can enrich teachers' learning experience. Teachers can learn from the resources that provide ideas about how to plan lessons and design students' learning activities and learn from self-reflection that focuses on how to improve their own pedagogical practice. They can also learn from co-teaching with the researcher to understand how to use the resources and learn from co-learning with the students to expand their understanding of a new concept. The findings revealed that teachers with different experience in sustainability and different motivations for making pedagogical changes responded and learned differently during the resource implementation, which indicates they require different supports for their professional learning. A work-based learning model (see Figure 31) for addressing teachers' different learning needs is presented below.

This particular model reflects the three key learning processes identified through the observations and reflections about how teachers learned about ESD and learned to implement the ESD resources in their teaching practice; this included learning from demonstration, learning from reflection and learning from practice. The model was developed based on the identified key learning processes, combined with some elements of theories of experiential learning and reflective learning as reviewed in section 2.3, which illustrates how teachers' perception and behavior can be changed through three key learning processes within a two-way cycle. Between the learning processes of demonstration and reflection, teachers are expected to gain concrete experiences about how to use the resources and observe how students respond to them in the classroom, and also to reflect on the new experiences in relation to their prior experiences. As a result, these learning processes facilitate a change in teachers' perceptions towards including the ESD resources as well as pedagogical practices. Through the learning processes of reflection and practice, which involve "active experimentation" (in Moon 2004, p. 126) and stress the understanding of the implications of new actions and development of new experiences, teachers' teaching behaviors can change (and this includes the use of student-centered pedagogy).

Figure 31

Work-based learning model for TVET teachers' professional development towards ESD inclusion



Note. From "Enhancing TVET teachers' capacity to develop students' generic green skills: a work-based learning model for professional development of teachers" by M. Pavlova and C. S. Chen, 2020, TVET@Asia, issue 14, p. 16 (http://www.tvet-online.asia/issue/issue-14/pavlovaetal)

Three major components of the work-based learning model, and the ways they facilitate teachers' perceptions and behavior change, are examined below.

Overall, demonstration is a pivotal starting point for introducing new teaching and learning resources and pedagogical approaches for curriculum reorientation. As indicated in the results section, teachers of this module were not very familiar with the concept of sustainability, or the relevant issues and pedagogical approaches that are needed for the inclusion of ESD. The traditional way of implementing the module was to follow the materials provided (PowerPoints with notes) and adopt a lecture-based teaching approach. Teachers in this situation did not think about making changes, as they did not possess content knowledge about ESD or the pedagogical skills to organize more interactive teaching and learning activities with which to engage students. These factors caused difficulties for the introduction of the developed ESD resources. Therefore, the lesson demonstration given by the researcher provided an opportunity for teachers to observe new classroom practices.

Putnam & Johns (1987) reviewed studies that examined different types of demonstrations used in teacher training programs and found that programs that involve demonstration are more effective than those that do not. They summarized the functions of demonstrations:

(1) to illustrate teacher instructional behaviors or thinking and decision making processes

> related to planning and reflection; (2) a stage in the development of desired teaching behavior; (3) an opportunity to assess the cognitive processing skills of students; (4) a means of illustrating the integration of theoretical, research and practical knowledge; (5) a way of critically questioning the rationale for the use of and/or the effects of ideas demonstrated; (6) to develop professors' credibility as they teach and manage students in a class; and (7) a means for professors to explore ideas and remain current about students. (p. 577)

Although the literature also revealed problems do occur with demonstrations, such as unintended messages or misinterpretations that can cause problems in transfer, the demonstrations used in this study had positive results and achieved most of the functions summarized in Putnam & Johns (1987) above. More specifically, the findings from classroom observations and reflective conversations revealed that the researcher's lesson demonstrations provided an opportunity for teachers to observe how students responded to the use of new resources, and to some extent this reduced the teachers' nervousness and uncertainty about change. In particular, when teachers saw the students' positive reactions and their active engagement in activities, the teachers' perceptions that the new resources can effectively enrich their teaching and students' learning changed. Since the teachers witnessed the changes themselves, they were more willing to find out more about the ESD resources and to try and include them in their classroom practices. Teacher B is an obvious example in this study: he was observed to passively engage in the project at the beginning, however after witnessing the positive change in students during the demonstration lesson, he became more interested and willing to learn more about how to use the resources. In addition, demonstrating how to implement the resources in authentic classroom practices is an effective way of clarifying the underlying principles of student-centered learning that are embedded in the resources and to introduce relevant pedagogical approaches. Thus, it can be argued that demonstration is a very pivotal step at the beginning of a professional learning program, as it presented teachers with evidence about how the change could turn out, the challenges teachers may face and also how to include/adjust the ESD resources into current modules, based on students' learning experiences (such as their learning backgrounds and learning habits).

Moreover, the cycle of demonstration, reflection and practice can facilitate the change from perception to behavior. Teachers' learning can occur and start with any of the identified processes in the model. However, findings from interviews and reflective conversations with teachers revealed that to start with demonstration, and then reflect on what was observed through reflective conversations before going to practice, is an effective approach for initiating changes from perception to behavior. The rationale underlying this approach is related to the relationship between perception and behavior, whereby perception change is a fundamental prerequisite for facilitating behavior change in teaching practice (e.g. pedagogical approaches and lesson design), and behavior change can, in turn, reinforce perception change. There are two basic principles underlying this model.

First, in the cycle between demonstration and reflection, demonstration plays a vital role in creating a valuable tension between the outcomes of current practices and the potential outcomes of theoretical or research-based ideas, which helps teachers become aware of problems (e.g. a lack of interaction between teachers and students) that exist in their current practices and the challenges they face. With respect to reflection, it is important to focus the reflection on how the

new resources help to improve, or even solve, the identified problems as well as how to implement the new resources in classroom practices.

Second, with reference to the experiential and reflective learning reviewed in section 2.3, reflection creates a link for connecting existing knowledge to new experiences that leads to future actions. This process facilitates the transformation between concrete experience and active experimentation (the application of new experience). Concrete experiences gained through demonstration can be transformed into new experiences through pre-reflection (reflecting before practice), while practical experience generated from active experimentation can become concrete experiences through post-reflection (reflecting after practice) as well. Thus, learning through reflection is an essential process for connecting demonstration and practice, and this leads to the potential for changes in perception and behavior towards ESD inclusion.

In addition, regarding how this model can support the four involved teachers' different learning needs, it is worth noting that the proposed work-based learning model is flexible enough to meet the learning requirements of different types of teachers. The findings demonstrate that the teachers who either have rich work experience related to sustainability or high motivation to make pedagogical change are more likely to enter the cycle between reflection and practice, and learn more effectively through practice. On the other hand, the teachers who either have insufficient work experience related to sustainability or lower motivation to make change are more comfortable to remain in the cycle between demonstration and reflection. They require more concrete experiences that are generated from demonstration as reflective sources to understand the ideas and the developed resources relevant to the pedagogical change. Therefore, for Teacher C, who has rich work experience relevant to sustainability and was more used to facilitate project-based learning, the perception towards ESD inclusion was very positive. He indicated he needed more support during the process of "learning from practice", such as adjusting the developed ESD resources for his class to maximize the effectiveness of those adapted resources for developing students' generic green skills. Teacher A, who had a bit more experience relevant to sustainability but less motivation to utilize student-center pedagogical approach than Teacher D, indicated he needed more support in terms of pedagogical understanding and assistance in facilitating small group work. The demonstration needed to clearly show him how to organize the learning activities to create more interactive learning opportunities for students. Furthermore, although Teacher D had little experience relevant to sustainability, he had a higher motivation to make pedagogical change towards the ESD inclusion, which rendered him an active learner while trying out the resources. He was found to need more support during the process of "learning through reflection", so the researcher needed to provide feedback to help increase his understanding about the resources and improve his practice related to ESD pedagogical strategies. Teacher B, who neither had experience relevant to sustainability nor higher motivation in making changes, was found to require more support to understand the principles underlying the resources to facilitate perception change. Thus, for Teacher B, learning through "demonstration" not only played an important role in helping him to gain content knowledge, but it also helped him understand how students learn and why ESD pedagogical strategies (e.g. learning from real-world problem solving, stimulus activities and debates) are effective in terms of developing students' generic green skills.

In summary, the proposed work-based learning model revealed the significance of demonstration as a key learning process for transforming teachers' perceptions towards embracing change from

the beginning. It also illustrated how the three identified learning processes work together to bring about the potential for changes in perception and behavior that can facilitate the inclusion of ESD. Finally, the model revealed the implication of adopting work-based learning for developing in-service teacher training and professional development programs.

6.3 Study limitations and further research

This section discusses the limitations of this study. It explains how the limitations impacted the research findings and how they were minimized. Suggestions as to how the limitations might be overcome in future research are also provided. Four limitations that focus on the design and conduct of the study, as well as the validity and applicability of the findings, are worth noting and are discussed below.

First, the major limitation was the relatively limited research studies base. Hardly any research that specifically focuses on generic green skills development in the TVET context can be found in the literature, which places a fundamental limitation on the empirical or theoretical basis for doing this study. The study has tried to minimize this kind of limitation by referring to the literature on sustainability education in higher education (e.g. Remington-Doucette et.al, 2013), the guidelines on greening TVET developed by UNESCO-UNEVOC for translating ESD into the TVET context, as well as the studies that introduce the data collection tools needed for this study. For instance, with respect to assessing the development of students' generic green skills, there is a lack of studies, guidelines or assessment tools that can provide empirical and theoretical basis for developing a classroom observation checklist (see Appendix A) that can be used to identify and evaluate the observable learning outcomes that demonstrate generic green skill development in classroom learning. To address this limitation, the researcher referred to studies that explore classroom observation tools for assessing teachers' teaching practices and students' competency development (e.g. Eddy, Converse & Wenderoth, 2015) and the generic green skills framework proposed in Pavlova (2017) (see section 2.2). However, challenges related to systematically referencing prior research studies to form the basis of the literature review remained as did laying a foundation for understanding research problems in the TVET context.

In order to further minimize the identified limitations, a pilot study was conducted in a TVET institution in Hong Kong to form the basis of this study from an empirical perspective, which was combined with the theory and practice of ESD pedagogy investigated in higher education to develop a theoretical framework for this study. It also provided direct experience for the researcher to understand the teaching and learning practice relevant to generic green skills development in the TVET context in order to further formulate the research questions and devise an appropriate research design for this study. In addition, in order to address the identified limitation, more research is needed that focuses on identifying and explaining the phenomena in developing students' generic green skills and enhancing teachers' competencies on greening of curriculum by implementing generic green modules within TVET context. In particular, the qualitative studies that provide empirical evidence for understanding the ESD pedagogical practice in TVET.

Second, there was a limitation that appeared due to the constraints on planning and implementing the intervention. As described in the research design, the module leader in the TVET institution decided to include three sets of materials into the current module syllabus (two were used in

workshops and one for designing the final group project) to ascertain how the resources could help to reorient the generic green module to include more industry green practice and help students learn better. Considering the need to prepare students with a basic understanding of some key environment concepts and relevant green practices before the workshops, he suggested the two workshops should be implemented in the middle of the semester. However, it was found that starting the interventions in the middle of the semester was not a good timing for both the teachers and students, since a regular teaching and learning pattern had already been established. More specifically, the pedagogical change suggested in implementing the resource requires teachers to implement student-centered teaching and students to be active learners and to engage in different learning activities. However, the teachers, to a great extent, got used to teaching by giving lectures using the provided teaching packages (PowerPoints, lecture notes) and the students also got used to being passive knowledge receivers. Some of the teachers also mentioned that it was hard for them in the middle of the semester to change the ways they teach and the ways students learn. This situation raised more challenges for the teachers and students in terms of making changes. Thus, it can be argued that to some extent this influenced the results in relation to both the teachers' and students' perceptions and engagement with the resource implementation, which further influenced the results demonstrating the effectiveness of the resource implementation in terms of the teachers' and students' competency development.

In addition, the interventions that were composed of two workshops and a final project, were considered by the teachers to be insufficient in terms of making a deep or transformative change in the teaching and learning, since the change in education really needed to be designed and implemented from a long future time perspective and receive sufficient support. This limitation might influence the development of certain kinds of generic green skills that require more learning time and opportunities for students to engage in real-world learning, which resulted in the appearance of a less positive finding: the learning activities were mainly effective in facilitating students' cognitive competencies development but had less impact on the development of the competencies that targeted at the "how to do" dimension. Therefore, after the data collection, more cycles of intervention were planned to be implemented, however due to constraints imposed by covid, the researcher did not have a chance to implement.

Thus, a follow-up project that focuses on reorienting the whole module using the developed ESD resources (see Table 14) to further explore the effectiveness of the pedagogical change for students' different kinds of generic green skills development is suggested. This will be conducted under the condition that the intervention is implemented at the beginning of the semester and lasts for that whole semester.

Third, the subjectivity of qualitative data analysis and interpretation and the researcher's theoretical sensitivity could limit the trustworthiness of, and conclusions drawn from, the findings. Subjectivity is evident in all forms of qualitative research since qualitative data needs to be interpreted through the researcher's voice, based on the understanding of participants' views and ideas. In this study, the researcher is the instrument that was involved in the setting of the inquiry, which developed the ESD resources with the team, co-taught with the teachers, conducted participant observations and interviews, collected relevant documents for assessing the impact of the resource implementation, and finally analyzed the different data sources by herself. Her experiences, views and understanding were unavoidably integrated into the interpretation of the findings. To enhance the trustworthiness of the findings, the researcher used

multiple methods for data collection and verified the conclusions drawn from the findings through triangulation of multiple data sources. For instance, the data collected for evaluating the impact on students' generic green skills development included participant observations, interviews with students and teachers as well as students' assignments and final group projects. The conclusions drawn from all these data were verified through triangulating what had been found in the observation checklists, the students' self-evaluation (they were asked, "Do you think the resources helped to develop your generic green skills? How?") and the teachers' evaluation (they were asked, "Do you think the resources help to develop students' generic green skills? How?") as well as the evidence presented in the students' assignments and group projects. In addition, the need for providing objective data to increase the trustworthiness of the findings generated from a subjective perspective was also considered in the tools developed for data collection. For example, in the classroom observation checklist, observers are required to list the observable and quantifiable learning outcomes that can demonstrate students' generic green skill development during classroom learning.

Furthermore, the researcher is aware that the experience and philosophical disposition she utilizes as a lens through which different data are analyzed might limit the analysis and interpretation of the findings too, such as the theoretical sensitivity developed through: 1) University studies on ESD. The concepts and case studies of ESD introduced in different courses and the relevant reading materials changed her educational philosophy and made her believe ESD is the solution to crucial educational problems; 2) Personal experience as a new teacher. She has high motivation for engaging in work-based professional learning, such as peer learning and assessment, and considers this has benefited her professional development significantly; and 3) Professional learning during the PhD study. A preliminary review of the literature on sustainability education, particularly in the pedagogical approaches that focus on real-world learning towards problem solving, such as project-based learning and transformative learning, laid the foundation for her understanding of ESD pedagogy. Each of these could limit her ability to see other potential possibilities outside her own understanding, and to some extent may become the source of biases. Therefore, to address potential biases in the interpretation of the results, the research discussed the preliminary, or emerging, findings with the teachers in the reflective conversations after each co-teaching; this helped the researcher understand the issues identified in co-teaching from different perspectives and to further verify her own interpretation of the findings. For example, the researcher found it was more difficult to engage part-time students in the group activities and considered this was because they were not interested in it. However, after talking to the teacher, she understood that the lack of interest was not just due to low learning motivation, but also related to the lack of time and energy to become involve in deep learning as the students all had jobs with long working hours. In addition, the researcher also reported the preliminary findings to the module leader and asked for his questions and comments during different stages of the study, in order to gain prompt feedback on the effectiveness of the intervention and his reflection on the findings. Furthermore, all the results in this study were reported based on vivid detail supported with quotes, which facilitated the researcher to generate the findings from the participants' original data and then verify the findings based on both the inductive and deductive processes. As mentioned in the data analysis section, the researcher also compared the findings with relevant literature and discussed the findings, with reference to the theoretical frameworks that reveal the studied phenomenon, for the purposes of refining the interpretation of the findings.

Last, but not the least, another main limitation in this study is the applicability of the findings. The main findings in this study include: 1) an ESD pedagogical model (POPBL+ model) developed to support pedagogical innovation for generic green modules in TVET; 2) the ESD resources developed based on the POPBL+ model; and 3) the conditions for the effective application of the POPBL+ model for the purpose of improving teaching and learning for generic green skills development. Since this study was specifically designed based on a TVET institution in Hong Kong, all the findings are applicable in practice to the involved TVET institution. However, the applicability to larger populations might still have some limitations. More specifically:

1) The POPBL+ model was first developed based on the literature review of ESD pedagogy and its relevant pedagogical approaches (e.g. project-based learning) as well as the findings from the pilot study conducted in a TVET institution in Hong Kong (see section 1.2), which to some extent seems to be only a result of an institution-based study that has contextual limitations on applicability. However, since the POPBL+ model is developed for addressing the common issues in sustainability education, (that is providing real-world learning opportunities for students to develop key competencies in sustainability), rather than focusing on addressing a specific issue within a specific context, it can be argued that this model has the potential applicability and can contribute to both theoretical and practical developments related to the use of ESD pedagogy for developing generic green skills in TVET. Additionally, the preliminary POPBL+ model was further improved according to findings from the model assessment conducted according to the "greening TVET monitoring and assessment framework" UNESCO-UNEVOC (2017) as well as the issues identified in the resource implementation in this study but which are also commonly found in literature (e.g. the lack of learning motivation). As a result the revised POPBL+ model provides a more systematic approach to facilitating pedagogical change in improving the teaching and learning of generic green modules in TVET. It also has broader, but focused, applicability in greening the TVET curriculum (including pedagogy innovation) by providing a conceptual framework that helps address issues related to educational change at different levels (e.g. classroom, institution and industry). However, the use and effectiveness of the adjusted POPBL+ model in facilitating pedagogical change towards greening of curriculum and generic green skills development in TVET still need to be explored further and confirmed in future research.

2) The ESD resources are comprised of two sets of teaching and learning materials. One set of materials is focused on introducing the concepts related to greening industry and society, such as the closed-loop economy. Although they included the introduction of some local sustainability issues, they are still applicable to the other contexts with small adjustments. Teachers can also use the concept introduction materials as the source of their professional learning in relation to greening the curriculum and sustainability education. While the other set of materials is comprised of case studies that focused on greening local industry, they will not fit other contexts, particularly those that introduce local greening facilities/solutions and suggest organizing a field trip as the main learning activity for the case study. However, they can still provide ideas about how to design learning activities that facilitate real-world learning in the context of greening and provide a design framework for teachers to develop their own localized case studies. They can also be used as supplemental materials to provide students with ideas about how to innovate the solutions for solving sustainability issues.

3) With respect to the conditions for the effective application of the POPBL+ model, all the identified issues and proposed suggestions in relation to effective teaching and learning are discussed with reference to the specific students, teachers and the teaching and learning context, the applicability of the findings seems limited. For example, the lack of motivation in making pedagogical change found in the involved teachers might not be the main issue for other teachers and the suggestions proposed for improving the teachers' motivation might not be useful to the other teachers either. To address this limitation, the discussion of the issues and suggestions referred to well-developed theories and studies that describe the examined phenomena from both theoretical and practical perspectives, which helped the researcher to understand the issues and develop suggestions for addressing the issues from a critical perspective. Thus, the findings can still contribute to a better understanding of the issues identified in this study (that are also discussed broadly in literature). For example, the significant role of mindset transformation on competency development in sustainability, which was found to influence TVET students' deep learning towards "seeing things differently" and in turn leads to inspiring different sets of values and greening practices. In addition, the findings can also provide empirical insight and support for future studies that focus on facilitating pedagogical change in the generic green module in TVET. In particular, the CBL model developed for facilitating students' transformative learning can be used as a pedagogical framework for connecting students' learning to real-world problem solving, and this has broad applicability on sustainability education at different levels. Furthermore, the work-based learning model developed for supporting teachers' professional learning can also be used as a conceptual framework to help teacher trainers design professional learning programs that respond to teachers' different learning needs in their professional development. However, once again the use and effectiveness of these proposed models still need to be further explored and confirmed in future research.

In conclusion, this section discussed the limitations focusing on the internal and external validity of this study. The limitation related to trustworthiness was minimized through appropriate data collection and data analysis methods. Further suggestions on the research design to improve the research impact were also proposed, based on the constraints in designing and implementing the intervention. In addition, the fundamental limitation of laying an empirical and theoretical basis for this study was minimized by referring to relevant literature and conducting a pilot study, although more future research that focuses on developing TVET students' generic green skills is badly needed. Last, the limitation related to applicability of the findings also needs to be addressed through future research that focuses on using the findings for practice and assessing its impact on desired outcomes, such as a study that examines the effectiveness of CBL approach in creating real-world learning opportunities for students' generic green skills development.

CHAPTER 7
CONCLUSIONS

This study developed a pedagogical model to address the issue of enhancing teaching and learning practices and finding an effective way to develop TVET students' generic green skills. The issue was identified based on literature review and a pilot study. The following research questions were formulated for the study:

1. What is an ESD pedagogical model that can specifically support pedagogical innovation for the purposes of improving the implementation of generic green modules in TVET?

2. How effective is the proposed ESD pedagogical model in terms of improving teaching and learning for generic green skills development?

1) What is the level of teachers' and students' acceptability towards the teaching and learning facilitated by the developed resources?
2) How do teachers and students engage in the resource implementation process?
3) What is the impact of the implementation of the ESD resources on students' generic green skills development as well as the enhancement of teachers' competencies in terms of greening of curriculum?

To answer these questions, the preliminary POPBL+ model, which is problem-oriented and project-based was developed to introduce a student-centered pedagogy and good practices identified from prior research on ESD. This model was designed based on the analysis of the literature and a pilot study and was then re-examined through the process of research reported in this thesis. To transform POPBL+ model into classroom activities, a pedagogical framework (Table 12) was designed to provide suggestions for pedagogical strategies and activities in order to engage students in the exploration of sustainable development issues.

The overall methodological approach for this study is drawn from action research (Deweyan Pragmatism). This action research study involved four teachers and four classes of students (a total of 115 students). Primary data for this study was collected via in-depth interviews, participant observations (including field notes), students' assessment items and group project reports, as well as the researcher's research journals. When planning the implementation stage of the action research, a series of ESD resources was developed to ensure it had a focus on student centered learning and to bring the real-world examples into the classroom. These resources were used to re-design a generic green module in a TVET institution and to implement the intervention of this study. Two cycles of intervention on two selected topics (closed-loop economy and green technology) were implemented in four different classes. One more topic (sustainable innovation) was used to design the students' final group project. Thus, these resources have been used for teaching and learning of a generic green module in a TVET institution in Hong Kong.

The results indicated the ESD resources are appropriately developed and useful for both the teachers and students in enriching their teaching and learning. The implementation of the ESD resources also had a positive impact on both the students' and teachers' desired

competency development. From this perspective, the proposed POPBL+ model was effective in facilitating pedagogical innovation for improving the implementation of generic green modules towards students' generic green skills development in TVET. However the impact on some of the students and teachers was not that significant due to the challenges and constraints discussed in the results chapter. Further literature searches were undertaken to further examine the results. Subsequently, an updated POPBL+ model was designed (Figure 27). The revised model emphasizes the importance of engaging community, workplaces and different stakeholders in creating real-world learning opportunities for students. It also suggests a student-centered approach that includes three critical components as the foundation for implementing problem-oriented and projected-based learning; that is, providing appropriate ESD resources, creating a supportive learning and teaching environment, and engaging teachers who are facilitators of students' learning. It could be argued that the applicability of the POPBL+ model has great potential for improving the pedagogical practice of generic green modules and facilitating the greening of curriculum in TVET (as argued in the limitations section).

Moreover, the findings in this study were generated from the examination of the teachers' and students' perception of, and engagement in, activities during the resource implementation and the assessment of its impact on students' and teachers' desired competency development. The discussion of the findings has been focused on: 1) the improvement of the POPBL+ model as an effective pedagogical framework for greening TVET curriculum; 2)the conditions for the effective application of the updated POPBL+ model for improving teaching and learning towards generic green skills development, which include, three conditions that address students' real-world learning for generic green skills development, and three conditions that address teachers' competency enhancement for greening of curriculum (including pedagogy innovation).

Therefore, this study answered the research questions and suggested further directions for research. Future studies should focus on exploring the ways to address the conditions (e.g. translating the CBL approach [Figure 29] into teaching and learning practice based on the developed pedagogical framework [Table 28]), and the use of the developed approaches/models (e.g. using the work-based learning model [Figure 31] to develop a teacher professional develop program); future studies should also focus on confirming the effectiveness of the revised POPBL+ model; since all of these would benefit research on generic green skills development in TVET. Additionally, what may need to be further examined but it is beyond the scope of this study, is how the development of generic green skills contributes to the development of specific green skills in TVET (which include the specific competencies required for greening industries and the topping-up competencies required in all industries). Consideration can also be given to, the ways in which the findings of this study, particularly the POPBL+ pedagogical model for pedagogical innovation and the developed learning approaches/models for facilitating students' and teachers' competency development in the context of greening, can be applied to support the greening of professional courses (including the innovation of pedagogical practice) in different subjects for students' specific generic green skills development in TVET. These further directions for research are based on the understanding of the importance of generic green skills development in supporting specific green skills development.

This study is significant as it developed an effective POPBL+ pedagogical model to fill the gap in the lack of empirical studies that specifically examine pedagogical practices for students' generic green skills development in TVET. It identified approaches and steps that can be used in planning teaching and learning for greening in TVET classrooms. A series of models and approaches that support the pedagogical innovation have been generated as a result of this research. This study's contribution to the literature on greening TVET is also related to attracting more attention of TVET institutions as well as TVET educators and researchers towards the issues of improving teaching and learning of generic green modules.

From the perspective of practice, the study contributes to the design of resources that use a student-centered pedagogy and industry-specific examples to contextualize learning and teaching approaches and to support students' real-world learning for the development of generic green skills. It re-designed an existing green module based on new pedagogical ideas and applied the work-based learning model for teachers' professional development. In addition, the design of the study also provides a methodological framework for conducting action research in TVET classrooms that can be used for further studies. It starts from developing appropriate resources, followed by working with relevant teachers to implement the resources and concludes with an evaluation of the effectiveness of the intervention in terms of producing the desired outcomes. Different data collection and analysis tools were also developed to support the data collection and analysis for this study, since there is a lack of usable and validated tools in the literature. These tools include two evidence-based classroom observation checklists for identifying the impact on students' generic green skills development (see Appendix A) and teachers' pedagogical practice and students' engagement (see Appendix B), a self-evaluation questionnaire for teachers' professional competency assessment (see Appendix D), and an assessment rubric for measuring students' project reports (see Appendix K) that are focused on generic green skills development. All these tools can be used and improved in future research (particularly in the empirical studies that focus on ESD pedagogy, teaching and learning for generic green skills development, and teachers' professional learning and development in the context of greening), although they need to be further validated to support data collection on identifying and assessing students' generic green skills development and teachers' competency enhancement.

In conclusion, this study developed a POPBL+ model that proved to be effective in supporting pedagogical innovation for improving teaching and learning towards generic green skills development in TVET. This model provides a framework for structurally integrating real-world learning opportunities into classroom learning. However, the effectiveness of its implementation varies for different types of students and teachers. Reflecting on the findings, the model was further improved; and the conditions that are important to facilitate the effective implementation of the updated model in supporting students' real-world learning and teachers' professional learning for greening of curriculum were further identified. From this perspective, this model can also be argued to contribute to addressing the pedagogical issues in sustainability education (e.g. effective teaching and learning that leads to behavior change) and driving the pedagogical changes from classroom practice.

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Appendix A: Classroom observation Checklist 1– Impact on learning outcome: focus group observation

1. Please tick the targeted items before your observation.

2. During your observation, write down the observable elements that can demonstrate the development of the identified skills.

3. At the end of the observation, please use **Limited =1, Moderate =2, Fully Present =3** to describe the development of each identified items.

Generic Green skills	**Specific items**	**To what extent**			**List the observable and quantifiable elements that demonstrate the items**
Cognitive competencies	☐ Environmental awareness and a willingness to learn about sustainable development	1	2	3	
	☐ Systems and risk analysis, skills to assess, interpret and understand both the need for change and the measures required	1	2	3	
	☐ Innovation skills to identify opportunities and create new strategies to respond to green challenges	1	2	3	
	☐ Understanding complexity and interconnectivity of sustainable development issues and challenges	1	2	3	
	☐ Identifying ways of how to be a part of the solution	1	2	3	
	☐ Ability to think about things differently				
	☐ Awareness of the habits in what you do and think	1	2	3	
	☐ Ability to make judgments based on evidences and sustainability values				
Intrapersonal competencies	☐ Adaptability and transferable skills to enable workers to learn and apply the new technologies and processes required to green their jobs	1	2	3	
	☐ Entrepreneurial skills to seize the opportunities of low-carbon technologies	1	2	3	

Interpersonal skills	☐ Strategic and leadership skills to enable policymakers and business executives to set the right incentives and create conditions conducive to cleaner production, cleaner transportation, etc. ☐ Coordination, management and business skills to facilitate holistic and interdisciplinary approaches that encompass economic, social and ecological objectives ☐ Communication and negotiation skills to discuss conflicting interests in complex contexts ☐ Marketing skills to promote greener products and services ☐ Networking, IT and language skills to enable participation in global markets Consulting skills to advise consumers about green solutions and to spread the use of green technologies ☐ Consulting skills to advise consumers about green solutions and to spread the use of green technologies	1	2	3	
		1	2	3	
		1	2	3	
		1	2	3	
		1	2	3	
Technological skills	☐ Quantification and monitoring (waste, energy, water) ☐ Management systems (waste, energy, water) ☐ Procurement and selection ☐ Material use and impact quantification ☐ Impact and use minimization ☐ Impact assessment ☐ Risk management	1	2	3	
		1	2	3	
		1	2	3	

Appendix B: Classroom observation Checklist 2 - Teachers' pedagogical practice and students' engagement

Learning Phases	Pedagogical Strategies	Learning Activities	List the observable and quantifiable elements that demonstrate teachers' interaction with students & students' engagement
Bringing the world in	☐ Problem-oriented ☐ Lecturing ☐ Discussion Others:	☐ Draw a concept map; ☐ Analyze the critical incidents (e.g. compare different solutions). Others:	
Simulating the world	☐ Project-based learning ☐ Stimulus activities ☐ Discussion ☐ Debates ☐ Critical incident Others:	☐ Reflection on related videos, photos and document ☐ Peer-review activities Others:	
Visiting the world	☐ Project-based learning ☐ Discussion ☐ Case study ☐ Reflexive accounts Others:	☐ Small group work ☐ Group presentation Others:	
Engaging with the world	☐ Project-based learning ☐ Group project ☐ Field trip Others:	☐ Interview ☐ Questionnaire ☐ Field- observation Others:	

Appendix C: Teachers' standards specific for greening curriculum

Standard	Focus area	Proficiency
Professional knowledge	Content and teaching strategies	Demonstrate knowledge and understanding of the SD concepts that form the basis for greening curriculum. Demonstrate understanding of generic green skills and their role in greening curriculum and in development of students' green mindset and generic competencies in the context of greening Demonstrate knowledge and understanding of student-centered strategies that can support active students engagement into learning about greening
	Content selection and organization	Organize concepts into themes or modules to be taught across different subjects or as a separate subject. Organize content in a logical sequence to achieve effective learning and teaching
	Curriculum assessment and reporting	Design and implement teaching related to greening effectively; use assessment as a tool for learning and a way to provide a feedback for students. Implement assessment that is aimed to evaluate students' thinking capacity, ability to find innovative solutions to problems, explore, debate, etc.
Professional practice	Establish challenging learning goals	Set clear learning goals (challenging but achievable) for all students for each learning activity that explore SD concepts, industry-based case-studies and others
	Plan, structure and sequence learning programs	Plan each activity within or across several lessons, at a workplace or extra-curricula in a coherent and structured way to effectively engage students.
	Use teaching strategies	Choose and apply variety of teaching strategies, use effectively student-centered strategies to engage students in critical thinking, problem-solving and innovation within the context of

		greening
	Develop, select and use resources	Select and design resources that are appropriate for your institutional context and industry greening practices in your region/country
Professional engagement	Identify and plan professional learning needs	Demonstrate an understanding of the areas in relation to SD concepts that they need to address in their professional development
	Engage in professional learning and improve practice	Understand and identify sources for professional learning in relation to greening curriculum
	Engage with professional teaching n etworks and broader community	Understand the importance of external professional networks and actively participate in networks and forums to broaden knowledge in relation to greening curriculum and improve practice

Source: **Teachers' standards specific for greening curriculum"** proposed in *UNESCO-UNEVOC resource guide for teachers: Embedding greening skills in classroom instruction* (Pavlova, 2019)

Appendix D: Questionnaire for the teachers' self-evaluation on competency enhancement

Title: The design and effective implementation of greening the curriculum: self-evaluation survey

Background and aims

This survey is part of a PhD study that aims to establish the effective implementation of a generic green module designed to develop students' generic green skills.

The survey is designed to collect data to understand **the impact** of your implementation of resources with the researcher in your classroom, as well as your **understanding and practice** of developing students' generic green skills.

This survey was developed based on the *Teacher competency framework specific for greening curriculum* (Pavlova, 2019). Please rate the competencies listed below **before** you implement the resources and **after** you have implemented them with the researcher in your class.

On a scale of 1 to 5, **5 refers to "very proficient"**, and **1 refers to "not at all proficient**".

It will take less than 10 minutes to finish. Thank you very much in advance for your support!

Section 1: Professional knowledge

1. In terms of the content and teaching strategies, I can demonstrate knowledge and understanding of:

1) **The sustainable development concepts** that form the basis of greening the curriculum.

Before: 1 2 3 4 5

After: 1 2 3 4 5

2) **Generic green skills** and their role in developing students' green mindset and their generic competencies in the context of greening.

Before: 1 2 3 4 5

After: 1 2 3 4 5

3) **Student-centered strategies** that can support students' active engagement in terms of learning about greening.

Before: 1 2 3 4 5

After: 1 2 3 4 5

2. In terms of content selection and organization, I can:

1) Organize **SD related concepts** into themes or modules that can be taught across different subjects, or as a separate subject.

Before: 1 2 3 4 5

After: 1 2 3 4 5

2) Organize **content in a logical sequence** to achieve effective learning and teaching.

Before: 1 2 3 4 5

After: 1 2 3 4 5

3. In terms of curriculum assessment and reporting, I can:

1) **Effectively design and implement teaching** related to greening.

Before: 1 2 3 4 5

After: 1 2 3 4 5

2) Use assessment as a tool and means of **providing feedback** to students about their generic green skills development.

Before: 1 2 3 4 5

After: 1 2 3 4 5

3) Implement assessment that is aimed to **evaluate students' competencies** (knowledge, values and attitudes) about finding innovative solutions to problems, exploration, debate, etc.

Before: 1 2 3 4 5

After: 1 2 3 4 5

Section 2: Professional practice

1. In terms of establishing learning goals, I can:

Set clear learning goals (that are challenging, but achievable) for all students, for each learning activity that explores SD concepts, industry-based case studies and others.

Before: 1 2 3 4 5

After: 1 2 3 4 5

2. In terms of planning, structuring and sequencing learning programs for generic green skills development, I can:

Plan each activity within, or across, several lessons, at **a workplace-based or real world problem-based or extra-curricula setting** in a coherent and structured way to effectively engage students.

Before: 1 2 3 4 5

After: 1 2 3 4 5

3. In terms of teaching strategies, I can:

Choose and apply a variety of **teaching strategies based on a student-centered** approach to engage students in critical thinking, problem solving and innovation in the context of greening.

Before: 1 2 3 4 5

After: 1 2 3 4 5

4. In terms of developing, selecting and using resources, I can:

Select and design resources that are appropriate for my institutional context, including the **practices of greening industry** in my region/country.

Section 3: Professional engagement

Before: 1 2 3 4 5

After: 1 2 3 4 5

Section 3: Professional engagement

In terms of identifying and planning professional learning needs, I can:

1. Demonstrate an understanding of **the areas in relation to the SD concepts that needed to be addressed** in my professional development.

Before: 1 2 3 4 5

After: 1 2 3 4 5

2. In terms of engaging in professional learning to improve my practice, I can:

Understand and identify **sources for professional learning** in relation to greening the curriculum.

Before: 1 2 3 4 5

After: 1 2 3 4 5

3. In terms of engaging with professional teaching networks and the broader community, I can:

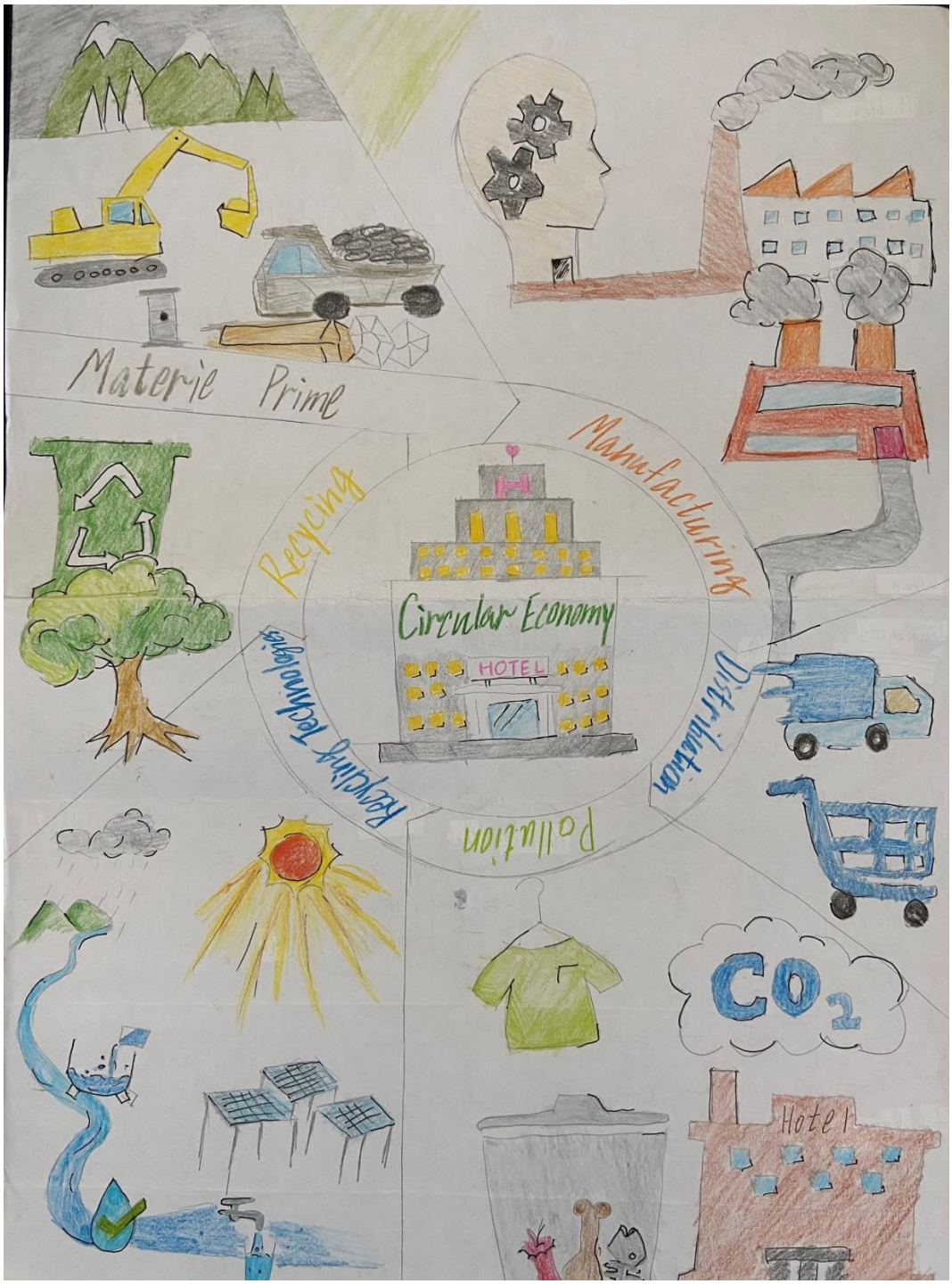
Understand the importance of **external professional networks** and actively participate in networks and forums to broaden my knowledge in relation to greening the curriculum and improving my practice.

Before: 1 2 3 4 5

After: 1 2 3 4 5

Source: Adjusted based on M. Pavlova (2019). *UNESCO-UNEVOC Resource Guide for Teachers: Embedding Green Skills in Classroom Instruction*. Unpublished report

Appendix E: The sample of the students' assignment



Study target : Hotel Industry

Waste Issue :

i) Materie Prime

When we build a hotel → need a lot of concrete / extract minerals → break the balance of nature.

ii) Manufacturing

When industry produce the important products to hotels
e.g. Uniforms , raw material of food
↳ produce CO_2 / green house gas

iii) Distribution

When industry try to deliver the raw material to hotels, the cars / other transport will produce CO_2. ↑ pollution

iv) Pollution

Hotel → old cloths (Always X recycle) ↳ keep a good image, food waste (X recycle) because of the image of hotel, electrical waste (Make customer be more comfortable)

Strategies

i) Recycling Technologies

1. Solar panel
2. Rainwater recycling system

∴ using renewable energy
∴ decrease the waste of coal / natural gas → ↓ greenhouse gas / Exhaust gas

ii) Recycling

1. Organic fertilizers

↳ use food waste → machining → fertilizers → plant more trees → greening
↳ ↑ CO_2 decomposer → benefit the quality of air of the city / environment.

2. Recycling bin

Uniform waste → Used Cloths Collection Bin → ↓ stress of landfill

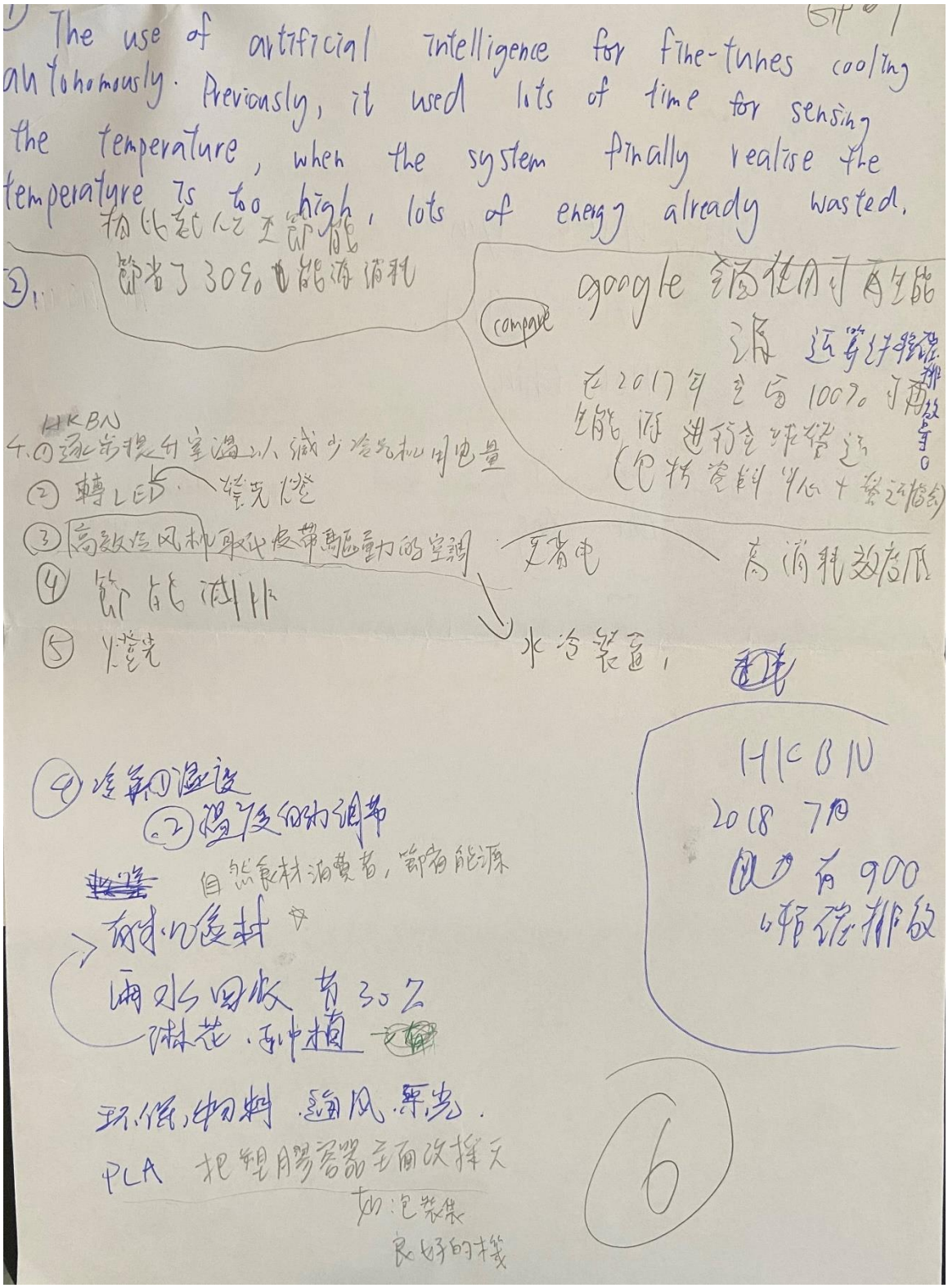
ENV3001 - Assignment 1

Group 3

Fung Lok Ying (18025197)
Lee Wing Yan (18028288)
Yau Chi Ho (18086080)
Li Yu Ki (18032050)
Lai Chun Lok (18009189)
Chu Ching Ki (18013247)

5

Appendix F: The sample of students' sample group discussion memos



Appendix G: Survey for improving the resources: Including generic green skills into TVET curriculum

Survey for improving the resources: Including generic green skills into TVET curriculum

This survey aimed at exploring how TVET educators perceive the resources developed for students' generic green skills development and also TVET teachers training.

Your feedback will be treated with confidentiality and will not be used for any other purpose other than that stated above

Section 1: Perception of the resources for students' generic green skills development

1. **To what extent do you think the resources can enrich your classroom practice in terms of pedagogy?**

1) Information sheet for concept understanding

1 2 3 4 5

2) Case study for concept application

1 2 3 4 5

3) Student worksheet for the case study

1 2 3 4 5

4) Teacher guidelines

1 2 3 4 5

2. To what extent do you think our resources can support you in terms of preparation for a lesson?

1) Saving time

1 2 3 4 5

2) Providing good ideas for your own resource development

1 2 3 4 5

3) Providing opportunities to learn about different concepts yourself

1 2 3 4 5

3. Which type of the resources will be mostly useful in lesson preparation?

1) Information sheet for concept understanding

1 2 3 4 5

2) Case study for concept application

1 2 3 4 5

3) Student worksheet

1 2 3 4 5

4) Teacher guidelines

1 2 3 4 5

4. To what extent do you think the resources can facilitate student to transform the learning from knowledge acquisition to knowledge application?

1 2 3 4 5

5. To what extent do you think the resources can help to develop students' attitude toward green practice?

1 2 3 4 5

6. To what extent do you think the resources can help to develop students' generic green skills?

1) Cognitive competence

1 2 3 4 5

2) Interpersonal skills

1 2 3 4 5

3) Intrapersonal competence

1 2 3 4 5

4) Technological skills

1 2 3 4 5

7. To what extent do you think the resources can help to influence students' behavior change toward sustainable practice?

1 2 3 4 5

Section 2: Teaching and learning

1. To what extent do you think the identified concepts can be integrated into your module/course?

1 2 3 4 5

2. To what extent do you think students will be interested in the case study developed for Green technology?

1 2 3 4 5

3. To what extent do you think students are interested in the learning activities developed for Green technology's case study?

1 2 3 4 5

4. To what extent do you think the interactive pedagogical approaches can be implemented in your classroom practice? For example, industry-based learning, real world problem solving outside and inside the classroom.

1 2 3 4 5

5. To what extent do you think you can effectively conduct the activities based on the teacher guidelines?

1 2 3 4 5

6. To what extent do you think students can understand how to engage in the activities based on the student worksheet?

1 2 3 4 5

Section 3: Others

1. Would you be interested in trying out our resources in your institute?

2. Would you like to implement the teacher training program for using and developing resources based on local context?

If yes, please leave us your contact, we will be very happy to share our resources with you, and cooperatively improve and further develop the resource

Appendix H: The concept information sheet for "Green Technology"

The name of the concept: Green technology	
Sustainable development goals (SDGs)	Goal 9: Industry, innovation and infrastructure Goal 11: Sustainable cities and communities Goal 7: Affordable and clean energy
1. Definition	Green technology is a 'type of technology which is **environmentally friendly**'. Its main purpose is to conserve nature, tackle problems associated with the depletion of natural resources, and to cure the negative impact of human activities, such as pollution and environmental degradation. The term 'green technology' is also known as **'environmental technology'** and **'clean technology'**. It includes various elements ranging from **renewable energy and power storage, smart buildings innovations, green living technology, to smart transportation and mobility, waste management and recycling and other (**Dasy, 2016; Babbitt, 2017**)**.
2. Goals/ principles/ models related to the concept	**2.1 Criteria of Green Technology** 1) It minimizes the degradation of the environment; 2) It has zero or low greenhouse gas (GHG) emission, is safe for use and promotes healthy and improved environments for all forms of life; 3) It conserves the use of energy and natural resources; 4) It promotes the use of renewable resources. (Bhardwaj & Neelam, 2015) **2. 2 Business goals of green technology** **1) Sustainability Goals** The systematic shift from short-term gain, which depletes natural resources, to the long-term prosperity of future generations. This kind of shift should be the mindset for a lot of organizations. **2) Product Life Cycle Goals** Performing life cycle evaluations can put an end to the 'cradle-to-grave' cycle of production, especially in relation to manufacturing. Products can be manufactured utilizing a life cycle evaluation to initiate 'cradle-to-cradle' cycles so that products can be reused/recycled at the end of their life. **3) Product Efficiency Goals** Decreasing pollution, waste and resource consumption during the manufacturing process at various stages. This may also involve making post-production more efficient by diminishing the impact of shipping, for example. **4) Closed-Loop Innovation** Technology controlled 'smart systems' monitor the consumption of resources and the management of waste, which close the loop for products, components and materials to

	promote resource efficiency. Remanufacturing, re-use and recycling approaches entail a multiple-times value creation which includes sustaining value beyond the original new product life cycle (Iravani, Akbari & Zohoori, 2017)
3. Application in daily life	**3.1 e-Technology** Email, online shopping, e-bills and e-payments, e-readers **3.2 Equipment** LED monitors, solar chargers, solar cells **3.3 Electronic Equipment Recycling** Computers, smart phones
4. Application in specific industries	**Link to Case studies in different sectors** **4.1 Construction sector:** Green buildings (Case 1: Hong Kong Science Park, Case 2: Zero Carbon Building, Case 3: Towngas Headquarters) **4.2 Energy sector:** Alternative energy use in data centers
5. Description of the related issues	**5.1 Green Building** Today, as industrial manufacturing is no longer the main economic activity in Hong Kong, the major source of electricity consumption is from buildings like housing estates, offices and malls. **Building-related activities account for around 90 percent of Hong Kong's total electricity consumption**, compared to a global average of 40 percent. In turn, this high level of energy consumption from buildings **accounts for 60 percent of the city's greenhouse gas emissions**. Therefore, green buildings play a crucial role in achieving energy savings in Hong Kong, and are also a global target set by the Paris Agreement 2015. **5.1.1 What is a green building?** A green building, also known as a sustainable building, is a structure that is **designed, built, renovated, operated or reused in an ecological and resource-efficient manner**. **Natural ventilation, natural daylight and rooftop gardening** are features designed to reduce the energy consumption from air-conditioning, ventilation and lighting systems, thus cutting greenhouse gas emissions (GHGs). Reducing reliance on non-renewable energy sources like traditional fossil fuels, such as oil, gas and coal, is one of the most common features of green buildings. These traditional energy sources release greenhouse gases and pollutants into the environment and accelerate global warming. Since green buildings are **designed with energy saving measures**, such as the **use of renewable energy sources** (e.g. solar, wind, hydro and geothermal energy), they can significantly reduce negative impacts on the environment. **5.1.2 What are the standards of green building in Hong Kong and in Mainland China?** **Standards of green building in Hong Kong:** 1) BEAM Plus **New Buildings** covers the demolition, planning, design, construction and commissioning of a new building project. The standard can also be applied to major renovations, alterations and additions.

	• **Site aspects** • **Materials aspects** • **Energy use** • **Water use** • **Indoor environmental quality** • **Innovations and additions** 2) BEAM Plus **Existing Buildings** measures the actual performance of a building and evaluates its facility management practices. The assessment covers all aspects of management, operation and maintenance and may be initiated at any time during a building's operational life. • **Site aspects** • **Management** • **Materials and waste aspects** • **Energy use** • **Water use** • **Indoor environmental quality** • **Innovations and additions** 3) BEAM Plus **Interiors** covers the design and construction of fit-out, renovation and refurbishment works in non-domestic, occupied spaces. • **Green building attributes** • **Management** • **Materials aspects** • **Energy use** • **Water use** • **Indoor environmental quality** • **Innovations and additions** 4) BEAM Plus **Neighbourhood** adopts a more holistic approach to assessing sustainability performance at the early, or inception, stage of a development project. It helps establish a broader framework of urban sustainability to enable the smoother implementation of the principles in later development stages. The tool relates to the design of space between buildings and focuses on the **socio-economic elements** of a development**.** • **Community attributes** • **Outdoor environmental quality** • **Site aspects** • **Materials and waste aspects** • **Energy use** • **Water use**

	• **Innovations and additions** **Standard of green building in Mainland China:** The Three-Star evaluation system has two different standards: one for **residential buildings** and one for **public (i.e. large commercial) buildings**. This standard can also serve as a reference for the evaluation of other buildings. The evaluation standard rates buildings according to a variety of prerequisites (called 'control items' in the Chinese system) and credits (called 'general items' in the Chinese system) in **six categories**: **1) Land savings and outdoor environment** **2) Energy savings** **3) Water savings** **4) Materials savings** **5) Indoor environmental quality** **6) Operations and management** A seventh category called 'Preference items' contains strategies that are both cutting edge and harder to implement, such as brownfield redevelopment, more than 10 percent on-site renewable power generation, etc. The China green building system grants three levels of ratings: one-star, two-star, and three-star, hence the nickname 'Three-Star System'. The numbers of items required for the particular level of assessment of residential buildings and public buildings are shown in Table 1 and Table 2 respectively. For both residential and public buildings, controlled items are mandatory. All the mandatory items should be first completed then building can go through an evaluation process for rating. General items and preference items are optional conditions for classifying green buildings into the three levels. The total amount of various general and preference items used in one building is the maximum result that this building can obtain.. The star level is decided by the minimum number of each component, not the total numbers satisfied (Geng et al., 2012). Table 1 Item Requirement for Grade Classification of Green Building (Residential Building)

Grade	General Items (Total: 40 Items)						Preference Items (Total: 9 Items)
	Land Saving & Outdoor Environment (Total: 8 items)	Energy Saving & Energy Utilization (Total: 6 Items)	Water Saving & Water Resource Utilization (Total: 6 Items)	Material Saving & Material Resource Utilization (Total: 7 Items)	Indoor Environment Quality (Total: 6 Items)	Operating Management (Total: 7 Items)	
★	4	2	3	3	2	4	-
★★	5	3	4	4	3	5	3
★★★	6	4	5	5	4	6	5

Table 2 Item Requirement for Grade Classification of Green Building (Public Building)

Grade	General Items (Total: 43 Items)						Preference Items (Total: 14 Items)
	Land Saving & Outdoor Environment (Total: 6 items)	Energy Saving & Energy Utilization (Total: 10 Items)	Water Saving & Water Resource Utilization (Total: 6 Items)	Material Saving & Material Resource Utilization (Total: 8 Items)	Indoor Environment Quality (Total: 6 Items)	Operating Management (Total: 7 Items)	
★	3	4	3	5	3	4	-
★★	4	6	4	6	4	5	6
★★★	5	8	5	7	5	6	10

5.2 Renewable Energy

More renewables in Hong Kong - the idea sounds a bit implausible. Hong Kong is a small, densely populated territory with a large electricity habit. Renewables suck in subsidies, take up space and don't produce very much electricity – and when they do, it's at unpredictable times.

But, is it really such a bad idea? In last year's fuel-mix consultation, the government estimated that the price of electricity in Hong Kong was set to almost double, as we invest in a gas generation plant, and replace cheap coal with expensive gas. This will bring our power prices more in line with countries that are putting restrictions on coal use. Recent overseas experience suggests that renewable energy, in the right policy environment, gets cheaper as it matures. Prices of onshore wind in Brazil and Europe are now similar to those of fossil fuels; the price of large-scale solar power in Britain's recent power auction was just 25 percent more than its gas-fired electricity.

	Here in Hong Kong, solar output is wonderfully punctual, peaking just when we need it, on hot summer days. Also, renewables are an insurance policy against volatile fossil fuel prices. Over the past decade, natural gas prices in Asia have quadrupled. The government last examined renewable electricity in 2002. According to its first-phase report on the potential applications of renewable energy in Hong Kong, our city could meet 17 percent of its electricity demand if a proportion of developed land and open space (roads and airports) had solar panels installed. A further seven percent of the electricity demand could be met by 1,000 well-situated wind turbines. However, the report concludes that the scope for growth is limited - perhaps reaching two percent in 2017, and three percent by 2022. But these numbers now seem out of date. In response to the call for greener energy and rapid world development, CLP Power is investigating the feasibility of a 200MW offshore wind farm in Hong Kong's southeastern waters. HK Electric has also looked into offshore wind farms. Clearly, it's time for the government to update its analysis about the potential for renewables. The scheme of control agreements, inked between the government and the city's two power suppliers, were developed with fossil fuels in mind. The power companies are rewarded on how many assets they build. Altering it for renewables might not be the most effective way to start. In the last agreement, the government encouraged the power companies to switch to renewables by providing an extra one percent in their permitted rate of return in exchange for investment in these alternative sources, but progress has been uninspiring. Only about 0.1 percent of the power they generate is from renewables. Other places do not pay a return on how much capital is invested. Renewable developers compete against, or join with, energy companies to produce renewable electricity. They are rewarded through a predictable and usually subsidized price for the power they produce. The price paid to generators of renewable energy in Europe is around HK$0.70 per kWh. This compares with the retail price we pay for electricity in Hong Kong of around HK$1.10 per kWh. One of the biggest obstacles to promoting renewable energy development is for outsider developers to access the power grid, the route to the market. Hong Kong has no law to regulate prices and contract terms for this. **Source:** Wong, G. (2015). *Hong Kong needs to switch on to renewable energy*. [online] South China Morning Post.
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Source: The developed ESD resources (Pavlova, Chen & Saral, Manuscript in preparation)

Appendix I: Industry-based framework of the developed ESD resources

INDUSTRY	Concept Name	Case Name	SDGs
Agri- and aquaculture	Biodiversity	Agriculture in India	SDG 15 SDG 11
		Organic agriculture in Hong Kong	SDG 15 SDG 11
	Marine resources	Overfishing in Hong Kong	SDG 14 SDG 12
Transportation	Air quality	Roadside and maritime emissions	SDG 11 SDG 7
	Social enterprise	Riders for health in Africa	SDG 8 SDG 11
	Ecological footprint	Biking in the Philippines	SDG 12 SDG 11
		Car Sharing initiative at Cornell University (USA)	SDG 12 SDG 11
	Sustainable innovation	Clean air – SMOG FREE PROJECT	SDG 9 SDG 11
Waste management	Water resources and water pollution	Wastewater treatment in Hong Kong	SDG 6 SDG 12
	Closed-loop economy	Sludge treatment in T. Park	SDG 7 SDG 9 SDG 12
		How sustainable fashion contributes to the closed-loop economy	SDG 9 SDG 12

	Waste management	Hong Kong's awareness on waste management	SDG 12 SDG 15 SDG 11
	Land contamination	WEEE. PARK	SDG 11 SDG 15
Manufacturing	Water resources and water pollution	Textile waste water	SDG 6 SDG 12
	Sustainable consumption	Wood-based fibers could lead sustainable fashion out of the woods	SDG 12 SDG 14 SDG 15
	Sustainable innovation	Clean air – SMOG FREE PROJECT	SDG 9 SDG 11
Public administration	Water management	Water politics	SDG 6 SDG 15
	Quality of life and economic indicators	Quality of life in economic development and the case of Hong Kong "from an expat point of view"	SDG 8 SDG 11
	Environmental justice and law	How the carbon trading scheme worked in China	SDG 16 SDG 9
	Carbon cycle and climate change/global warming	Reduction in CO^2 emission in Sweden	SDG 13 SDG 11
	Sustainable development	National policy on the environment for greening the economy in Malaysia	SDG 11
Renewable Energy	Marine resources	Marine renewable energy	SDG 14 SDG 9
	Renewable energy	Renewable Energy Example 1: Iceland	SDG 7 SDG 9

		Example 2: Hong Kong	
	Green technology	How much energy do data centers use?	SDG 9 SDG 11 SDG 7
Knowledge Sector	Corporate social responsibility	How Hong Kong's CSR experience can enhance the success of Belt and Road initiative	SDG 8 SDG 11 SDG 12
	Urban heating	Urban heating in Hong Kong	SDG 11 SDG 13
Construction	Urban heating	Cooling Singapore	SDG 11 SDG 13
	Green technology	Green buildings Example 1: Hong Kong Science Park Example 2: Zero Carbon Building Example 3: Town Gas Headquarters	SDG 9 SDG 11 SDG 7
	Sustainable innovation	Clean air – SMOG FREE PROJECT	SDG 9 SDG 11
	Energy conservation and efficiency	Energy efficient building designs and materials	SDG 7 SDG 12 SDG 13
Retail	Sustainable innovation	Over packaging in retail sector: Can "AirCarbon" help	SDG 8 SDG 9
Hotel Industry	Sustainable development	Greening of the hotel industry in Singapore	SDG 11

Source: Industry-based framework of the developed ESD resources (Pavlova, Chen & Saral, Manuscript in preparation)

Appendix J: Student Worksheet for Group Project – Urban innovation for reducing the greenhouse gas (GHS) in Hong Kong

Student Worksheet for Group Project – Urban innovation for reducing the greenhouse gas (GHS) in Hong Kong	
Sustainable Development Goals	Goal 9: Industry, innovation and infrastructure Goal 11: Sustainable city and community
Generic Green Skills	**Transpersonal Competencies** - Adaptability and transferable skills that help workers learn and apply the new technologies and processes required to green their jobs. **Interpersonal Skills -** Strategic and leadership skills to enable policymakers and business executives to set the right incentives and create conditions conducive to cleaner production, cleaner transportation, etc.
Learning Objective	**You will be able to:** Identify **problems related to climate change & global warming** in Hong Kong. Explore the identified problems and the solutions to deal with it. Adapt the solutions provided in case studies for solving the identified problems.
Module Intended Learning Outcome	1. State and explain some of the environmental and sustainability problems we are facing. 2. Suggest ways to deal with the environmental and sustainability problems with reference to previous/existing studies. 3. Evaluate a product, service or proposal from environmental point of view under given criteria/procedures. 4. Practice environmental considerations in a given workplace and daily living environment.
Format	Individual learning with group discussion
Assessment	**You will be assessed based on:** 1. The **group work**: a final proposal; 2. Your **personal contribution** in developing and writing up this proposal.
Student Activities: **You need to:** Select **ONE case study below** for your **EA Group Project**. Clear air: SMOG FREE PROJECT AirCarbon technology: "Air + Greenhouse Gas= PLASTIC" Carefully read the **case study 1 and 2** and understand **how sustainable innovation can contribute to urban sustainability.** Think about **what are the urgent urban issues cause by climate change & global warming in Hong Kong** such as air quality, urban heating, marine resource and **how do they influence the sustainability** of Hong Kong. You are required to prepare at least two issues to discuss with your group mates.	

During the group discussion:

1. List all the issues identified by all your group mates and brainstorm the negative environmental impacts of them.

The urgent urban issues in Hong Kong	How do they influence the sustainability of Hong Kong? List the **negative environmental impacts**.

2. Formulate a group project, <u>6 students per group</u>.

3. Discuss in group and pick up one issue as the group project.

4. Make a project plan refer to the following requirements.

Time	**Tasks**
Week 3-4	**Define the identified sustainability issue.** Why it is a sustainability issue how it influence environmental, social and economic development? You should include data provided by relevant study, news or database, or collect data by yourself through interview or simple survey. You are suggested **write a summary (around 500 words)**.
Week 4-5	**Explore how relevant sectors respond to the issues?** You should try to understand people's view (needs for improvement) about the issues from different perspectives. You can search relevant news and reports online, however you are more encouraged to go to the real world (e.g. community, workplace, campus) to ask people how do they think about the issue? You are suggested to use the **mind mapping** to present your finding.
Week 5-6	**Explore the potential solutions for the issue.** You are required to **<u>refer to the solutions provided by two successful cases</u>** 1) the "Clear air: SMOG FREE PROJECT"; 2) "AirCarbon technology: "Air + Greenhouse Gas= PLASTIC", and **think about how to adjust it to Hong Kong context**. **Specify your solutions with some graphs to illustrate how it works? You are required to justify how these solutions can help to improve the identified urban sustainability issue.**
Week 6-7	**1. Draft the proposal to specify** how to implement the solutions that can help to solve the identified urban sustainability problem. **2. Ask for comments** from classmates or teachers**.**
Week 8	**Finalize the proposal according to the comments and submit it on time. Suggested word count: 2000-2500.**

Ps: The proposal format provided below is **a business proposal**, which just for your reference, you can adjust it as needed. For more guideline about how to write a proposal you can also refer to the website list below:

https://www.nyu.edu/content/dam/nyu/research/documents/Contracts/guidelinesforscopeofwork.pdf

https://ccspd.org.uic.edu/files/2017/02/CCSPD-Proposal-Form.pdf

https://www.process.st/how-to-write-a-proposal/

SUGGESTED CONTENT FOR PROJECT PROPOSAL

I. Summary
II. Introduction
III. Needs/Problems
IV. Goals/Objectives
V. Procedures/Scope of Work
VI. Timetable
VII. Budget
VIII. Key Personnel
IX. Evaluation
X. Endorsements
XI. Next Steps
XII. Appendix

Summary

This section should include information for those readers who will not read the entire document but who will need a summary of the proposal. Although this section appears first in the document, it is usually written last.

The summary should remain on a separate page and not exceed one page.

The summary should contain the following elements:

- Brief identification and purpose of your organization
- The purpose and anticipated end result of this proposal
- The type and amount of support requested
- The total anticipated budget
- Other information you deem pertinent

Introduction

Introduce your organization here.

It is best to begin by explaining how and why your organization was founded. It is also a good idea to provide a mission statement so that your readers know who you are and what you do.

Your introduction can include information such as the purpose of your organization, a description of its activities, a description of its target population, and evidence to show that it is a healthy organization.

Needs/Problems

Identify the needs or problems to be addressed. Include the target population and any statistical information that you may have. Ideas for information to include here are:

- Length of time needs/problems have existed
- Whether problem has ever been addressed before, and what the outcome was
- Impact of problem to target population
- Impact of problem to surrounding populations

Goals/Objectives

State the desired goals and objectives to address the needs/problems stated above. Also include key benefits of reaching goals/objectives.

- Specific & measurable goal 1
- Specific & measurable goal 2
- Specific & measurable goal 3

Procedures/Scope of Work

Provide detailed information about proposed procedures, if available, and the scope of work. Include information on activities such as recruiting, training, testing, and actual work required.

Timetable

Provide detailed information on the expected timetable for the project. Break the project into phases, and provide a schedule for each phase.

	Description of Work	Start and End Dates
Phase One		
Phase Two		
Phase Three		

Provide detailed information on the activities needed for the project. Break the activates into specific

implementation time and responsibility. Please refer to the sample below:

ACTIVITY	IMPLEMENTATION TIME			RESPONSIBILITY
1. Design and implement training program for the proposed solution	Month 1	Month 2	Month 3	Program Manager (PM)
	XXXX			
1.1 Conduct needs assessment		XXXX		Consultant
1.2 Design training modules			XXXX	Consultant
1.3 Conduct training			XXXX	Consultant
2. Project pilot	XXXXX	XXXX	XXXX	Program Manager
2.1 Data collection		XXXX		Project researcher
2.2 Assessing effectiveness			XXXX	Environmental department

Budget

State the proposed costs and budget of the project. Also include information on how you intend to manage the budget.

Description of Work		Start and End Dates
Phase One		
Phase Two		
Phase Three		
	Total	**$ 0.00**

Key Personnel

List the key personnel who will be responsible for completion of the project, as well as other personnel involved in the project.

Client	[name]
Sponsor	[name]
Project manager	[name]
Team	[name], [name], [name], [name]

Evaluation

Discuss how progress will be evaluated throughout and at the end of the project.

– Formulate clear indicators for each objective and result

– Indicate how and when to conduct monitoring and evaluation activities to determine project's progress and outcome

– State which methods will be used to monitor and evaluate the project

– Identify who will carry out the project evaluation.

Endorsements

Provide the names and addresses of individuals and companies who support and endorse the project.

Next Steps

Specify the actions required of the readers of this document.

- Next Step 1
- Next Step 2
- Next Step 3

Appendix

Provide supporting material for your proposal here. It may be:

Company history

Research materials

Statistics or estimates

External quotes or tenders

Detailed cost / benefit spreadsheets

Other relevant information or correspondence.

[Name], Project Client	[Name], Project Sponsor	[Name], Project Manager
Date: _____	Date: _____	Date: _____

References:

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Source: The developed ESD resources (Pavlova, Chen & Saral, Manuscript in preparation)

Appendix K: Rubric for Mini-Project report assessment (Specific for Generic Green Skills Assessment)

RUBRIC FOR MINI-PROJECT REPORT ASSESSMENT (Specific for Generic Green Skills Assessment)

10-9 marks (Grade A)	*8-7 marks (Grade B)*	*6-5 marks (Grade C)*	*4-3 marks (Grade D)*	*2-1 marks (Grade F)*	***Mark***
• *Students **sufficiently reflect on** the identified sustainability problems referring to their industrial experience /individual life*	• *Students **considerably** reflect on the identified sustainability problems referring to their industrial experience/ individual life*	• *Students **basically** reflect on the identified sustainability problems referring to their industrial experience /individual life*	• *Students **less** reflect on the identified sustainability problems referring to their industrial experience/ individual life*	• *Students **insufficiently** reflect on the identified sustainability problems referring to their industrial experience/ individual life*	
• *Students proposed **very innovative** solutions/ strategies to response to the sustainability issues.*	• *Students proposed **innovative** solutions/ strategies to response to the sustainability issues.*	• *Students proposed solutions/ strategies to response to the sustainability issues with **a few innovations**.*	• *Students proposed solutions/ strategies to response to the sustainability issues with **less innovation.***	• *Students proposed solutions/ strategies to response to the sustainability issues **with very limited innovations**.*	
• *Students analyzed the cause and effect of the identified sustainability problems in relation to different stakeholders and proposed **very effective** strategies to enable them to response to the green challenges.*	• *Students analyzed the cause and effect of the identified sustainability problems in relation to different stakeholders and proposed **effective** strategies to enable them to response to the green challenges.*	• *Students analyzed the cause and effect of the identified sustainability problems in relation to different stakeholders and proposed **basically effective** strategies to enable them to response to the green challenges.*	• *Students analyzed the cause and effect of the identified sustainability problems in relation to different stakeholders and proposed **less effective** strategies to enable them to response to the green challenges.*	• *Students analyzed the cause and effect of the identified sustainability problems in relation to different stakeholders and propose **ineffective** strategies to enable them to response to the green challenges.*	
• *Students specify **strikingly clear** on how to adjust and promote/implement the solutions (e.g. greening concepts and technologies) based on local context.*	• *Students specify **clearly** on how to adjust and promote/implement the solutions (e.g. greening concepts and technologies) based on local context.*	• *Students specify **basically clear** on how to adjust and promote/implement the solutions (e.g. greening concepts and technologies) based on local context.*	• *Students specify **relatively unclear** on how to adjust and promote/implement the solutions (e.g. greening concepts and technologies) based on local context.*	• *Students specify **unclear** on how to adjust and promote/implement the solutions (e.g. greening concepts and technologies) based on local context.*	
• *Students propose technological solutions to real world problems and justify how the proposed technologies help to solve the identified problems with **very sufficient evidences.***	• *Students propose technological solutions to real world problems and justify how the proposed technologies help to solve the identified problems with **sufficient evidences**.*	• *Students propose technological solutions to real world problems and justify how the proposed technologies help to solve the identified problems with **a few evidences.***	• *Students propose technological solutions to real world problems and justify how the proposed technologies help to solve the identified problems with **little evidences.***	• *Students propose technological solutions to real world problems and justify how the proposed technologies help to solve the identified problems with **very little evidences.***	