CLASSROOM STRATEGY USING CONSTRUCTIVIST APPROACH FOR TEACHING-LEARNING SUSTAINABILITY CONCEPTS IN A UNIVERSITY CONSTRUCTION COURSE

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DEDICATION

To my husband, Meeftah, for always being supportive and understanding.

To my daughter, Farah Izzati, for always believing and caring.

To my late parents, Md Nurdin and Zaleha, for always being the wonderful motivators that they were.

And to all the family members, THANK YOU.

Thank you for your loving support and belief in my dreams

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ABSTRACT

The concept of sustainable development has been introduced to the global stage by the United Nations. To achieve sustainable development, education is an essential tool. Education for Sustainable Development (ESD) is becoming increasingly important at all levels of the educational system including Higher Education Institutions (HEI). Many HEI have taken the initiative to integrate the concept of sustainable development into their curriculum and educational activities. Thus, the integration of teaching and research is becoming a key issue in higher education. There is no exact pedagogy for sustainable development education, but there is a broad consensus that it requires a shift toward active, participative, and experiential learning methods that engage learners and make a difference to their understanding, thinking and ability to act. The main objective of this study is to explore the application of the constructivist approach as the instructional design in sustainable development education. This research employs both quantitative and qualitative methods. The sample consists of Civil Engineering Diploma students. A set of survey questionnaire has been administered among them. Eleven respondents underwent semi-structured interview. The respondents were also given the pretest and posttest at the beginning and the end of the semester as well as an open-ended questionnaire in the classroom. They also did field trip report and group work assignment. Generally, this study contributes to the pool of knowledge in teaching and learning pedagogy which eventually will help to educate students on sustainable development more effectively.

ABSTRAK

Konsep pembangunan mapan telah diperkenalkan ke pentas dunia oleh Pertubuhan Bangsa Bangsa Bersatu. Untuk mencapai pembangunan mapan, pendidikan menjadi instrument penting. Pendidikan bagi pembangunan mapan menjadi semakin penting di semua peringkat pendidikan termasuk di institusi-institusi pengajian tinggi. Banyak institusi pengajian tinggi telah mengambil inisiatif untuk mengintegrasikan konsep pembangunan mapan dalam aktiviti pendidikan dan kurikulum mereka. Oleh itu, intergrasi pengajaran dan penyelidikan telah menjadi satu isu penting dalam pengajian tinggi. Tidak ada satu pedagogi yang tepat bagi pendidikan pembangunan mapan tetapi terdapat satu kesepakatan umum yang mengatakan bahawa ia memerlukan perubahan ke arah pendekatan pendidikan yang aktif, mengutamakan penglibatan pelajar dan memberikan pengalaman kepada pelajar yang mana ini akan memberikan perbezaan dalam cara mereka memahami, cara pemikiran dan keupayaan mereka untuk bertindak. Objektif utama kajian ini adalah untuk meneroka applikasi pendekatan konstruktivis sebagai rekabentuk pengajaran dalam pendidikan pembangunan mapan. Kajian ini mengunapakai kedua-dua kaedah kualitatif dan kuantitatif. Sampel terdiri daripada pelajar Diploma Kejuruteraan Awam. Satu set borang kajiselidik telah diedarkan di kalangan mereka. Sebelas responden menjalani temubual separuh berstruktur. Responden juga diberikan pra dan pasca ujian di awal dan akhir semester dan juga menjawab soal selidik terbuka ketika kelas berlangsung. Mereka juga menulis laporan lawatan lapangan dan tugasan kerja berkumpulan. Secara umumnya, kajian ini menyumbang kepada pengetahuan tentang pedagogi pengajaran dan pembelajaran dimana akhirnya akan mampu menbantu mendidik para pelajar dalam pembangunan mapan dengan lebih berkesan.

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DESD	-	Decade of Education for Sustainable Development
ESD	-	Education for Sustainable Development
GHESP	-	Global Higher Education for Sustainability Partnership
GUNI	-	Global University Network for innovation
HEI	-	Higher Education Institutions
HESD	-	Higher Education for Sustainable Development
IAU	-	International Association of Universities
ISO	-	International Organisation for Standardisation
NGO	-	Non-governmental Organisations
SD	-	Sustainable development
SPSS	-	Statistical Package for the Social Sciences
ULSF	-	University Leaders for a Sustainable Future
UN-DESD	-	UN Decade of Education for Sustainable Devel
UNEP	-	United Nations Environment Programme
UNESCO	-	United Nations Educational, Scientific and Cultural Organization
UNU	-	United Nations University
WCED	-	World Commission on Environment and Development
WSSD	-	World Summit on Sustainable Development
NFPCM	-	Needham's Five Phase Constructivist Model

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Today sustainability has recognised as a crucial issue faced by the twenty first century society (Komiyama & Takeuchi, 2006). Through education people become conscious of the need to preserve resources and safeguard the environment while in quest of economic growth. The concept of sustainable education is pursuing the balance between environmental conservation, economic growth and social development WCED 1987. In 1992 at the Rio Earth Summit United Nations highlighted the importance of education in attaining sustainable development.

In 2002 UNESCO declared the Decade of Education for Sustainable Development DESD from January 2005 to December 2014. United Nations stressed a rigorous work plan to develop environmental education around the world to recognise sustainable development. This appeal is in line with Chapter 36 of Agenda and was restated at the meeting in Johannesburg in 2002. The main purpose of sustainable education is to transform students' perception toward sustainability which then should change students' attitude in order to put into action the concept of sustainability (Cotgrave & Alkhaddar, 2006). Arbaat Hassan stated the need for efforts to be made to change young people's environmental perception (Arbaat Hassan, 2013) because young people would eventually be affected. Hence there is a need to formulate solutions for environmental problems. The environmental education (Brody & Ryu, 2006) should play a vital role in building awareness and changing people's values, skills, attitude and behaviour. Additionally, students'

perceptions toward the environment (Noora Kokkarinen, 2010) can be related to a variety of educational establishments. A study done has reported that although students' background did affect attitudes, education (Horvath, 1999) was the most important factor that influenced their attitudes towards environment. A subsequent study concluded that factors such as the educators' knowledge on sustainability and sustainable development (Segalàs, 2009) were able to affect attitudes toward sustainability. Because of this logical transformation from education to behaviour, students' behaviour toward sustainability can be transformed by changing their attitudes, which is considerably inspired by sustainable education.

The main objective of Decade of Education for Sustainable Development (DESD) is to assimilate concept of sustainable development into all features of education and learning. This educational strategy will inspire changes in behavior that will create a more sustainable future in terms of environmental, economic and a just society for the present and future generations. The Decade of Education for Sustainable Development DESD, also offers governments of the world the opportunity to rethink and reorient various scopes of education and skills training (DESD, 2002) so that the learning process is related to real life applications and supports learners to view the world through concern for sustainability and sustainable development.

Through Education for Sustainable Development (ESD) any students or any individual will be able to attain the necessary knowledge, skills, attitudes and values necessary to shape a sustainable future. Education for Sustainable Development (ESD) is where the important of sustainable development concerns such as climate change, (DESD, 2002) disaster risk reduction, biodiversity and sustainable consumption are included into teaching and learning (Lambrecht, 2011). Education for Sustainable Development (ESD) also requires teaching and learning methods that could successfully result in behavior changes in learners, where they are more likely to take actions or make conclusions with respect to sustainable development. Furthermore, it is also suggested that Education for Sustainable Development (ESD) could boost competencies like critical thinking, imagining of future scenarios and decisions making (Barth, 2007).

1.2 Background of Problem

In Tbilisi Declaration 1977, Higher Education Institutions (HEI) were requested to consider development of environmental programs. The program would provide the faculty and staff with environmental awareness, specialise training, participation in international and regional co-operative projects, and advise and educate the public regarding environmental issues (Wright, 2014). UNESCO-UNEP also stressed that Higher Education Institutions (HEI) should be the centre for research, teaching and training of qualified personnel, who must be acessible to undertake research on environmental education. The Higher Education Institutions (HEI) are responsible to train experts in formal and non-formal education. The environmental education in colleges and Higher Education Institutions will differ from traditional education. They would teach students vital basic knowledge for work in their future profession.

One of the education disciplines which are directly related to human activities and the nature is the engineering discipline. Some of the Civil Engineering works include buildings, bridge, railway lines, airport construction and other structure and infrastructure. However, the construction of any of the buildings and infrastructures has an impact the current environment in several ways. The impacts of a construction project may include: noise caused by operating plant and construction equipment, air pollution due to dust from earthworks or emissions from plant and equipment, water pollution due to soil erosion ,waste disposal due to spoil, water discharges due to dewatering excavations, and heavy blasting and traffic impacts from detours and motorist inconveniences (Simon 2012). Traffic movement may also be affected by lane closures and temporary diversions and delays due to congestion and longer routes. Hence, the stakeholders in the construction industry must play their roles well in ensuring that the environment is protected and conserved by incorporating sustainability in their work. Thus, it is vital for engineers who are one of the main stakeholders in the industry to be knowledgeable of sustainable development. This is the first move to ensure that environmental impacts of their deeds are considered in all the decisions made in their positions.

When this study was conducted and based on the curriculum content of the UTM Diploma programme in 2007 there has been no indication of Education of Sustainable Development being operationalized in the Diploma programme. Until the present time, there is still lacking of sustainable development elements in the Civil Engineering Construction course. The detail of the Civil Engineering Construction course outline is given in Appendix A, which included the weekly schedule and assessment. The content of the weekly reflect the lecture topics and there is no element of sustainable development incorporated in those topics. Based on the course outline, it can be said that the nature of the topics is very much teacher orientated. This means that the teacher dominates the teaching process and the students merely receiving information without much participation. Therefore, it is recommended that the university considers incorporating knowledge on sustainable development into the programme especially Civil Engineering Construction course.

1.3 Statement of the Problem

A study done by Cotgrave and Alkhaddar (2006) stated that the most relevant aspects of sustainability to construction course students were to develop an understanding of the principles of sustainable construction during the design and construction phases. Developing knowledge of sustainable construction is important because many of these graduates will gain employment with contractors that undertake design and build contracts. They may therefore be in a position to influence designer's choice of materials and systems, and also promote more sustainable practices via the design and construction process. An awareness of the environmental impact of a building over its whole life is also very useful, and this is closely linked to the initial design (Cotgrave & Alkhaddar, 2006). Thus, it is justified that the knowledge of sustainable development needs to be included into the engineering curricula.

The challenge is most engineering courses mainly emphasis on 'memorisation of facts and well-established procedures' (Huntzinger, 2007). On the other hand, the effective teaching and learning of sustainable development

knowledge requires students to solve complex and ambiguous problems which require creative and critical problem solving skills. Unlike needing to memorise facts or solve straight forward equations. Hence, it is an essential to consider the best way not just to incorporate the concept of sustainable development into engineering curriculum, but also the appropriate approach to teach the relatively 'subjective' knowledge to engineering students which are used to be given facts and formulas. A strategic, well thought and holistic approach (Giesen, 2006) in incorporating the knowledge will ensure the effective learning of students which are the hope for a better and more sustainable future.

Based on the literature review it was considered that constructivist approach in teaching and learning of sustainable development is most appropriate to be used in this research (Kocevar-Weidinger, 2004). It is believed that learning occurs as learners are actively involved in a process of learning and knowledge construction rather than passively receiving information. The students are responsible for their own learning and knowledge construction. They assist their colleagues to learn and ultimately lead to create an atmosphere of satisfaction and achievement among themselves.

In this study, the preferred teaching and learning approach is constructivism. Constructivism is basically a theory of learning about how students learn. One of the applications of constructivism in teaching is to solve ill-defined and ill-structured problems which involve higher order thinking skills, such as understanding, applying, evaluating, and creating (Preissinger, 2015). Many of these ill-defined and ill-structured problems are related to everyday or real-life problems. Many experts believe that environmental and sustainability problems are considered as everyday problems. These problems are for example climate change, resource depletion and pollution. They are known as Wicked Sustainability Problems (WSPs). WSPs are highly complex, challenged, and lack definite solutions (Lonngren & Svanstrom, 2015). In order to solve these problems it requires holistic approaches and most of these approaches are beyond technical systems analysis and optimization. Integrating sustainable development into the Civil Engineering Construction course has the potential of playing a crucial role in preparing students to deal with the mentioned problems. The students' potentials, skills and capabilities can be developed through

the integration of sustainable development in the course. With the employment of constructivist approach, which is student-centred approach, the students can get themselves involved greatly in the learning process.

The Needham's Five Phase Constructivist Model (NFPCM) is selected as the teaching model in this study. This model consists of five phases namely, orientation, generating ideas, restructuring the ideas, applying the ideas and finally reflection. In this model, each phase is explained and suggestions are given on the activities which are suitable to be conducted in class. The NFPCM is chosen for this study due to several reasons. The first is that this model has five phases that are helpful and easily conducted by teachers especially those who are inexperience in conducting lessons using the constructivist approach. The second reason is based on the literature review conducted, this model receives the most positive responses among researchers. The findings of their work show that this model works well in classroom (refer Table 2.9). The third reason is that this model is adaptable to other programs and the suggested activities can be adjusted to o levels of difficulty and thinking. Finally, this model offers room for students to participate more actively since it is student-centered. It can provide students to gain more experience and knowledge so that learning can be meaningful to them. All these are illustrated in Table 2.9. Therefore, this study will employ the Needham's Five Phase Constructivist Model (NFPCM).

1.4 Research Objectives

The main objective of this research is to employ a constructivist approach in teaching and learning in classroom setting to incorporate the knowledge on sustainable development into the Civil Engineering Construction course. The incorporating of sustainable development knowledge into the course will increase awareness and encourage changes in behaviours and attitudes of the students so that they will be able to contribute to a more sustainable future. The teaching and learning of sustainable development will ensure that the students will take into consideration not just scientific and technical knowledge toward the environment (Matsuura, 2007) aspects of a project but also environmental, economic and social aspects. In

sustainable development learning environment, in solving problems, students have to consider not only scientific and technical aspects of the problem, they too have to consider the environmental, economic and social matters. These three aspects are considered vital toward achieving sustainable development. The research objectives (RO) of the study are as follows:

i. To determine the awareness of sustainable development among engineering students.
ii. To determine the students' knowledge on sustainable development through the pretest and posttest conducted.
iii. To examine the students' knowledge on sustainable development after using Needham's Five Phase Constructivist Model (NFPCM) in the classroom setting.
iv. To produce a guideline on teaching and learning approach in integrating knowledge on sustainable development in Civil Engineering Construction course based on constructivist approach.

1.5 Research Questions

To achieve the above research objectives, the following research questions (RQ) are used.

Objective 1: To determine the awareness of sustainable development among engineering students.

RQ1. What is the engineering students' awareness toward sustainable development?

Objective 2: To determine the students' knowledge on sustainable development through the pretest and posttest conducted.

RQ2. What is the knowledge that the students' have on sustainable development through the pretest and posttest conducted?

Objective 3: To examine the students' knowledge on sustainable development after using the Needham's Five Phase Constructivist Model (NFPCM) in the classroom setting.

RQ3. What is the students' knowledge on sustainable development after using the Needham's Five Phase Constructivist Model (NFPCM) in the classroom setting?

Objective 4: To produce a guideline on teaching and learning approach in integrating knowledge on sustainable development into Civil Engineering Construction course based on constructivist approach.

RQ4: What are the components of the guideline on teaching and learning approach in integrating knowledge on sustainable development into Civil Engineering Construction course based on constructivist approach?

1.6 Conceptual Framework

The conceptual framework for this research is shown in Figure 1.1. A conceptual framework can be represented in graphical form or written in narratives form. The conceptual framework can assist the researcher in deciding the types of data to collect and also the variables to be considered. In this research there are two independent variables. A variable is defined as anything that has a quantity or quality that varies. It is a characteristic or attribute of an individual or an organization that (i) researchers can measure or observe and (ii) varies among individuals or organizations studied. An independent variable is a variable believed to affect the dependent variable. This is the variable that the researcher, will manipulate to see if it makes the dependent variable change. In this study the independent variables are knowledge on sustainable development and awareness of sustainable development.

In this context the knowledge on sustainable development is applying the concepts, principles and practices of sustainable development to building and

construction industry. Apart from the technical knowledge, sustainable development should also take into consideration the economy, environment and social aspects. Awareness in this study refers to grasp on having the concern and sensitivity towards the environment and its problems. Thus, in the context of this research the awareness covers five aspects which are (i) the perception of sustainable development (ii) attitudes towards sustainable development (iii) environmental consciousness (iv) attitude to change and finally (v) personal views on incorporating knowledge on sustainable development into Civil Engineering Construction course.

A dependent variable is an attribute or a characteristic that is dependent on or influenced by the independent variable. An independent variable is an attribute or characteristic that influences or affects an outcome or dependent variable (Creswell, 2003). In this study, the dependent variable is will be understanding of sustainable development. The understanding of sustainable development is manifested through the guideline in which it provides the appropriate teaching and learning approach, learning strategy and appropriate evaluations to be implemented. This guideline is based on Needham's Five Phase Constructivist Model (NFPCM).

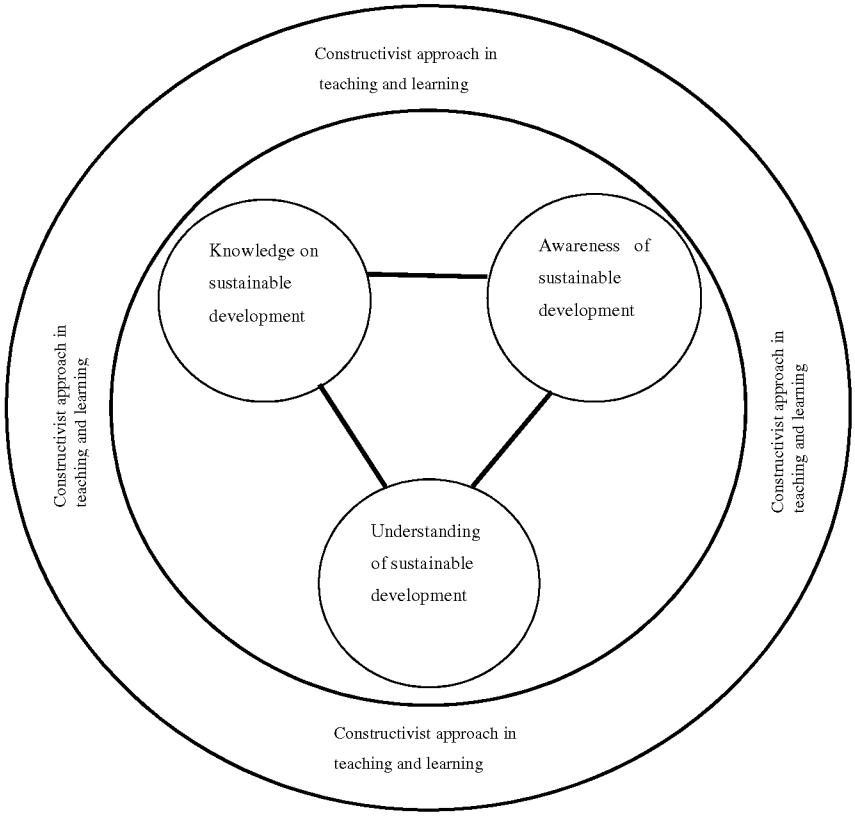

Figure 1.1 Conceptual framework

1.7 Significance of the Research

The research will contribute to the body of knowledge in teaching and learning sustainable development in Civil Engineering Construction course. Successful integration of sustainable development knowledge into engineering curriculum requires a change in the teaching and learning approaches. Effective teaching and learning of sustainable development knowledge through engineering courses would result in future engineers who are able to (ESD, 2014):

i. consider what the concept of global citizenship means in the context of their own discipline and in their future professional and personal lives
ii. consider what the concept of environmental stewardship means in the context of their own discipline and in their future professional and personal lives
iii. think about issues of social justice, ethics and wellbeing, and how these relate to ecological and economic factors
iv. develop a future-facing outlook; learning to think about the consequences of actions, and how systems and societies can be adapted to ensure sustainable futures.

1.8 Scope and Limitation of the Research

This research will limit its scope to incorporate knowledge on sustainable development into construction course. In Malaysia, the awareness of sustainable development in Civil Engineering students is still not at large (Shafii, Arman Ali, & Othman, 2006). It has been recognized that the building and construction industry has an enormous responsibility within the environmental debate. Each individual, organization and institution has an obligation to consider ways to protect the environment and reverse the damage done to it over the past decades (Peter Paa-Kofi 2013). The proposed classroom approach could act as a guideline for teaching and learning sustainable development into other Civil Engineering courses.

The sample is the Civil Engineering Diploma programme students at one of local public universities. The research focuses the application of constructivist approach in teaching and learning through the Needham's Five Phase Constructivism Model to gain knowledge and understanding of sustainable development among the students. The research is limited to third year students who have just completed their Civil Engineering Construction course during their second semester of their second year. The existing Construction course does not have knowledge of sustainable development in the syllabus.

1.9 Operational Definitions

This research uses some terms from Civil Engineering and education. In order to obtain clearer picture on the research, few terminologies used need to be clarified for comprehension. Listed below are some terms that will be mentioned in the research.

1. Construction course

In this study the Construction course deals with the construction of buildings. The syllabus consist of: construction activities, introduction to substructure: foundation and piles, introduction to temporary works: scaffoldings and formworks, introduction to superstructure: floors, walls, internal fixtures and fittings, and roof and introduction to external works.

2. Civil Engineering Construction course

In this study the Civil Engineering Construction course deals with the construction of buildings. In course is in Civil Engineering programme. The syllabus consist of: construction activities, introduction to substructure: foundation and piles, introduction to temporary works: scaffoldings and formworks, introduction to superstructure: floors, walls, internal fixtures and fittings, and roof and introduction to external works.

3. Sustainable development (SD)

Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

4. Sustainable Construction

Sustainable construction is generally described as the application of sustainable development to the construction industry. It is also considered as a subset of sustainable development.

5. Education for Sustainable Development (ESD)

Education for sustainable development is the process of equipping students with the knowledge and understanding, skills and attributes needed to work and live in a way that safeguards environmental, social and economic wellbeing, both in the present and for future generations.

6. Knowledge on Sustainable Development

In this context the knowledge on sustainable development is applying the concepts, principles and practices of sustainability to building and construction industry. Apart from the technical knowledge it has to consider the economy, environment and social aspects.

7. Awareness of Sustainable Development

In this study the aspect of awareness is regarding the concern and sensitivity towards the environment and its problems. The awareness in this research covers the (i) perception of sustainable development (ii) attitudes towards sustainable development (iii) environmental consciousness (v) attitude to change (vi) personal views on incorporating knowledge on sustainable development into Civil Engineering Construction course.

8. Understanding of sustainable development

The understanding of sustainable development is manifested through the guideline in which it provides the appropriate teaching and learning approach, learning strategy and appropriate evaluations to be implemented. This guideline is based on Needham's Five Phase Constructivist Model (NFPCM)

9. Constructivism Theory

Constructivism is a learning theory found in psychology which explains how people might acquire knowledge and learn. It therefore has direct application to education. The theory suggests that humans construct knowledge and meaning from their experiences. It emphasis is in the process of learning and not on searching for the right answer. This theory is proposed by a number of theorists such as Jean Piaget and Lev Vygotsky.

10. Constructivist Approach in Teaching

Constructivist teaching is based on the belief that learning occurs as learners are actively involved in a process of meaning and knowledge construction as opposed to passively receiving information. Learners are the makers of meaning and knowledge. Constructivist teaching fosters critical thinking, and creates motivated and independent learners.

11. Constructivist Teachers

In the constructivist classroom, the teacher's role is to prompt and facilitate discussion. The teacher's main focus should be on guiding students by asking questions that will lead them to develop their own conclusions on the subject. According to constructivist approach, teacher should adapt the role of facilitator and good practitioner in the classroom and not a mere teacher.

12. Teaching Plan

A teaching plan is an instructional design to guide teachers in their teaching. In this study, the teaching plan employs constructivism approach based on Needham's Five Phase Constructivist Model (NFPCM)

13. Ill-Defined Problem

An ill-defined problem is one that addresses complex issues and thus cannot easily be described in a concise, complete manner. A problem which has no clear solution strategy, but may allow single correct answers about which qualified experts would agree (Lonngren & Svanstrom, 2015).

14. Ill-Structured Problem

Ill-structured problems can be defined as problems which do not have known solutions. Experts in the domain/discipline do not agree regarding whether a particular solution is appropriate, because it has various/several solutions and solution paths" (D. H. Jonassen, 1997).

15. Wicked Sustainability Problems (WSPs)

The wicked sustainability problems (WSPs) are highly complex, challenged, and lack definite solutions (Lonngren & Svanstrom, 2015).

16. Types of knowledge

There are two types of knowledge considered in this study the factual knowledge and conceptual knowledge. The factual knowledge is knowledge that is basic to specific disciplines. This dimension refers to essential facts, terminology, details or elements students must know or be familiar with in order to understand a discipline or solve a problem in it. The conceptual knowledge is knowledge of classifications, principles, generalizations, theories, models, or structures pertinent to a particular disciplinary area (Wilson, 2013).

1.10 Organization of the Thesis

This thesis consists of five chapters. Chapter 1 provides the background of the problem, statements of the problem, the research objectives, the research questions, conceptual framework, significant of the research, the scope and limitation of the research. Chapter 2 consists of literature review related to the research such as teaching and learning theories related to constructivist teaching and learning approach. Chapter 3 describes the research methodology comprising the research design, research samples, data collection and data analysis techniques. Chapter 4 presents the findings of the research. Chapter 5 discusses the findings, presents the implications of the study, conclusion and contribution of the study, and lastly recommendations for further research.

1.11 Summary

This chapter is an introduction to the research topic and explains the foundation of the research as given in Section 1.1. Section 1.2 describes the background of the problem. The statement of the problem is presented in Section 1. The research objectives and research questions are in Sections 1.4 and 1.5 respectively. The conceptual framework is explained in Section 1.6. It links the concepts, theories, processes and the variables considered in the study. The significance of the research is stated in Section 1.7. The scope and limitation of the research is discussed in Section 1.8. The operational definitions are specified in Section 1.9 and the organization of the thesis is in Section 1.10.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter discusses the literature related to the research that is being carried out. A literature review is a critical analysis of the literature, or research, related to a specific topic or research question. According to Clare and Hamilton (2003) a literature review is "*an extensive critical review of the extant literature on the research topic*". Manalo and Trafford (2006) described a literature review "*contains a critical analysis and the integration of information from a number of resources, as well as consideration of any gaps in the literature and possibilities for future research*". The literature starts with the sustainability and Higher Education Institution, learning theories, rationale of selecting constructivism, constructivism approaches, constructivist theory, constructivist view of learning, constructivism classroom : teachers' role, learning strategies in constructivist teaching and learning, teaching model and previous local studies. This is followed by the sustainable development, construction industry and its impact on the environment, and sustainable construction.

2.2 Sustainability and Higher Education Institution

In 2002 the United Nations declared the Decade of Education for Sustainable Development from 2005 to 2014 (DESD, 2002). The main objective of The Decade

of Education for Sustainable Development (DESD) is to integrate the principles, values, and practices that create sustainable development into all aspects of education and learning. Education alone will not be enough to attain a sustainable future, but this goal can never be achieved without learning sustainable development Education for Sustainable Development (ESD) is meant for everyone, and its takes place within a perspective of lifelong learning, engaging all possible spaces of learning, formal, non-formal and informal from early childhood to adult life. Education for Sustainable Development (ESD) calls for a reorientation of education approaches-curriculum and content, pedagogy and examinations. Spaces for learning include non-formal learning, community-based organizations and local civil society, the workplace, formal education, technical and vocational training, policy-making bodies and others (DESD, 2002)

Since 1990s till now the International Association of Universities (IAU) and UNESCO have been active in Higher Education Institutions (HEI) all over the world to promote sustainable development. Many literature and researchers recognized that HEI play an important role in promoting sustainability. Jones and Ferrer-Balas (2008) stressed that the HEIs are places of knowledge production and dissemination of sustainable development. They act as formal schooling and provide graduate who are trained and acquired necessary skills to become responsible citizens (Ferrer-Balas, Bruno, Mingo, & Sans, 2004) . As such, existing HEI curriculum should be transformed to address the current environmental problems and educate the students to become responsible citizens of the world (Jones, Trier, Richards, & P., 2008).

Magdelena (2008) mentioned that there are four categories on ways higher education may contribute to building a sustainable future. Firstly, the HEI can be a model in promoting sustainable practices. Secondly, the HEI can teach students the required skills to face sustainability challenges. Thirdly, the HEI can conduct real world problem-based research to addressing the urgent sustainability challenges facing society. And lastly HEI can promote and enhance engagement between individuals and institutions as trans disciplinary agents, highly integrated with and interwoven into other societal institutions (Magdalena Svanström, 2012). Lee (2007) stated that the HEI have a crucial role for sustainable development. The role of HEIs could be categorised into three major areas (Lee, 2007)

1. HEI are responsible to do research and discover the necessary knowledge, skills and behaviours for sustainable development. HEIs have to determine the best solution taking into consideration of the three pillars of sustainable development; economic, environmental, and social in tackling the tasks and issues, which are often in encountering with each other.

2. HEI are responsible to train teachers and other personnel involved in teaching sustainable development. HEIs have to conduct various courses of interdisciplinary approaches with the aim to assist teachers familiarised with the complex problems of society going to face.

3. HEI are responsible to educate all future professionals from various disciplines whom will be the future leaders of various sectors and areas and will act as qualified agents for sustainable development. Thus it is very pertinent to educate and build up group of leaders in each sector of society either public or private, which will be taking the leading roles in promoting the values of sustainable development and transforming the unsustainable sector toward the more sustainable society.

Cortese (2003) stress that one of the critical roles of HEI is to prepare future policy makers in taking up an active role in society. With this consideration the HEI should instilled the students with the necessary competences to cope with complex sustainability challenges. The students should have the necessary knowledge, skills; and attitudes to act sustainability (Cortese, 2003).

Waas (2009) provides some required competencies which were developed by an international group of education for sustainable development experts. The competencies are systemic thinking and handling of complexity, anticipatory thinking, critical thinking , acting fairly and ecologically, cooperation in heterogeneous groups, participation, empathy and change of perspective, interdisciplinary work, communication and use of media, planning and realizing innovative projects, evaluation, and ambiguity and frustration tolerance (Tom et al., 2012). Since teaching and learning is one of most important components in reorientation education towards sustainable development Waas (2009) summarized some alternative ways in teaching and learning approach of sustainable development

(Tom et al., 2012). He suggests to shift the teaching and learning approach from the teacher-centered to the student-centered.

Based on the discussion above the HEI should review their responsibilities toward education for sustainable development. As such, the existing HEIs curriculum and pedagogy should be transformed so that they would be able to address the sustainable development problems we are facing today. In addition, they are also to educate the students to become responsible professionals and good citizens. Hence, this research is obliged to undertake the challenge of incorporating knowledge on sustainable development into the university's program.

2.3 Learning Theories

According to Webster dictionary the word learning means the acquisition of knowledge or skill; for an example, the learning of languages; and the knowledge or skill received by instruction or study; acquired knowledge or ideas in any discipline of science or literature. Learning can be commonly defined as the act, process, or experience of gaining knowledge or skill and one of the most important activities in humans' life. In psychology and education learning is described as a that brings together cognitive, emotional, and environmental influences and experiences for acquiring, enhancing, or making changes in one's knowledge, skills, values, and world views (Illeris, 2006). The process of learning focuses on what happens when the learning takes place and the explanations of what happens are known as learning theories.

Learning theories are a structured set of principles describing how a person attain, recollect, and remember knowledge. The principles of the theories can be used as procedures to choose instructional tools, practices and approaches that promote learning. By studying and knowing the different theories, a person can understand how learning occurs.

The theories of learning are explanation on how people learn and thereby assist in understanding the inherently complex process of learning. Basically there are three main categories of learning theories: behaviourism, cognitivism, and constructivism. The behaviourism focuses only on the objectively observable aspects of learning, the cognitive theories look beyond behaviour to explain brain-based learning and constructivism views learning as a process in which the learner actively constructs or builds new ideas or concepts. Behaviourists viewed learning as a sequence of stimulus and response actions (Taylor, 2002) in the learner. They view the teachers or instructors role as one of modifying behaviour, by setting up situations whereby learning is reinforced by the desired responses being exhibited. Behaviourism was the findings of American psychologist John B. Watson in 1913.Watson based his studies on the works of Pavlov and his dogs in the 1890's.

Cognitivists believe that learning occurs when the learner processes information. Jean Piaget began a research program in the 1920's that played a major part in the development of cognitive theories. He developed his theory by watching and observing children. Piaget's theory used the premise that as a child develops, they build and develop cognitive structures such as mental maps or linked concepts in their response to experiences that occur within their environment (Peggy, 2013). Constructivism approach to learning, emphasise on the ability of the learners to solve real life problems. Constructivism is founded on ideas that by reflecting on our experiences, we generate our own understanding of the world. Major proponents of constructivism theory include Malcolm Knowles, Carl Rogers, and David Kolb.

Table 2.1 shows the brief description of the theorist involved and learning process of each learning theory. The different theories are based on different assumptions (Yilmaz, 2008). The theories of learning can inform way of teaching and the use of different instructional resources (Matthews, 2003) including technology, but ultimately the learning activities in which the student actually engages mental, physical, and social determine what a student learns in the classroom. Classroom learning involves social, emotional, and participatory factors in addition to cognitive, and theories of learning need to take these factors into account. Most current theories of learning presuppose that the goal of education is to

develop the ability of students to understand the content and to think for themselves, presumptions that are consistent with the majority of modern-day schools.

Table 2.1: Learning theory, brief description and learning process (Ertmer & Newby, 2013)

Learning theory	Brief Description	Learning process
Behaviourism	The behaviourist theory is based on the concept of operant conditioning. Behaviourism is more concerned with behaviour than with thinking, feeling, or knowing. It does not concerned with the mind or human consciousness.	The learning process is based on objectively observable changes in behaviour. The learning is simply as acquisition of a new behaviour or change behaviour All learning is shaped by the stimuli in the environment and that free will plays no role in the process.
Cognitivism	The cognitivist Theory is based on the idea that individuals process the information they receive rather than merely responding to stimuli. Cognitivist is concerned with things that happen in the head cognitive processes. Learning occurs as it associate new information to existing knowledge, concepts and ideas	The learning process occurs through internal processing of information. The learning involves the reorganization of experiences, either by attaining new insights or changing old ones. Teaching should proceed in a way that allows learners to discover ideas for themselves. At certain times in a learner's intellectual growth, different mental structures emerge. Social contexts influence the individual development. The ideas that learners develop in the classroom conform to these socially accepted usages and meanings.

Learning theory	Brief Description	Learning process
Constructivism	The constructivism theory is based on the idea that the learners construct their own perspectives of the world, based on their own experiences and internal knowledge. The learning theory found in psychology explains how people acquire knowledge and learn. The learner decides and converts information, constructs hypotheses, make decisions depending on cognitive structure provides meaning and organization to experiences.	The learning process occurs when learners construct new ideas or concept based on prior knowledge and or experience. Learning is simply the process of adjusting the mental models to accommodate the new experiences. For real learning to occur, learners have to make that information their own so that it becomes significant and use it their purposes.

2.4 Rationale of Selecting Constructivism

Basically the learning theories consist of behaviourism, cognitivism and constructivism. Table 2.2 shows the comparison of the main learning theories. The table describes the examples and applications, the role of teacher, the role of students and how learning occurs in respective learning theory. It specifies that the learning theory of the constructivism is used to handle ill-defined problem. *"An ill-defined problem is one that addresses complex issues and thus cannot easily be described in a concise, complete manner". Hayes (1981) defined ill-defined problems, as problems which have no clear solution strategy, but may allow single correct answers about which qualified experts would agree (Lonngren & Svanstrom, 2015).*

Some educators or experts believed every day or real-life problems as ill-defined problems or ill –structured problems. However, ill structured problems differ from ill-defined problem. *"Ill-structured problems can be defined as problems which do not have known solutions. Experts in the domain/discipline) do not agree regarding whether a particular solution is appropriate, because it has various/several solutions and solution paths"* (Jonassen, Strobel, & Lee, 2006)

Most of environmental and sustainability problems are considered as everyday problems. They have been identified as being not purely technical. (Lonngren & Svanstrom, 2015). Few of the examples of environmental and sustainability issues such as climate change, resource depletion, and pollution are known as wicked sustainability problems (WSPs). The wicked sustainability problems (WSPs) are highly complex, challenged, and lack definite solutions (Lonngren & Svanstrom, 2015). In order to solve these problems it requires holistic approaches. Most of these approaches are beyond technical systems analysis and optimization.

Engineering education has the potential to play an important role in preparing students to contribute to deal with these problems. In order to deal with wicked sustainability problems (WSPs) the students need the wicked sustainability problems (WSPs) knowledge. The knowledge is defined as *"the ability to holistically and integrative understand and address wicked sustainability problems (WSPs) while considering the normative context of sustainable development"*. However, generally engineering education practice commonly prepares students to address well-structured rather ill-defined or wicked sustainability problems (WSPs). *"Well-structured problems are constrained problems with convergent solutions that engage the application of a limited number of rules and principles within well-defined parameters."* Well-structured problems are clearly presented with all the information needed at hand and have convergent answers and single solving processes to reach a final solution (Jonassen et al., 2006).

However, to be able to handle ill-defined or ill-structured problems learner must have certain abilities and skills. The required abilities and skills could not well develop in teacher-centered classroom so the learner must go through other teaching

paradigm. Therefore, there is a rationalisation of engaging the constructivist approach in teaching and learning in the classroom setting. The constructivist approach is student-centered.

Table 2.2: Comparison of learning theories (Preissinger, 2015)

	Behaviourism	**Cognitivism**	**Constructivism**
Best for teaching	Task-based learning involving low-order thinking skills, such as remembering, understanding, and applying.	Problem solving involving higher order thinking skills, such as understanding, applying, evaluating, and creating.	Solving ill-defined problems involving higher order thinking skills, such as understanding, applying, evaluating, and creating.
Examples and applications	Exercise Memorisation Repetation	Organise information Linking concepts Provide, organize and structure lecture Real world examples Discussions Problem solving	Case studies Research Problem based learning Brainstorming Collaborative learning Group work Discovery learning Stimulations
Role of the teacher	Presents learners with structured material stimulus and prompts for the right response.	Provide learners with strategies that allow them to connect new knowledge to existing knowledge,	Aids learners in exploring topics and coming to their own understanding by asking questions.

	Behaviourism	Cognitivism	Constructivism
Role of the Learner	A blank slate, a passive participant to stimulus-response.	An active participant, engaged in transforming, rehearsing, storing, and retrieving information.	An active participant, building interpretations of the world based on individual experiences.
How does learning occur?	When learners can transfer stimulus-response to more general and new situations.	When learners retrieve information and apply it in a new or different situation.	When learners use their knowledge in a real-world situation.

2.5 Constructivism Approach

Constructivism is not a unified theory; rather, it is characterized by multiple perspectives (Almon Shumba, 2012). Two main approaches to constructivism are cognitive constructivism and social constructivism. The former is associated with the work of Piaget and the latter with that of Vygotsky (Schcolnik, Kol, & Abarbanel, 2006). In both approaches, there is an underpinning assumption that students learn by constructing their own knowledge and actively constructed in the human mind (Neo & Neo, 2010). The social constructivism concentrates on how the development of that formal knowledge has been created (Richardson, 2003). The cognitive approach focuses on the ways in which meaning is created (Schcolnik et al., 2006) within the individual mind and how shared meaning is developed within a group process. The development of a social focus within cognitive constructivism has been an important contribution within this form, particularly for pedagogical processes. It acknowledges the social nature of formal knowledge development within an expert community and of knowledge creation that take place within a social grouping such as a classroom.

Figure 2.1 shows the two main approaches in constructivism. The two approaches are cognitive constructivism and social constructivism. In cognitive constructivism, the ideas are constructed individually through personal process as mentioned in Piaget's theory. The social constructivism idea is related to Vygotsky's theory and constructed through interaction with the teacher and others (Powell & Kalina, 2009). Piaget's theory proposes that humans cannot be given information in which they must understand and use; instead humans must construct their own knowledge. Lev Vygotsky, believed in social interaction and that it was integral part of learning. According to Vygotsky, social constructivism is based on the social interactions a student in the classroom along with a personal critical thinking process. Vygotsky's theory involved cognitive dialogue, the zone of proximal development (ZPD) social interaction, and culture and inner speech (Rodriguez, 2011).

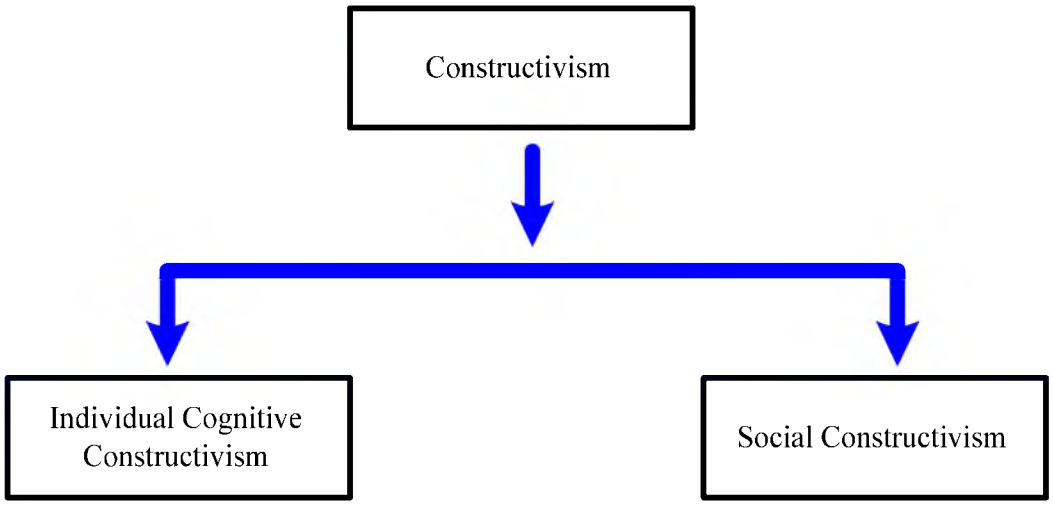

Figure 2.1 Constructivism approaches (Rodriguez, 2011)

Figure 2.2 shows the comparison and contrast of cognitive constructivism, Piaget's theory and social constructivism, Vygotsky's theory (Rodriguez, 2011).

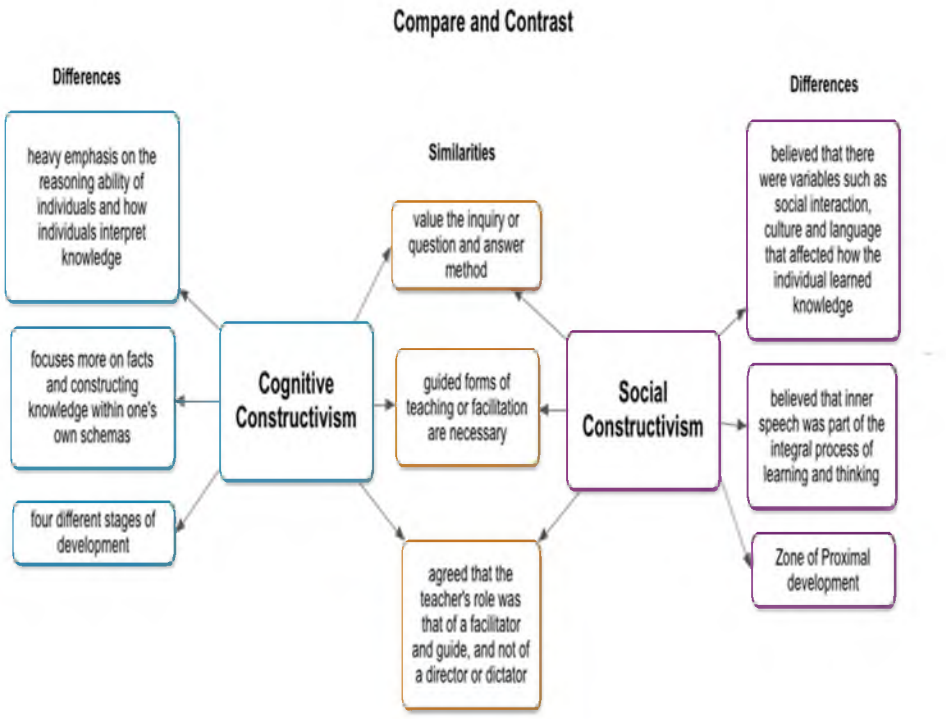

Figure 2.2 Comparison and contrast between cognitive constructivism and social constructivism (Rodriguez, 2011)

In this study both the cognitive and social constructivism are been given consideration. These approaches can be applied to students' learning. This means the students construct their new knowledge based on their own understanding and prior knowledge; and also through their interaction with others for example their colleagues and teachers. Hence, this approach encourages students to confront the real world problems which are within their everyday experience. Therefore, the researcher will include both approaches the individual cognitive constructivism and social constructivism into the proposed guideline in teaching and learning so that the students have the varied opportunities in sustainable development knowledge.

2.6 Constructivist Theory

Constructivism is a theory of learning (Schcolnik, Kol, & Abarbanel, 2006). and knowing. It is an epistemological concept (Beyhan, 2013) that draws from a variety of fields, including philosophy, psychology (Almon Shumba, 2012) and

science (Quale, 2002). The key principles of constructivist learning are: (a) learning is an active process in which the learner uses sensory input and constructs meaning out of it (Ültanır, 2012) or is a constructive process in which the learner is building an internal illustration of knowledge, a personal interpretation of experience (Ebrahimi, 2013); and (b) people learn to learn as they learn (Carwile, 2007) learning consists both of constructing meaning and constructing systems of meaning. Thus, the trend has been to move from a passive view of knowledge towards a more adaptive and active view (Loyens, Rikers, & Schmidt, 2009).

The history of constructivism in education and philosophy indicate that it is not a new theory. Constructivism as applied to education is derived from the work of Swiss developmental psychologist Jean Piaget and Russian psychologist Lev Vigotsky. However, its underlying principles have had a long history in American education (Richardson, 2003) influenced by the 18th century French philosopher Jacques Rousseau, and later, the theories of John Dewey, G. Stanley Hall, and Arnold Gesell. Jean Piaget and John Dewey (Ültanır, 2012) are the two main contemporaries who developed the precise idea of constructivism. Constructivism has multiple roots in the psychological, sociological, philosophical and critical educational theories (Almon Shumba, 2012). Constructivist theorists maintain that learning is more effective when teachers use constructivist methods that typically involve more student– centered (Almon Shumba, 2012) active learning experiences, more student–student (Kocevar-Weidinger, 2004) and student–teacher interactions, (Amarin & Ghishan, 2013) and more work with concrete materials and in solving realistic problems (Almon Shumba, 2012).

Constructivism is basically a theory about how students learn. Many works have been on these theories and they summarised that students learn by fitting new information together with what they already know. During the recent years this theory has been one of the latest catchwords in higher educational circles. Since then many Higher Education Institutions (HEI) have used constructivist teaching models in teaching and learning sciences. The constructivist teaching models emphasis on active and collaborative learning, and simultaneously stress on students and teachers discovering and constructing knowledge together. The model also presents the students with opportunities to construct new knowledge based on their prior

knowledge and understanding from previous authentic experiences. Such prior knowledge is often referred to as a 'presage variable' and represents the different backgrounds, experiences and knowledge bases that students bring with them to the learning situation. This approach encourages students to confront real world problems which are within their everyday experience.

Subsequently other characteristics of constructivist teaching models that should be included are: prompting students to observe and formulate their own questions; allowing multiple interpretations and expressions of learning; encouraging students to work in groups; and in the use of their peers as resources to learning (Zhao, 2003).

Thus based on this constructivist theory, everyone has the background and the potential ability to learn about and acquire knowledge. Hence the constructivist teaching models are very useful approach to teaching and learning knowledge on sustainable development. Therefore, the characteristics of the constructivist teaching models can be considered in developing the proposed guideline for teaching and learning sustainable development into Civil Engineering Construction course.

2.7 Constructivist View of Learning

Constructivist learning arose from Piagetian and Vygotskian perspectives (Ruey, 2010), emphasising the impact of constructed knowledge on the individual's active, reflective thinking (Almon Shumba, 2012). While Piaget focused more on individual cognitive constructivism(Brooks & Brooks, 1999) Vygotsky stressed that sociocultural systems have a major impact on an individual's learning (Beyhan, 2013). Based on the two mentioned approaches the basic assumptions and principles of the constructivist view of learning are summarised by Yilmaz (2008) as shown in Table 2.3.

Table 2.3: Summary of constructivist view of learning (Yilmaz, 2008)

• Learning is an active process.
• Learning is an adaptive activity.
• Learning is situated in the context in which it occurs.
• Knowledge is not innate, passively absorbed, or invented but constructed by the learner.
• All knowledge is personal and idiosyncratic.
• All knowledge is socially constructed.
• Learning is essentially a process of making sense of the world.
• Experience and prior understanding play a role in learning.
• Social interaction plays a role in learning.

Hence, the above constructivist view of learning can be applied to educational practices that can be implemented are explained in the following table.

Table 2.4: General principles of the constructivist view of learning applied to educational practices (Richardson, 2003)

• Learning is an active process of knowledge construction Knowledge construction is an active process of learning. It can be reinforced by exposing the learners to relevant situations and experiences in addition to the classroom setting.
• Dialogues and discussions Discussions and dialogues positively affected the learning process. It is a form of interchanges between individuals, such as learners, teachers and individuals from relevant industries. Besides stimulates thinking and reflecting on the learners the discussions and dialogues reinforce learning.
• Variation of understanding across different learners. Each individual understands concepts and information received differently. This variation of understanding is influenced by a number of factors such as the learners' prior knowledge and ability to organize relevant theories to form an interconnected understanding of a subject matter. These variations could positively impact the collective understanding of a concept as it could convey new perspectives, ideas, hypothesis, opposing view that test the current theories and invention and test them for validity.

• Disequilibrium facilitates learning Disequilibrium facilitates learning and thus teachers need to create a learning environment that allows students to 'disturb' the lesson by asking questions or expressing their ideas on issue or matter discussed. The learners are then allowed to explore and generate many possibilities through which the students can resolve the 'disturbance' and then return to equilibration
• Reflective abstraction is the driving force Students need to reflect on the learning process such as journals or any connections made across experiences or strategies so that they are aware not just of what they are learning, but also of how they are learning.
• Learner ownership The construction of knowledge leads to authentic learner ownership and this means that the knowledge becomes part of the owner. This is a continuous process throughout the development of learning. Hence, the courses should support the student-centered learning which will then encourage to knowledge construction.
• Spontaneous interactions In constructivism approach teachers are required to react spontaneously. The teachers should not exert to detail the plan lessons; instead, they should give time for the spontaneous interactions that can be contributed in the learning process.

Based on the above general principles of the constructivist view of learning, the researcher will accommodate these principles into the proposed guideline in the teaching and learning approach. With that the students and the teacher will fully gain the benefits of teaching and learning using constructivist approach in acquiring and constructing knowledge on sustainable development.

2.8 Constructivism Classroom – Teachers' Role

Constructivism is a set of assumptions governing the way people learn and make sense of the world. It's founded on the premise that, by reflecting on personal experiences, people create their own understanding of the world they live in. Constructivist teaching is based on constructivist learning theory. Constructivist teaching is based on the belief that learning occurs as learners are actively involved in a process of meaning and knowledge construction as opposed to passively

receiving information. Learners are the makers of meaning and knowledge. Constructivist teaching fosters critical thinking, and creates motivated and independent learners. This theoretical framework holds that learning always builds upon knowledge that a student already knows; this prior knowledge is called a schema. Because all learning is filtered through pre-existing schemata, constructivists suggest that learning is more effective when a student is actively engaged in the learning process rather than attempting to receive knowledge passively (Santhoshi, 2014)

Therefore in constructivist learning environment, the teacher is no longer perceived as the sole authority of the knowledge, but rather as the facilitator of learning, guiding and supporting learners in the process of constructing knowledge (Beyhan, 2013) and providing the students with experiences that allow them to develop problem-solving, critical-thinking and creative skills, and apply them in a meaningful manner. Table 2.5 shows several recommended considerations of constructivist pedagogy to be practice by constructivist teachers in the learning environment.

Table 2.5: Constructivist pedagogy practice by constructivist teachers in the learning environment (Kim, 2005)

1. Constructivist teachers invite student questions and ideas.
2. Constructivist teachers accept and encourage students' invented ideas.
3. Constructivist teachers encourage student's leadership, cooperation, seeking information, and the presentation of the ideas,
4. Constructivist teachers modify their instructional strategies in the process of teaching based upon students; thought, experience and or interests.
5. Constructivist teachers use printed materials as well as experts to get more information.
6. Constructivist teachers encourage free discussions by way of new ideas inviting student questions and answers.
7. Constructivist teachers encourage or invite students' predictions of the causes and effects in relation to particular cases and events.
8. Constructivist teachers help students to test their own ideas.
9. Constructivist teachers invite students' ideas, before the student is presented with the ideas and instructional materials.

10. Constructivist teachers encourage students to challenge the concepts and ideas of others.
11. Constructivist teachers use cooperative teaching strategies through student interactions and respect, sharing ideas and learning tasks.
12. Constructivist teachers encourage students to respect and use other people's ideas through reflection and analysis.
13. Constructivist teachers welcome the restructuring of his/her ideas through reflecting on new evidence and experiences

Thus, in this study the researcher will try to employs the constructivist pedagogy into the proposed guideline as much as possible. These pedagogies are of great help to teachers in their efforts to assist students to understand the components of the subjects they are teaching. In addition the learning and construction of knowledge will occur efficiently.

2.9 Learning strategies in Constructivist Teaching and Learning

A learning strategy is way to complete a learning task. According to Schumaker and Deshler (2006) a learning strategy is "an individual's approach to a task. It includes how a person thinks and acts when planning, executing, and evaluating performance on a task and its outcomes". Therefore, teachers who use learning strategies teach students how to learn, rather than teaching them specific curriculum content or specific skills. Researchers and practitioners who have studied and applied learning strategy instruction in the classroom generally agree on the how of instruction (Protheroe, 2008).

Over the past decades many teaching strategies have been proposed by various educators to improve education of all students. However no single one of these proposed teaching strategies meets the needs of all students. Anyway all learners need teaching strategies which arouse the unique interest and curiosity to learn. The use of real-life applications and asking stimulating open-ended questions enhance the learning experience for all students (Akpan, 2016) Table 2.6 shows the

different learning strategies used in behaviourist, cognitivist & constructivist learning.

Table 2.6: Comparison between behaviourist, cognitivist & constructivist (Petten, 2014)

	Behaviourist	**Cognitivist**	**Constructivist**
View of the learning process	Change in behaviour	Internal mental - process information	Process in social context, interaction between teacher and learner, negotiation of meaning
Learner fostered	Surface learning and basic skills	Deep processing – exploring, organizing	Collaborative learning
Key considerations	Stimuli to promote learning	Learners customise their learning: provide a range of learning activities	Prior knowledge: design learning to assist students to build on what they know. Opportunity: what a learner can do individually vs. assisted by peer interaction and teaching. Inquiry learning: teachers are not the sole possessors of knowledge and perspective but co-learners and guides.
Role of student	Passive learning -responding to stimuli	Active learning - process, store, and retrieve information for use.	Learners create their own unique knowledge - learning is based on prior knowledge.
Role of teacher	Teacher designs the learning environment	Teacher manages problem solving and structured activities especially with group learning strategies	Teacher mentors peer interaction and continuity of building on known concepts.

Table 2.7 shows some of the learning strategies employed in constructivist approach in teaching and learning. Apart from the learning strategies mentioned there are communication skills, as well as collaboration and exchange of ideas to be considered (Bhattacharjee, 2015). The students are required to express their ideas clearly, sharing and collaborating tasks in group work. In exchanging ideas they learn to negotiate with each other and evaluate each of their contributions in a socially acceptable manner. These are essential attributes to success in their future real working world, where learners will always be exposed to various experiences which they will have to cooperate and navigate among the ideas of others. This is contrary to the traditional classroom in which students work primarily alone, learning achieved through repetition, and subjects are strictly adhered through syllabus and guided by textbooks.

Table 2.7: Summary of some of the learning strategies used in constructivist approach in teaching and learning (Bhattacharjee, 2015; Kalpana, 2014, Li 2012)

a) Active learning	Active learning is one of the strategies in constructivism. The centre of instruction is the learner. The knowledge and creation of knowledge is interactive. Different viewpoints would exist and all student questions are valued. The importance of context related to the learning process is emphasized. The students are actively engaged and have greater ownership of their learning. They share ideas, ask questions, discuss concepts, and revise their ideas where necessary.
b) Collaborative learning	Collaborative learning is another central strategy for constructivism. The students work together in a group small enough for everyone to participate on a collective task The classroom relies heavily on collaboration among students. In constructivist environment the students learn about learning not only from themselves, but also from their peers. The classroom setting is very collaborative, which contributes to enhanced learning outcomes. The collaborative learning does not just sharing a workload or coming to a consensus, but allows learners

	to develop, compare, and understand multiple perspectives on an issue. The learning environment makes it possible for students to build their theories and articulate these theories to one another.
c) Authentic learning	Authentic learning is another learning strategy for constructivism. In authentic learning learners are actually participating and working on real-world problems. It engages learners the opportunities of solving real-world complex problems and finding out solutions. In this way the learners practice the skills and knowledge that are relevant and real to workplace situations. When authentic learning occurs instruction is designed to facilitate, simulate and recreate real-life complexities and occurrences.
d) Inquiry learning	The main activity in a constructivist classroom is solving problems. The students use inquiry methods to ask questions, investigate a topic, and use a variety of resources to find solutions and answers. They are seeking for truth, information, or knowledge -- seeking information by questioning. Inquiry-based learning is an approach to teaching and learning that places students' questions, ideas and observations at the centre of the learning experience. The teacher plays an active role throughout the process by establishing a culture where ideas are respectfully challenged, tested, redefined and viewed. Through the process of inquiry the students construct much of their understanding of the natural and human-designed worlds. Inquiry is not so much seeking the right answer -- because often there is none -- but rather seeking appropriate resolutions to questions and issues Concept to classroom.

In addition of employing various strategies in constructivist approach in teaching and learning some other activities are encouraged in the constructivist classrooms (Gray, 2007). There are:

- Experimentation – students carry out experiment and then discuss the outcomes of the experiment in the class
- Research projects - students explore issues and present their findings and conclusions to the class.
- Field trips - students position the concepts and ideas and discuss in the class in a real world situation. Field trips would generally be followed by class discussions.
- Films/ video - these provide visual context and thus bring another perspective into the learning experience, where it also provides self-reflection and assessment and feedback on oneself for improvements.
- Class discussions - This practice is used in all of the approaches described above. It is one of the most important distinctions in constructivist teaching methods.

The sustainable development issues are always surrounded by uncertainty and ambiguity. So in order to solve or determine the possible solutions for the sustainable development problems the learner need to be equipped with the necessary knowledge and skills to manage this uncertainty. They have to make judgments about the best and most suitable course of action based on the available evidence. The learners should have higher-level creativity, cognitive and critical thinking skills to enable them to evaluate the implications of their solutions beyond their immediate technical context (Armstrong, 2011). However, these required skills and the ability to collect, evaluate, and utilize information are often not fully developed in the teacher-centred classroom (Huntzinger et *al.*, 2007). Thus, all the above learning strategies can be apply in teaching and learning of knowledge on sustainable development in Civil Engineering Construction course.

2.10 Teaching Model

Teaching models are just instructional designs. They describe the process of specifying and producing particular environmental situations which cause the students to interact in such a way that specific change occurs in their behaviour. Teaching model is a plan or pattern that can be used to shape curriculum or course, to select instruction materials, and to guide a teacher's action. It consists of guidelines for designing educational activities and environment. It specifies ways of teaching and learning that are intended to achieve certain intended kind of goals (Gupta, 2014).

Basically the main functions of teaching model are (Asim, 2012)

i. Formulate a complete and perfect teaching scheme.
ii. Enable teachers to analyse and evaluate its strength and weakness so as to plan and implement appropriate follow-up actions.
iii. As basic guidance for teachers for reflection during feedback session.
iv. Provide guidance to planners and teachers to enable them to plan and perform the teaching process effectively.

In this research Needham's Five Phase Constructivist Model (NFPCM) was chosen for the classroom setting. This model was first proposed by Richard Needham in 1987 (Needham & Hill, 1987) to assist students in enhancing their learning in science subject. The work was known as 'Learning in Science Project in a school in United Kingdom. The constructivist model consists of the five phases is presented in Table 2.8.

This model was selected for this study because it has good and clear guideline for every phase of the model. Some studies had been done in Malaysian secondary and technical schools using this Needham's Five Phase Constructivist Model. Few examples are given in Table 2.8.

Table 2.8: Needham's Five Phase Constructivist Model (NFPCM) (Kee, 2015)

Phase	Purpose	Examples of activities
1. Orientation	To attract students attention and interest.	Experiment, video and film, demonstration, problem solving
2. Generation of idea	To be aware of the student's students prior knowledge.	Experiment, small group discussion, concept mapping and presentation.
3. Restructuring of idea.	To realize the existence of alternative ideas, ideas need to be improved, to be developed or to replace with scientific ideas.	Hands-on and minds-on activities.
i. Explanation and exchanging ideas	To determine the alternative ideas and critically assess the present ideas.	Activities that utilized science-process skills. Group communication.
ii. Exposure to conflict ideas	To test the validity of the present ideas.	Small group discussion and presentation.
iii. Development of new ideas	To improvise, develop or to replace with ideas.	Discussion, reading and teacher's input
iv. Evaluation	To test the validity of the new ideas	Experiment, project and demonstration.
4. Application of idea	To apply the new ideas to different situation.	Writing of individual's report on the project work.
5. Reflection	To accommodate ones idea to scientific	Writing of individual's report on the project work, group discussion, personal notes.

The explanation of each phase of Needham's Five Phase Constructivist Model (NFPCM) is:

i) The orientation phase is to attract students' attention and interest and motivate them to keep their interest during the teaching and learning process.

ii) The phase of generating ideas are for the teachers' to identify students' alternative thinking or prior knowledge and encourage them to think and inquire why they are not thinking comparable with the scientific ideas. The questions that encouraged to think have to be initiated by the teachers.

iii) The phase of restructuring ideas is information and activities to be conducted in helping the students' to develop new concepts and subsequently the students will be able to explain for example the definitions concepts, discussion and replace the old ideas with the new ideas.

iv) The phase of application idea is ability to apply the new idea to a new situation and associate them with other fields or in the real world problem.

v) The reflection phase is to assess and evaluate student understanding of the new ideas and see that the students had changed. Examples of activities are reflective questioning of the students as what they think, what evidence you have or what you know about things that matter. The effect on student is to assess whether the students understand the concept and be able apply what they had learned.

Table 2.8 has 3 columns. The first column depicts the phase of the model. There are five phases and the explanation of the each phase is written in the preceding paragraph. The second column presents the purpose of each phase. The third column shows the examples of the activities that be done so that the outcome of the learning is effective. However, these activities could be replaced with others which could give the same impact on the students' learning. The activities are up to discretion of the teacher who is applying the constructivist approach teaching and learning.

2.11 Previous local studies

There were many studies been done using Needham's Five Phase Constructivist Model (HFPCM). Some of these studies are shown in Table 2.9 and these work were carried out in the local environment. The findings are shown briefly in the fourth column of the Table 2.9. Some had significant results, and some have difficulties and challenges in implanting the Needham's Five Phase Constructivist Model (HFPCM).

Table 2.9: Previous local studies conducted using Needham's Five Phase Constructivist Model (NFPCM)

Journal	Findings
Application of Needham's Five Phase Constructivism Model in (Civil, Electrical and Mechanical) Engineering Subject at Technical Secondary School (Hashim & Kasbolah, 2012)	Some problems in implementing few phases of Needham's
The Instructional Material Blended with Needham 5 Phases Strategy in Teaching Visual Art Education (Mohamed, 2013)	Teacher - Recommended
Malaysian primary teachers' classroom practice of teaching and learning science(Yunus, Ismail, & Raper, 2004)	Teachers lacking of experience in conducting constructivist approach in teaching.
Amalan pengajaran dan pembelajaran sains menggunakan pendekatan konstruktivisme 5-fasa needham dalam kalangan guru KPL (Omar, 2007)	Teachers need professional course for constructivist approach in teaching.
Penggunaan model konstruktivisme lima fasa needham dalam pembelajaran sejarah (Nair & Muthiah, 2005)	Significant results but the teachers had to be supervised in conducting constructivist approach in teaching
Keberkesanan modul pengajaran fizik yang dibangunkan mengikut perspektif konstruktivisme (Mohamad, 2012)	Positive result. The teaching and learning has to be systematic in manner in order to achieve significant result.
Keberkesanan Kaedah Konstruktivisme Dalam Pengajaran Dan Pembelajaran Matematik (Zainuddin & Suardi, 2010)	Students – significant results
Keberkesanan model konstruktivisme lima fasa needham dalam pengajaran komsas bahasa Melayu (Jasin & Shaari, 2012)	Students – significant results

Journal	Findings
Rekabentuk dan keberkesanan pembelajaran berbantukan multimedia pendekatan konstruktivisme bagi sains kbsm (Mat & Halim, 2002)	Students – moderate achievement
Aplikasi pendekatan konstruktivis medalam rekabentuk pengajaran berasaskan komputer: pengaruhnya terhadap pencapaian berdasarkan aras kognitif pelajar. (Munip, 2012)	Signifant results

From the findings of the journal articles most stated that the teaching and learning activities are pertinent components in achieving the efficiency of Needham's Five Phase Constructivist Model (NFPCM) in the classroom. Table 2.8 does not provide enough details into how to execute effectively the constructivist model. Thus, Table 2.9 is used as a reference as which teaching and learning activities are most appropriate to be employed. The activities stated in the third column of Table 2.8, are supposed to assist the students' learning. However, these examples of activities in Table 2.8 might be vague to be engaged especially to those who are inexperienced or lack of experience in using constructivist approach in teaching. For those who are the first time applying constructivist approach in teaching will face with some difficulties and challenges. To overcome this, the researcher had tried to derive the most suitable activities and strategies in learning to match each phase in the Needham's Five Phase Constructivist Model (NFPCM). The selected learning strategies are referred to Table 2.7. These learning activities and strategies will be detailed and become one of the components in the Teaching plan depicted in Tables 3.9, 3.10 and 3.11 in Chapter 3. Thus, from the teaching plans the components of the teaching and learning approach in integrating knowledge on sustainable development in Civil Engineering Construction course will be developed as shown in Table 4.16, Chapter 4.

2.12 Sustainable Development

The concept of sustainable development first emerged as a reaction to a growing concern about human impact on the natural environment. The concept was defined by Brundtland in 1987 as *'development that meets the needs of the present without compromising the ability of future generations to meet their own needs'* (Drexhage & Murphy, 2010). The definition recognises that while development may be required to meet human needs and improve the quality of life, it must happen without diminishing the capacity of the natural environment to meet present and future needs. The sustainable development movement campaigned that sustainability protects both the interests of future generations and the earth's capacity to restore. At first it stressed environmental policies but, since 2002, has changed to embrace social justice and the fight against poverty as key principles of sustainable development.

The underlying concepts of sustainable development are defined by Agenda 21. Agenda 21 promote the three pillars of sustainable development as interdependent and mutually reinforcing concepts. Figure 2.1 shows the three pillars of sustainable development. The pillars represent the economic, social, and environmental. The first pillar is on social sustainability is the ability of a social system, the second pillar is on environmental sustainability is the ability of the environment, and the third pillar is economic sustainability is the ability of an economy. If anyone of the pillars is weak then the system as a whole is unsustainable (UNCED, 1992)

Sustainable development is not only a goal for decision makers, political leaders and companies. It affects everyone and is part of even the most minor decisions people make in life. People need to know how to generate creative solutions to current global challenges; about reflecting on new lifestyles which combine well-being, quality of life and respect for nature, environment and other people (Plessis, 2002).

Figure 2.3: The three pillars of sustainable development (UNCED, 1992)

2.13 Construction Industry and its Impact on the Environment

The construction industry contributes significantly to the development of both developed and developing countries. The industry provides the basic amenities and infrastructure such as residential building, roads, airports, railways, ports, power electricity, communication utilities, and also the other basic infrastructure needed in a country (Jamilus Hussein, Zuhairi Abd. Hamid, Ghani, & Zain, 2010). It also acts as catalyst and enables other industries namely manufacturing, professional services, financial services, education and others to grow. It employs a large number of people and therefore has a positive effect on the economy of a country (Ahmed, 2012). However, this construction industry also consumed large amount of non-renewable energy generating fairly large amount of pollutants including air and noise emission, solid waste and water discharge (Dixon, 2010). Researchers depicted it as a major contributor to environmental pollution, and compared to other industries, it has inherited as non-environmental friendly.

According to March (1992), construction industry from environmental impact perspective could be categorized as ecology, landscape, traffic, water, energy, timber consumption, noise, dust, sewage, and health & safety hazard (Simon Ofori Ametepey, 2012). Air pollution is contributed by activities such as land clearings, demolition works, burning of toxic wastes and operation of diesel engines. Demolition works as an example, typically produced high level of dust from

concrete, cement, wood, stone and silica which can cover a wide area and over a long period of time, and are harmful to dwellers and detrimental to the environment. On the same note, remnants of diesel, oils, paints, solvents, cleaners and other harmful chemicals, and construction debris and dirt are typical of water pollutants from construction sites (Janda, 2009).

Another building construction activity of great impact is the use of resources like timber and non-fuel materials, which could lead to habitat destruction, loss of arable land and loss of biodiversity. The deforestation of the Amazon rain forest also impacted global warming (Edoka Augustine Ijigah, 2013), which forms one of the three greatest and most imminent threats to the survival of our civilization, other than peak oil the growing energy gap between supply and demand and resource depletion.

In meeting societal needs for development, its activities before, during and after the creation of the construction products have adverse effects on the environment. Some of the negative effects of construction activities include land misuse erosion, desertification, destruction of natural resources and vegetation, change in direction of flow of underground water, loss of wild life and their habitat, air and noise pollution, waste/effluent discharges, on-site wastage, health and safety impairment, generation of solid and gaseous wastes and again resource depletion (Adogbo & Chindo, 2009).

Construction environmental impacts could also be classified as an extraction of environmental resources such as fossil fuels and minerals; extending consumption of generic resources, namely, land, water, air, and energy; the production of waste that require the consumption of land for disposal; and pollution of the living environment with noise, odours, dust, vibrations, chemical and particulate emissions, and solid and sanitary waste (Shen & Tam, 2002). Chen (2005) stated the construction impacts can be considered under eight categories: soil and ground contamination, ground and underground water, construction and demolition waste, noise and vibration, dust, hazardous emissions and odours, wildlife and natural features impacts and archaeology impacts (Chen, Li, & Wong, 2005).According to Cardoso 2005, typical negative impacts of the construction activities include waste production, mud, dust, soil and water contamination and damage to public drainage

systems, destruction of plants, visual impact, noise, traffic increase and parking shortage and damage to public space (Chen et al., 2005).

Since construction industries have been identified to contribute to the environment in many negative ways therefore there is a need to strike a balance between human and economic requirement and the environmental consideration. Thus to ensure environmental sustainability and the achievement of sustainable development goals, sustainable construction need to be promoted both by the government, industry and practitioners. One of the ways to promote the sustainable construction is to incorporate the knowledge on sustainable development into Civil Engineering Construction course.

2.14 Sustainable Construction

Construction activities, whether through the manufacturing of materials or through the physical activities of construction, always lead to a number of environmental issues, amongst which include loss of arable land, release of toxics into the biosphere, deforestation, noise as well as dust pollution. These issues need serious attention and scrutinization to strike a balance between human requirement and environmental consideration, in order to achieve environmental sustainability and its development goals. They should be further supported by both the government authorities in its legislature and the industry practitioners during project execution.

Sustainable construction is generally described as the application of sustainable development to the construction industry. It is also considered as a subset of sustainable development, which encircles matters such as tendering, site planning and organization, material selection, recycling, and waste minimization (Irurah, 2011).

There are many definitions given by researchers to describe sustainable construction and few of them are presented below. Charles Kibert, the first person to propose the definition as : “Sustainable construction is the creation and responsible

management of a healthy built environment based on resource efficient and ecological principles" (Kibert, 1994), He proposed during the First International Conference on Sustainable Construction in Tampa 1994, the 6 principles for the sustainable construction as follows ; (i) minimization of resource consumption, (ii) maximization of resource reuse, (iii) use renewable and recyclable resources, (iv) protect the natural environment, (v) create a healthy and non-toxic environment and (vi) pursue quality in creating the built.

Haselbach & Fiori (2006) defined Sustainable Construction as "a process of a product during its service life which aims in minimizing the use of energy and emissions that are detrimental to environment and health, and produces these relevant information to customers for their decision making". Another definition by Lanting (1998); "a way of building which aims at reducing negative health and environmental impact caused by the construction process or by the built environment" (Haselbach & Fiori, 2006)

The International Council for Research and Innovation in Building and Construction CIB defined "Sustainable construction as one that uses the principles of sustainable development into the comprehensive construction cycle from the extraction and beneficiation of raw materials, through its planning, design and construction of buildings and infrastructure, until their final deconstruction and management of the resultant waste. It is a holistic process aiming to restore and maintain harmony between the natural and built environments, while creating settlements that affirm human dignity and encourage economic equity (Plessis, 2002).Although there are various definitions by researchers, the aims and goals of sustainable construction remain the same. Sustainable construction is a way for the building industry to move forward in achieving sustainable development, taking into account its environmental, economic and social impact.

Manoliadis and Tsolas (2006) defined ten factors for change to implement sustainable construction, which are : energy conservation, waste reduction, indoor conservation, incentive programmes, performance-based on standards, land use regulations and urban planning policies, education and training, re-engineering the economic and ecological value system, new kinds of partnerships and project

stakeholders, and product innovation and/or certification and recognition of commercial buildings as productivity assets. These factors should stimulate stakeholders to adopt sustainable design in their building project (Odysseus Manoliadisa, 2006).

The advantages of implementing knowledge on sustainable development are related to these three main aspects:

i) environmental benefits are in the improvement of air and water quality, minimization of energy and water consumption and reduction of waste disposal,

ii) the economic benefits by reducing operating and maintenance cost and increasing revenue and

iii) its social benefits by enhancing occupants' comfort and health and minimizing absenteeism, turnover rate and liabilities (Baloi, 2003).

Therefore the above discussion shows that the importance of employing sustainable construction in the construction industry. The sustainable construction is the way of material process and building activities to minimize the use of energy and emissions that are detrimental to environment and health. Generally it describes the application of sustainable development to the construction industry

2.15 Summary

The literature which is pertinent to the research has been reviewed. The review started with Sustainability and Higher Education Institutions (HEIs) stated in Section 2.2. HEIs should transform its curriculum and pedagogy to address the sustainable development problems. The learning theories are given Section 2.3. There are many theories involved in learning. Theories of learning explain on how people learn and thereby assist in understanding the inherently complex process of learning. Basically there are three main categories of learning theories:

behaviourism, cognitivism, and constructivism. The Rationale of Selecting of Constructivism is given in Section 2.4. It indicates that the learning theory of the constructivism is used to handle ill-defined problem. To be able to handle ill-defined or ill-structured problems learner must have certain abilities and skills. The required abilities and skills could not well develop in teacher-centered classroom so the learner must go through other teaching paradigm.

Section 2.5 is regarding the Constructivism Approaches. Two main approaches to constructivism are cognitive constructivism and social constructivism. The cognitive approach focuses on the ways in which meaning is created (Schcolnik et *al.*, 2006) within the individual mind and how shared meaning is developed within a group process. The social constructivism concentrates on how the development of that formal knowledge has been created (Richardson, 2003). Section 2.6 is about Constructivism Theory. Constructivist theorists claims that learning is more effective when teachers use constructivist methods that typically involve more student–centered (Almon Shumba, 2012) active learning experiences, more student–student (Kocevar-Weidinger, 2004) and student–teacher interactions, (Amarin & Ghishan, 2013) and more work with concrete materials and in solving realistic problems (Almon Shumba, 2012).

Section 2.7 is regarding Constructivist View of Learning. Constructivist learning arose from Piagetian and Vygotskian perspectives (Ruey, 2010), emphasising the impact of constructed knowledge on the individual's active, reflective thinking (Almon Shumba, 2012). Section 2.8 is about Constructivism classroom: Teachers' role. In constructivism, the teacher is no longer perceived as the sole authority of the knowledge, but rather as the facilitator of learning, guiding and supporting learners in the process of constructing knowledge (Beyhan, 2013) and providing the students with experiences that allow them to develop problem-solving, critical-thinking and creative skills, and apply them in a meaningful manner.

Section 2.9 discusses Learning Strategies in Constructivist Teaching and Learning. A learning strategy is a person way of organizing and using a particular set of skills in order to learn content or accomplish other skills more effectively and efficiently. In constructivist classroom teachers use various learning strategies to

teach students how to learn, rather than teaching them specific curriculum content or specific skills. Section 2.10 is regarding the Teaching Model. A teaching model is a plan or pattern that can be used shape curriculums long-term courses of studies, to design instruction materials, and to guide instruction in the classroom and other settings. In this research Needham's Five Phase Constructivist Model (NFPCM) has been employed for the classroom setting. It is chosen because it has good and clear phases for those who are inexperience of practicing teaching and learning constructivism in the classroom setting.

Section 2.11 is regarding Sustainable Development. The concept of sustainable development first emerged as a reaction to a growing concern about human impact on the natural environment. The concept was defined by Brundtland in 1987 as 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (Drexhage & Murphy, 2010). Section 2.12 is regarding Construction Industry and its Impact on the Environment. The construction industry contributes significantly to the development of both developed and developing countries. Lastly Section 2.13 defines Sustainable Construction. Sustainable construction is generally described as the application of sustainable development to the construction industry. It is also considered as a subset of sustainable development which encircles matters such as tendering, site planning and organization, material selection, recycling, and waste minimization (Irurah, 2011).

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

This chapter describes the methodology employed in order to achieve to the research objectives as stated in Section 1.4. The main objective of the research is to employ a constructivist approach in teaching and learning to incorporate the knowledge on sustainable development into the Civil Engineering Construction course. This chapter consists of operational framework, research design, research setting and population, research instruments, research procedure, data collection, reliability and validity, application of Needham's Five Phase Constructivist Model (NFPCM) to teaching, data analysis and the lastly the summary of the chapter.

3.2 Operational Framework

The operational framework of the research is depicted in Figure 3.1. It describes the sequences of work to accomplish the research objectives. The research work began with preliminary study. The researcher did some informal discussion with few construction industry stakeholders. They suggested that the university should consider incorporating sustainable development into the engineering curricula. A body of literature on sustainable development and sustainable construction were reviewed. Thus the researcher did some literature work and

indeed found out there was a need to include knowledge on sustainable development into engineering education.

The preliminary study and literature review leads to problem identification and thus the development of the Research Objectives (RO) and research questions (RQ). Once the RO and RQ had been formulated the research setting was identified. The students involved were third year students doing Diploma in Civil Engineering. The students' participation in the research was involuntary basis.

A survey questionnaire was conducted on the students followed by the pretest and then the semi-structured interview. This was done during the first week of the semester. After collecting the data from the survey questionnaire, pretest and semi-structured interview the researcher determined the teaching and learning approach to be employed in the classroom setting. From the literature review the researcher considers that the constructivist teaching and learning approach (Kocevar-Weldinger, 2004) is suitable for the students' learning of sustainable development.

For the class intervention the Needham's Five Phase Constructivist Model (NFPCM) was used in the classroom setting. During the classroom intervention, open-ended questions, field trip report and group work assignment were delegated to the students. The posttest and semi-structured interview were conducted on the final week of the semester. All the data collected were then analysed. Lastly, is to produce a guideline for integrating knowledge on sustainable development into Civil Engineering Construction course.

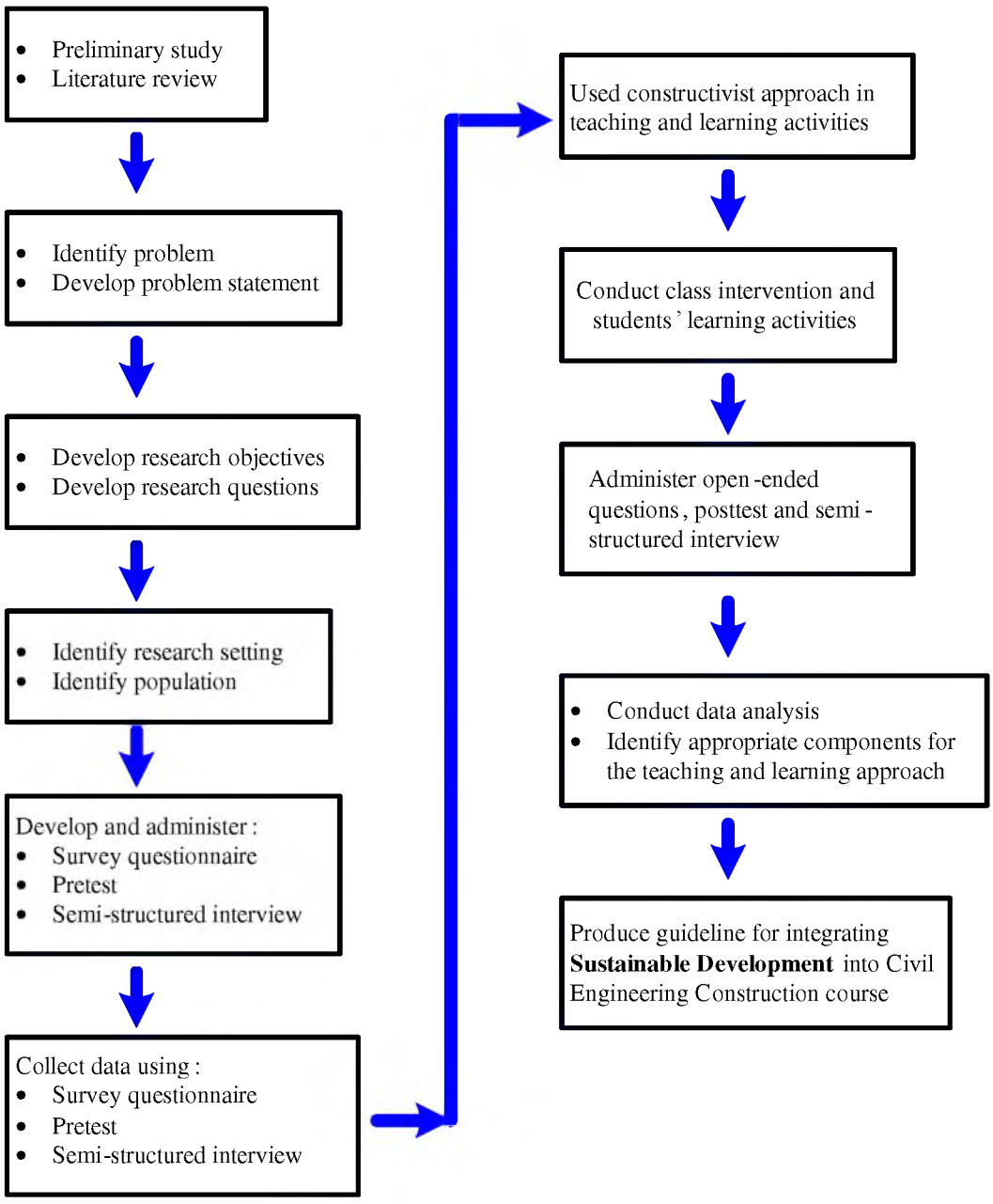

Figure 3.1 Operational Framework

3.3 Research Design

This research employs qualitative and quantitative approaches to collect and analyse the data (Fischlers, 2012). Both approaches are employed to ensure that the data will sufficient and sound. An advantage of using the quantitative approach in this study was that it enabled the research to generalize the findings within the

research setting and advantage of the qualitative approach in this study was a deeper understanding of the participants' knowledge on sustainable development. The quantitative data can provide a rich description, interpretation, and expression of psychological events by the researcher and research participants and allow the theory to emerge instead of being predetermine (Creswell, 2003). Table 3.1 shows the research objectives, research questions, types of data and methods of collecting the data used in conducting the research.

Table 3.1: Research objective, question, types of data and methods of collection

Objective	Question	Types of Data	Methods of collection
RO1.To determine the awareness of sustainable development among engineering students.	RQ1. What is the engineering students' awareness towards sustainable development?	1. Quantitative	• Survey questionnaire
RO2.To determine the students' knowledge on sustainable development through the pretest and posttest conducted.	RQ2. What is the knowledge that the students' have on sustainable development through the pretest and posttest conducted?	2. Quantitative	• Pretest and posttest
RO3.To examine the students' knowledge on sustainable development after using Needham's Five Phase Constructivist Model (NFPCM) in the classroom setting	RQ3. What is the students' knowledge on sustainable development after using the Needham's Five Phase Constructivist Model (NFPCM) in the classroom setting?	3. Qualitative	• Open-ended question • Field trip report, • Group work assignment

Objective	Question	Types of Data	Methods of collection
RO4. To produce a guideline on teaching and learning approach in integrating knowledge on sustainable development into Civil Engineering Construction course based on the constructivist approach.	RQ4: What are the components of the guideline on teaching and learning approach in integrating knowledge on sustainable development into Civil Engineering Construction course based on the constructivist approach.	4. Qualitative 5. Quantitative	• Deduce from the above findings

3.4 Research Setting and Population

The research was conducted at Universiti Teknologi Malaysia (UTM), Kuala Lumpur. The university conducts courses of engineering, architecture, quantity surveyor, town and country planning and technology management. All the mentioned courses are at diploma level and the university aims to produce semi-professionals who may opt to go for further study to degree level or join the workforce. The duration of the diploma program is between three and five years, comprising between six to ten semesters. The diploma program typically requires a completion of a minimum of 90 credit hours.

This research involves students of Civil Engineering Diploma programme as respondents in the study. They were in the first semester of the third year course. They had done the Civil Engineering Construction Course during the second year. The students' participation in the research is non-voluntary basis.

3.5 Research Instruments

Research instruments are measurement tools or device (for example, survey, test, questionnaires) designed to obtain data on a topic of interest from research subjects (Miller, 2016). In this research survey questionnaire, pretest and posttest, open-ended questions, field-trip report, group work assignment and semi-structured interview are used as the research instrument to collect the data. The research phases are shown in Figure 3.2. The research instrument phases are divided into two parts. The first part consists of survey questionnaire, pretest and semi-structured interview. These three research instruments were conducted before starting of the class intervention. The second part of research instrument consisted of open-ended questions, field trip report, group work assignment, posttest, and semi-structured interview. These research instruments were administered during the class intervention.

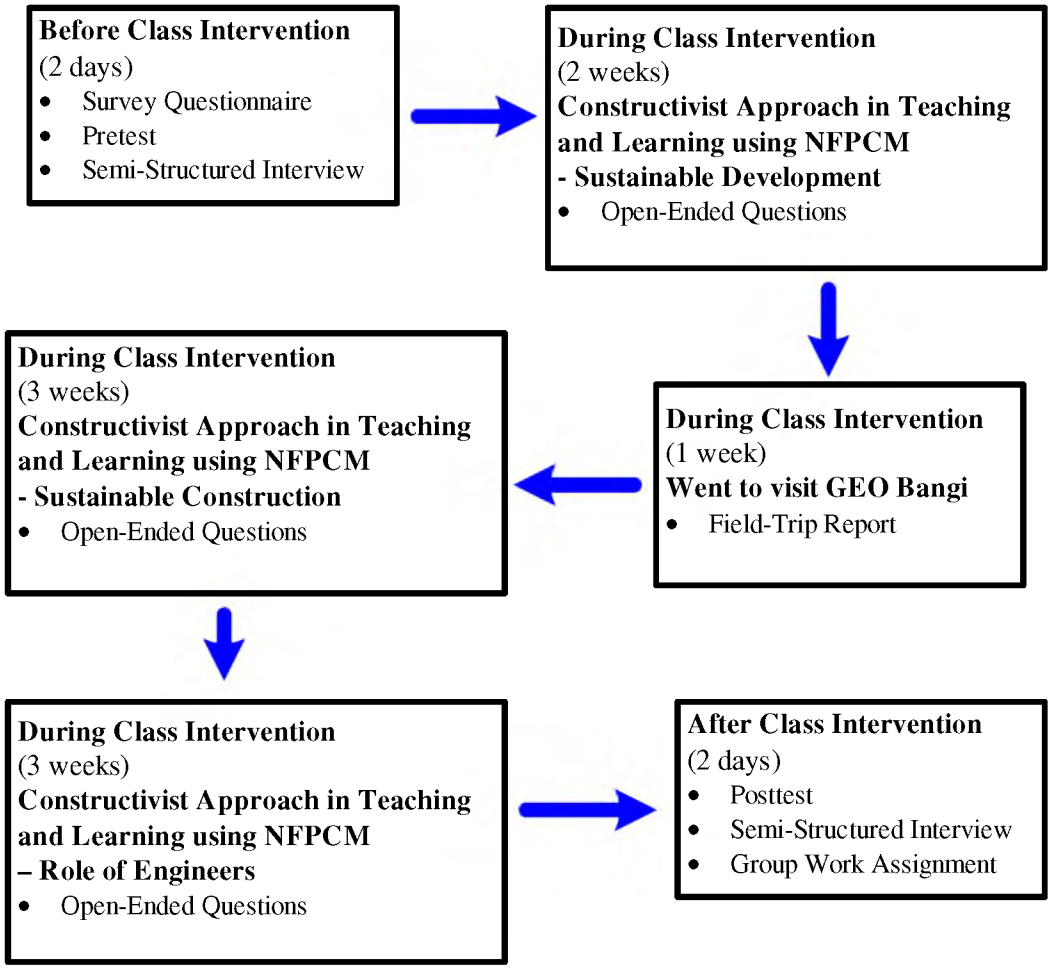

Figure 3.2 Summary of research instruments applied before and after the class intervention

3.5.1 Survey Questionnaire

Survey research is a commonly used method of collecting information about a particular population by sampling some of its members There are many modes to conduct survey for collecting data such as face-to-face survey, questionnaires survey, telephonic survey, postal or mail out survey and internet-based survey. The selection of the appropriate method depends upon a number of factors, including access to potential respondents, the literacy level of respondents, the subject matter, the motivation of the respondents and resources A questionnaire is a research tool that uses questions to gather information from respondents. It is a type of survey that is meant to help with the statistical analysis of the responses (Trochim, 2006)

In this research a survey questionnaire was administered among the students at beginning of the semester before the start of the class intervention. The questionnaire was used to measure the awareness of sustainable development amongst the third year diploma Civil Engineering students. The variables for the awareness of sustainable development in this research consists of perception of sustainable development, attitudes on sustainable development, environmental conscious, motivation to change and personal views of on incorporating sustainable development into Civil Engineering Construction course.

In the survey questionnaire, the students were requested to respond to each item on a five-point Likert scale: 5 Strongly Agree, 4 Agree, 3 Slightly Agree, 2 Disagree, 1 Strongly Disagree. Introducing the Likert scale is an initiative to obtain precise responses from which discussion may be derived from the statistical analysis. The validation for the survey questionnaire is given in Appendix E.

3.5.2 Pretest

After administering the survey questionnaire, a pretest was conducted on the students. The purpose of the pretest is to assess the students' prior knowledge on sustainable development before starting of the class intervention. The pretest can

give the students a preview of what will be expected of them. This could help the students begin to focus on the key topics that will be covered in the class.

The pretest consists of seventeen questions and a multiple choice questions test. The test is to a measure the amount of pre-existing knowledge and understanding of sustainable development. The outcome of the pretest would help the teacher to find some knowledge gaps among the students.

The questions are divided into 2 types of knowledge. The definition of knowledge is presented in Table 3.2 below.

Table 3.2: Types of knowledge (Wilson, 2013)

Knowledge	Definitions
Factual Knowledge	is knowledge that is basic to specific disciplines. This dimension refers to essential facts, terminology, details or elements students must know or be familiar with in order to understand a discipline or solve a problem in it.
Conceptual knowledge	is knowledge of classifications, principles, generalizations, theories, models, or structures pertinent to a particular disciplinary area.

3.5.3 Semi-structured Interview after the Pretest

A semi-structured interview was conducted on eleven numbers of students after administering the survey questionnaire and pretest. It is a qualitative method of inquiry that combines a pre-determined set of open questions (questions that prompt discussion) with the opportunity for the interviewer to explore particular themes or responses further. A semi-structured interview does not limit respondents to a set of pre-determined answers (unlike a structured questionnaire) (Harrell, 2009) Polit and Beck (2006) define an interview as: 'A method of data collection in which one person (an interviewer) asks questions of another person (a respondent): interviews

are conducted either face-to-face or by telephone. In this research the semi-structured interview was done face to face.

3.5.4 Open-ended Questions

The class intervention started after the survey questionnaire, pretest and semi-structured were done. The class began with the introduction of knowledge on sustainable development. At the end of class session a set of open-ended questions was given to the students. The responses for the open-ended questions were done individually and collected before the class ended for the day.

An open-ended question is designed to encourage a full, meaningful answer using the students own knowledge and or feelings. The answers could come in the form of a list, a few sentences or something longer such as a speech, paragraph or essay .The open-ended questions require a response with more depth and a lengthier response and are also helpful and discover more about the person or situation. Sometimes the answers given might show some uniqueness and unexpected among the responses and these unanticipated answers could be extremely valuable. At times the written answers reveal a great deal about the respondent thinking. The essential logic of their reasoning and the steps in their thinking process to their language choices and frame of reference, there was a huge amount could be learned from reading their thoughts in their own words (Farrell, 2016).

It is the opposite of a closed-ended question, which encourages a short or single-word answer such as Yes/No. In a situation that requires contextualisation, complex description and explanation, a simple Yes/No or multiple-choice answer is not enough.

3.5.5 Field Trip Report

The students were asked to write about their educational knowledge and experience during the visit to Green Energy Office (GEO), Malaysia's first certified green building and a low carbon emission. The students had to hand in the witting individually. In addition the students had to do their group work assignment.

3.5.6 Group Work Assignment

The students had to write few essays based on the topics assigned to them. They have to work within their respective group. The writings would help the students to develop their eloquence and be creative in their thinking and writing skills.

3.5.7 Posttest

A multiple-choice test was conducted on the students at the final week of the semester after completed the class intervention. The questions were similar to the pretest which was done at early of the semester. The aim of the posttest is to see if there was a knowledge gap in the finding. The result will show in the form of improvement in the knowledge on sustainable development that had occurred among the students.

3.5.8 Semi-structured Interview after the Posttest

A semi-structured interview after posttest was conducted on eleven students. The prepared questions were almost similar to semi-structured interview after the pretest. The students were allowed to respond freely and given space to answer in as

much detail as they could. They could convey their feedback and ideas in their own understanding of the questions or subject matter.

3.6 Research Procedure

The research procedure highlighted the process of the research that was conducted. The following sub-sections explain the research procedures that were undertaken.

3.6.1 Survey Questionnaire

A survey questionnaire was administered to the students at the beginning of the semester before starting the class intervention. The survey questionnaire consist of seven parts, each part for the purpose to investigate demography, perception of sustainable development, environmental awareness, perceptions of Malaysia's environmental problems, attitude to change and personal views of incorporating sustainable concept and principles into Construction course. The main aim of the survey questionnaire was to determine the students' awareness of sustainable development. The survey questionnaire for the students was adopted from Measuring Knowledge, Attitudes and Behaviours towards Sustainable Development: Two Exploratory Studies' (Michalos, 2009). The survey questionnaire consisted of seven parts, each part for the purpose of: to investigate demography, perception of sustainable development, attitudes on sustainable development, environmental awareness, motivation to change and personal views of on incorporating knowledge on sustainable development into Civil Engineering Construction course. There were some questions designed by the researcher based on the literature review. The designed questions were to accommodate the personal views on incorporating knowledge on sustainable development into Civil Engineering Construction course.

3.6.2 Field Trip Report

Apart from the classroom intervention the students were brought to a field trip with the aim to enrich their horizon regarding sustainable development. A visit to the Green Energy Office GEO, Malaysia's first certified green building and a low carbon emission building was arranged for the students. The GEO building, the first of its kind in South East Asia is located on a 5-acre land in Section 9, Bandar Baru Bangi, Selangor, just 40 km south of Kuala Lumpur and was especially designed to be energy efficient. Before going for the trip the students were advised to bring their own stationaries to jot down some information about Green Energy Office GEO building. They were encouraged to ask questions to the GEO officer. On arrival at the GEO Building the students were given a brief explanation by the officer. The officer gave some information why GEO Building is important and how it does contribute to the green issue solution in Malaysia. After the questions and answers session, a short tour was organized in the GEO building. While touring in the building the officer explained the concept and design of the building and purpose of using certain construction materials in the building. After returning from the field trip the students were asked to write a brief report on their field trip experience. The writing of this report help the students to enhance their understanding and ability to understand the links between theory and practice. After the field trip they seemed to be able to integrate the new acquainted knowledge and principles introduced in the classroom with the real life world problem. The writing process of the field trip greatly assisted the students in their written communication skills. In an addition their other potentials such as critical and creative thinking skills were developed too.

3.6.3 Group Work Assignment

Group work is another learning strategy which is highly recommended. Cooperative learning involves having students work together to maximize their own and one another's learning (Burke, 2011). In Needham's model it is stated in the generation of idea and restructuring of idea phase (See Table 2.8). From the constructivist of point of view it is considered as active and collaborative learning.

At the beginning of the semester, the students were asked to form a group of four. Each group was assigned a project, which had to be completed before the semester ended. It was emphasized that they had to work together and not individually until the project was completed and graded. The group work started as early as the second week of the semester so that the students could familiarize themselves with one another. A good team relationship is essential for a successful teamwork. They were told to avoid breaking up at any costs. Each group had to find its way to handle unproductive group members. It was also emphasized that the quality of work of an individual member will definitely affect the overall quality of the assignment submitted hence each member of the group is dependent on and responsible towards one another.

The group project assignment is used to assist the students to enhance understanding of sustainable development in construction course. In order to develop the social skills of the students the students were asked to form a group of four at the beginning of the semester. Each group was assigned same set of project, which had to be completed before the semester ended. It was highlighted that they had to work together and not individually until the project was completed and graded. The group work started as early as the second week of the semester so that the students could familiarize themselves with one another. A good team relationship was essential for a successful teamwork. They were told to avoid breaking up at any costs. Each group had to find its way to handle unproductive group members. It was also emphasized that the quality of work of an individual member will definitely affect the overall quality of the assignment submitted hence each member of the group is dependent on and responsible towards one another.

3.6.4 Classroom Teaching Procedure for Sustainable Development

Firstly, the class was posed with a general question what is an environmental issues? To start with, the researcher gave a brief introduction by saying environmental issues have been a national, regional and global concern. The researcher expected that this question would create curiosity among the students

because environmental issues and problems have been a concern to the world and Malaysia for the last decade.

The students were given a set time to discuss among their respective groups on the environmental issues and problems. They had to think the possible means and ways on how to reduce and solve the environmental issues. They were encouraged to make some suggestions or improvements on the existing ways of solving the problems either on a national, regional and global scale. They were also motivated to take charge of their own learning at this stage by discussing among their group members. After the group discussion, the students had to present their ideas, thoughts and opinions through their own selected representatives in front of the class. Their ideas and thoughts were allowed to be debated and challenged by other groups.

After the students' presentations, the researcher discussed the concepts and knowledge related to the topics. There were told there is one main concept which had been agreed globally which is known as the "sustainable development". The students were given some time to really digest the concept and principle. They were given the opportunity explore how to use and apply the new concept in various situations. They were allowed to ask questions to the researcher or discuss among their peers. With the assimilation of the new information learnt the students' knowledge and understanding could further be developed and enhance.

Before the class session ended, the students were given a set of open-ended questions. The aim of these questions was to determine the students learning and understanding on the newly introduced knowledge. This would help the researcher in creating an assessment on how the activity is assisting the students' learning and construction of knowledge.

3.6.5 Classroom Teaching Procedure for Sustainable Construction

In this lesson, the class was given a statement "Construction activities have great impact on the environment". The aim was to invoke the students' curiosity.

They were asked to discuss among their group members why construction activities create environmental issues and problems. They had to suggest few examples of construction activities which they thought would create impacts on the environment.

After the groups discussion the students were asked to present their ideas and thoughts by their respective representatives. Their presented ideas were allowed to be debated and challenged by other groups. After the groups' presentations then the researcher introduced the concept, principle and knowledge of sustainable construction and the relationship between sustainable development and sustainable construction. The students were informed that concept, principle and knowledge of sustainable construction is mainly to reduce the impact of construction activities on the environment. There were many other issues related to construction activities being discussed. Then the students were given some time to interact with the researcher. They were given the opportunity to make some suggestions or suggesting certain appropriate methods to be used in construction activities to reduce the impact on the environment.

Lastly, the students were given a set of open-ended questions. They had to submit the written answers individually. The students' statements would reflect their understanding of the knowledge for what they had learnt for that day.

3.6.6 Classroom Teaching Procedure for Role of Engineers

To begin of, the students were given a topic "The role of engineers in creating an environmentally sustainable future". They were asked to discuss among themselves on and how engineers could contribute and play an effective role in helping to solve and reduce environmental problems. They were required to discuss the role of engineering in modern life. This was to give more opportunity to generate the students' ideas on given topic. Then the students had to present their opinions, thought and ideas. Their thoughts and ideas were allowed to be debated among the groups.

After the class presentation, the researcher discussed the idea of educating the engineers in sustainable development. An article titled "The role of engineers in creating an environmentally sustainable future' was given to the students. After a brief reading session, in-depth discussion took place in class. The idea of in-depth discussion was to instill responsibility among the students who would be engineers in the future. In order to further motivate the students an article titled "Sustainable Development in Islam" was distributed. As there were only two non-Muslims in class out of forty-four students, the researcher took the opportunity to discuss the concept of sustainability from the religion point of views. The researcher informed the two non-Muslim students earlier of the intention as to avoid any issues on sensitivity. The concept of sustainable development is very much mentioned in Al-Quran. There are many statements detailed in the Al-Quran regarding caring for and protecting the environment. The Al-Quran stated that it is responsibility of the citizens of the world to care and protect the environment.

3.6.7 Pretest and Posttest

A knowledge test is conducted to examine the students' knowledge and understanding of sustainable development and sustainable construction before the class commence and after the class intervention. The questions were formulated by the researcher and validated by an expert. The validation forms are attached in the Appendix F. The pretest and posttest consists the same set of questions. The schedule of the pretest and posttest is shown in Table 3.3. The pretest was conducted on the first week of the semester. The test was to examine the students' knowledge on sustainable development and sustainable construction prior of introducing sustainable development knowledge into the Civil Engineering Construction course.

The posttest was conducted during the final week of the semester after completing the class intervention for the semester. The aim was to determine whether there were changes in the students' knowledge and also to investigate how much learning occurs during the intervention.

Table 3.3: Schedule of pretest and posttest

Pretest	Time	No of samples	Classroom location
4th July 2011, Tuesday	2.15 pm	42	**BS8-PSZ**
20th Sept 2011, Tuesday	2.15 pm	43	**BS8-PSZ**

3.6.8 Interview Protocol

After the administering the pretest among the students an interview was conducted. An interview plays an important role in a research. The aim of interview is to gain insight about things that could not be observed. For an example the students' thoughts and perspectives could be only being acquired through the interview. It is a valuable data-gathering technique which enables the researcher to gain direct information.

In this research a semi-structured interview was employed. The interview was done with eleven students. The selection of students was based on voluntary basis. The face-to-face semi-structured interview was conducted at the corner of the classroom away from their colleagues. The researcher acted more or less as a moderator or facilitator, and less as an interviewer (Punch, 2009). In this interview the relationship between researcher and respondents were semi-formal, with the latter knowing exactly what is required from them in the interview.

Prior to the interview, the researcher took the initiative to explain the purpose of the and confidentially of the interview. The students were asked of their cooperation in the interview. Most of the questions asked are based on knowledge on sustainable development. The questions have some similarity with the pretest questions. All questions used in the interview are prepared and listed word-for-word beforehand. Since it was semi-structured interview the researcher was not obliged to ask questions according to sequence of the questions. The researcher explained the questions to the interviewees if they did not understand or find confusing. This is to ensure that a reliable source of information could be obtained. The students were

informed about the audio-recording of the interview and they agreed that interview would be taped. The best and common way to record the interview data is by audio-recording of the interview. The conversation or discussion was recorded for transcription. The recorded discussion was then transferred to the researcher's computers for transcribing and coding purposes. The transcribing processes were done by the researcher herself so that the researcher would be able to recall the interview and become familiar with the data .Each participant was assigned a code to protect identification and confidentiality. After the interview ended, a little token was given to the interviewees as an appreciation.

3.6.8.1 Semi-structured Interview after the Pretest

There were eleven students selected in the semi-structured interview. The interview was conducted face-to-face. The main aim on was to determine students' knowledge and understanding on sustainable development. Most of the questions were similar to pretest questions. According to Gillham (2002), people did not lie but were just not accurate. The researcher recorded the discussion although handwritten notes were also being taken.

3.6.8.2 Semi-structured Interviews after the Posttest

The semi-structured interview was conducted after the posttest at the end of the semester. There were eleven students involved in the interview. The nature of interview conducted was the same as the semi-structured interview after the pretest. The data gathered were compared with the previous interview. The aim of comparing is to investigate whether there are changes to the students' knowledge gaps. The changes occurred in the students will provide the researcher with some information of the students' learning and knowledge construction.

3.7 Data Collection

The data in the study were gathered through survey questionnaire, pretest, posttest, open-ended questionnaire, field trip report, group work assignment and semi-structure interview. The quantitative data were from survey questionnaire, pretest and posttest. The qualitative data were from the open-ended questionnaire, field trip report, group work assignment and semi-structure interview.

3.7.1 Survey Questionnaire

A survey questionnaire was distributed to the students. They were asked to answer all the sections in the questionnaire. The questionnaire consists of demography, perception of sustainable development, attitudes on sustainable development, environmental awareness, and perceptions of Malaysia's environmental problems, attitude to change and personal views of on incorporating knowledge of sustainable development into Construction course. The collected data is used to determine the students' demography profile and the awareness of sustainable development among the students.

3.7.2 Field Trip Report

A field trip is one of the learning strategies used in learning. This strategy is in line with constructivist of point of view of learning. In the Needham's Five Phase Constructivist Model the field trip generates the existence of alternative ideas (see Table 2.8). From the constructivist point of view of learning, it is considered as an active and collaborative learning and gives valuable learning experiences. It is a shared social experience that provides the opportunity for students to encounter and explore novel things in an authentic manner. It is also important to recognize that learning outcomes from field trips can range from cognitive to affective outcomes. Among the many potential outcomes, research has shown that field trips expose

students to new experiences (Greene, 2014). After the field trip visit the students were asked to write a report. In the report the students had to write what had they learnt and gained from the visit. The data is collected through the students' individual written report.

3.7.3 Group Work Assignment

Group work is another learning strategy which is highly recommended. Cooperative learning involves having students work together to maximize their own and one another's learning (Burke, 2011). In Needham's Five Phase Constructivist Model it is stated in the generation of idea and restructuring of idea phase (See Table 2.8). From the constructivist point of view of learning, it is considered as active and collaborative learning.

The students were given an assignment. They had to work within their respective groups. The purpose is to examine the student's knowledge and understanding of the subject matter and at the same time assist them to build up their social interaction skills among themselves. The data is collected through their group work assignment.

3.7.4 Open-ended Questions

After every class session the students were given open ended questions to be completed. They were not allowed to copy or discuss with their colleagues. They had to write their written responses individually and hand in at the end of the class period. The purpose of the questions was to assess the student's knowledge and understanding of sustainable development at the end of the class. The data is collected through their written responses.

3.7.5 Pretest and Posttest

The pretest and posttest were conducted to examine the student's knowledge gaps and understanding of sustainable development. There were 17 questions and the students had to complete the test in the class. The questions for the pretest and posttest were of the same set of question. The pretest and the posttest were conducted before the class intervention at the beginning of the semester and the posttest was conducted towards the end of the semester.

3.7.6 Semi-structured Interview

The semi-structured interview was conducted twice on the students, one after pretest at the beginning of the semester and another one after the posttest at the end of semester. The questions posed were almost similar between the two semi-structured interviews. The objective of the interview was to assess the student's knowledge and understanding of sustainable development.

3.8 Awareness of Sustainable Development

In this research the awareness of sustainable development was measured through (i) Perception of sustainable development (ii) Attitudes towards sustainable development (iii) Environmental consciousness (v) Attitude to change (vi) Personal views on incorporating knowledge on sustainable development into Civil Engineering Construction course.

3.8.1 Perception of Sustainable Development

The constructs given stated in Table 3.4 is to examine the students' perception on sustainable development. It is used to check the students understanding of concept, belief, impression and meaning of sustainable development.

Table 3.4: Perception on sustainable development

Perception of sustainable development	
i.	Economic development, social development and environmental protection are all necessary for sustainable development
ii.	Sustainable development can balance the need for development and the need for environmental protection
iii.	Sustainable consumption includes using goods and services in ways that minimize the use of natural resources and toxic chemicals, and reduces waste
iv.	Sustainable development can be defined as fulfilment of human needs through simultaneous socio-economic and technological progress and conservation of the earth's natural systems
v.	The concept of sustainable construction is derived from that of sustainable development

3.8.2 Attitudes towards Sustainable Development

The constructs given in Table 3.5 is regarding attitudes towards sustainable development. Attitudes can be explained as manner of thinking or feeling about something (Dictionary, 2011). These constructs was used to consider the students' view and outlooks towards sustainable development.

Table 3.5: Attitudes towards sustainable development

Attitudes towards sustainable development	
i.	Every student should receive education that teaches the knowledge, perspectives, values, issues and skills for sustainable living in a community
ii.	The present generation should ensure that the next generation inherits a community at least as healthy, diverse and productive as it is today
iii.	Overuse of our natural resources is a serious threat to the health and welfare of future generations
iv.	We need stricter laws and regulations to protect the environment
v.	There is no point in getting involved in environmental issues, since governments and industries have all the power and can do what they like

3.8.3 Environmental Conscious

Table 3.6 is about environmental consciousness. Attitude towards environment can be defined as a multidimensional, behaviour-oriented concept i.e, the propensity to engage in pro-environmental behaviours (Hidalgo, Manuel, & Fuentes, 2013). The constructs are used to determine students' belief and knowledge about environment.

Table 3.6: Environmental Consciousness

Environmental consciousness	
i.	Humans must live in harmony with nature in order to survive.
ii.	We are approaching the limit of number of people the earth can support.
iii.	Serious and disruptive shortages of essential raw materials are likely if things continue.
iv.	Lack of awareness and education – people just do not know what to do to protect the environment.
v.	Government does not place enough emphasis on protecting the environment to be pace with the development.

3.8.4 Motivation to Change

Table 3.7 is motivation to change to protect the environment. In this context motivation to change means the willingness to change in attitude and feeling regarding the environment. This is to investigate the students' belief and view in significantly contributing to the environmental protection.

Table 3.7: Motivation to change

Altitude to change	
i.	There is a lot that I as an individual can do to help protect the environment
ii.	I do what I can do to improve the quality of my country as it is going to inherited by my children
iii.	We have a duty to look after things; human have no right to destroy natural systems, it's just the right thing to do
iv.	I am willing to have environmental problems solved even if this means sacrificing many goods
v.	I think each of us can make a significant contribution to environmental protection.

3.8.5 Personal Views of Incorporating Knowledge on Sustainable Development into Civil Engineering Construction Course

Table 3.8 is about the personal views on incorporating sustainable development concept and principles into Construction course. This is to examine the students regarding opinions and feeling of introducing sustainable concept into Civil Engineering Construction course.

Table 3.8: Personal views on incorporating knowledge on sustainable development into Civil Engineering Construction course

Personal views on incorporating sustainable concept and principles into Construction course
i. Knowledge on concepts of sustainability, sustainable development and sustainable construction should be taught to the students
ii. If future construction professionals are equipped with knowledge of sustainability, this could help improve the construction industry performance with regards to environmental protection
iii. The most relevant of sustainability to students is to develop an understanding of the principles of sustainable development during the design and construction phases
iv. Incorporating the principles of sustainability will change the undergraduates' attitude and thus they can make real changes to the industry in the future
v. Education is extremely important because it influences a person's attitudes and attitudes in turn influences behaviours

3.9 Reliability and Validity

The reliability and validity of the research findings are very important in any quantitative research. Reliability means consistency (Punch, 2009). Joppe (2000) defines reliability as the extent to which results are consistent over time and an accurate representation of the total population under study is referred to as reliability and if the results of a study can be reproduced under a similar methodology, then the research instrument is considered to be reliable (Golafshani, 2003)

Validity means the extent to which an instrument measures what is claimed to measure; as an indicator is valid to the extent that is empirically represents the concepts it purports to measure (Pallant, 2007; Punch, 2009). Joppe (2000) explains validity in quantitative research as validity determines whether the research truly measures that which it was intended to measure or how truthful the research results are (Golafshani, 2003).

One of the most popular reliability statistics in use today is Cronbach's alpha to determine the internal consistency or average correlation of items in a survey instrument to gauge its reliability (Tavakol, 2011).This research has concluded about the internal reliability using Cronbach alpha. The reliability coefficient of Cronbach alpha is shown below

i. Perception of sustainable development, 0.740
ii. Attitudes towards sustainable development,0.659
iii. Environmental consciousness, 0.706
iv. Motivation to change, 0.761
v. Personal views on incorporating knowledge of sustainable development into Civil Engineering Construction course, 0.715

3.10 Application Needham's Five Phase Constructivist Model (NFPCM) in Teaching

The application of Needham's Five Phase Constructivist Model (NFPCM) into classroom teaching is done through the teaching plan. The teaching plan was designed as shown in Section 3.10.2 and details from this teaching plan is use as guide in Section 3.10 in applying Needham's Five Phase Constructivist Model (NFPCM) into classroom setting.

3.10.1 Classroom Approach using Needham's Five Phase Constructivist Model (NFPCM)

At the very beginning of class intervention in the first week of the semester the students were informed that there would some changes in the teaching approach. They were told that constructivist teaching and learning approach would be implemented. This approach is more of student-centred rather than teacher-centred. The students were informed that the number of lectures was to be kept to a minimum and they were expected to explore, explain and discuss the topics given to them.

They were made aware that they must take responsibility for their own learning by participating in the classroom discussions. They were strongly encouraged to participate actively in the learning process rather than passively receiving information. Even though printed materials will be given but it would more of as references after the teaching and learning process had taken place.

The first phase of the Needham's Five Phase Constructivist Model is known as orientation. Normally the approach started off with a question, a case or a problem or showing a video to the students in the class. The aim of the orientation phase was to create interest, generate curiosity and raise questions among the students. In a typical constructivist classroom the students work by themselves. The researcher only intervenes as a guide to assist the students. Thus, in this phase the active learning is suitable to be applied.

The second phase is known as generation of ideas. In this phase the researcher posed another question or statement which was linked to the first phase. The students were encouraged to discuss and brainstorm among themselves within their respective groups. At the end of the given time, the students were asked to present and explain their ideas, thoughts and opinions. From the presentations, the researcher would be able to realise whether the prior knowledge of the students had been relevant to the new knowledge and understanding that are going to be introduced and discussed. This was also an opportunity for the researcher to verify what prerequisite knowledge and understanding the students were lacking of or what misconceptions the students might have which could interfere with their understanding of the new knowledge. Hence, the collaborative learning is suitable be applied in this phase because the students are working in a group.

In the third phase, in the restructuring of ideas the students were encouraged to explain the new knowledge introduced, in their own words verbally. They worked within their own respective groups. The students were allowed to compare, debate and challenge their colleagues' ideas. At the same time, the researcher would pose challenging questions related to their explanations. After the students' presentation then the researcher introduce the new knowledge. The students were given some time to understand and assimilate the new knowledge. The cooperative learning is

appropriate to be used in this phase. Here the students have to make a presentation, defend their ideas and challenge others of their opinions. Thus, this phase is challenging to the lecture too because it is not easy to ask the students to made presentation to the class and to replace their existing ideas with the new ideas.

After assimilation of the new knowledge, the students were then given the opportunity to apply the knowledge to different situations. The students were asked to give some examples. The given examples given by the students might lead to a new round of discussion. In this phase both the students and lecturer are having some challenges. The students want to inquire more of the knowledge and the way to apply it to various problems. The lecturer must have the ability to explain the knowledge and its application. Thus inquiry learning is most applicable in this phase.

Once the students had a good understanding of the new knowledge, the students were assigned to work on open-ended questions from a given exercise. They have to write the answers individually in their own words. After they had submitted their written answers, the class began to discuss the assigned questions. This process provides an opportunity for the students to discourse among themselves. At the same time the researcher observed whether there were any new development occurred in the students' learning. The written statements submitted also help the researcher to assess the students' construction of knowledge has taken place. In this phase the lecturer is interested in knowing how much learning had occurred among the students. Thus, the challenge is to engage activities whereby students will express their reflections in understanding problems through their thinking and communication skills either verbal or written potentials. Thus, their thinking and communication skills are really desired in this phase.

3.10.2 Teaching Plan

A teaching plan is an instructional design to guide teachers in their teaching. In this study, the researcher has come out with three teaching plans. These plans employ constructivism approach whereby they are based on NFPCM. In these

teaching plans, there are columns. The first column presents the five phases of NFPCM and their purposes. The second column depicts the choice of content. Here, the content of the subject taught is listed and the purposes of having the content are to instill interest and awareness among the students, to provide knowledge, to apply knowledge and to reflect the learning process; in which whether the students have acquired the knowledge or otherwise. Finally, the third column presents the learning approach. The learning approach here refers to the activities that the students have to do in class. These activities are designed to create effective learning outcomes among the students. The teaching plans on sustainable development, sustainable construction and role of engineers are presented in Table 3.9, 3.10 and 3.11 respectively. The validation of the 3 teaching plans is given in Appendix G.

3.10.2.1 Teaching Plan 1 – Sustainable Development

Teaching Plan 1 is designed for the purpose of introducing the knowledge on sustainable development into Civil Engineering Construction course.

Table 3.9: Teaching Plan 1 – Sustainable Development

Needham Phases	Choice of content	Learning approach
Orientation To stimulate interest and attract attention of students	What do you mean and understand by environmental issues?	**Active** The students discuss the problem within their respective group members.
Generation of ideas To be aware of the students' prior knowledge.	How to solve the environmental issues?	**Collaborative** The students continue with their discussions and come out with possible answers to the question posed by the teacher.
Restructuring of ideas To realize the existence of alternative ideas and to replace these ideas with scientific ideas.	Knowledge of sustainable development	**Cooperative** Each group of students presents the results of their group discussion to the class. Other students in the class actively

Needham Phases	Choice of content	Learning approach
		participate by challenging ideas presented by their colleagues.
Application of ideas To apply the new ideas to different situation.	The application of knowledge sustainable development.	**Inquiry** The students make further inquiry to know more details of knowledge application towards the problem.
Reflection To investigate students' learning and construction of knowledge.	Open-ended questions.	**Thinking and communication skills** The students individually answer the written open-ended questions, before leaving the class.

3.10.2.2 Teaching Plan 2 - Sustainable Construction

The purpose of Teaching Plan 2 is to incorporate the knowledge on sustainable construction into Civil Engineering Construction course.

Table 3.10: Teaching Plan 2 – Sustainable Construction

Needham Phases	Choice of content	Learning approach
Orientation To stimulate interest and attract attention of students	Construction activities have great impact on the environment.	**Active** The students discuss the problem within their respective group members.
Generation of ideas To be aware of the students' prior knowledge.	How to solve the construction activities issues?	**Collaborative** The students continue with their discussions and come out with possible answers to the question posed by the teacher.
Restructuring of ideas To realize the existence of alternative ideas and to	Knowledge of sustainable	**Cooperative** Each group of students presents the results of their

Needham Phases	Choice of content	Learning approach
replace these ideas with scientific ideas.	construction	group discussion to the class. Other students in the class actively participate by challenging ideas presented by their colleagues.
Application of ideas To apply the new ideas to different situation.	The application of knowledge on sustainable construction	**Inquiry** The students make further inquiry to know more details of the knowledge application towards the problem.
Reflection To investigate students' learning and construction of knowledge.	Open-ended questions.	**Thinking and communication skills** The students individually answer the written open-ended questions, before leaving the class.

3.10.2.3 Teaching Plan 3 - The Role of Engineers in Creating an Environmentally Sustainable Future

The purpose of Teaching Plan 3 is to instill concern, attitude and awareness towards protecting the environment and the role of engineers in creating an environmentally sustainable future.

Table 3.11: Teaching Plan 3 -The role of engineers

Needham Phases	Choice of content	Learning approach
Orientation To stimulate interest and attract attention of students	What is the role of engineers in protecting the environment?	**Active** The students discuss the problem within their respective group members.
Generation of ideas To be aware of the students' prior knowledge.	The contribution of engineers in modern life.	**Collaborative** The students continue with their discussions and come out with possible answers to the question posed by the teacher.

Needham Phases	Choice of content	Learning approach
Restructuring of ideas To realize the existence of alternative ideas and to replace these ideas with scientific ideas.	The role of engineers in creating an environmentally sustainable future.	**Cooperative** Each group of students presents the results of their group discussion to the class. Other students in the class actively participate by challenging ideas presented by their colleagues.
Application of ideas To apply the new ideas to different situation.	Educating engineers for sustainable development	**Inquiry** The students make further inquiry to know more details of the knowledge application towards the problem..
Reflection To investigate students' learning and construction of knowledge.	Open-ended questions.	**Thinking and communication skills** The students individually answer the written open-ended questions, before leaving the class.

The three teaching plans can be represented by the block diagram as shown below. It shows the five phases according to Needham's Five Phase Constructivist Model (NFPCM) and the learning strategies involved.

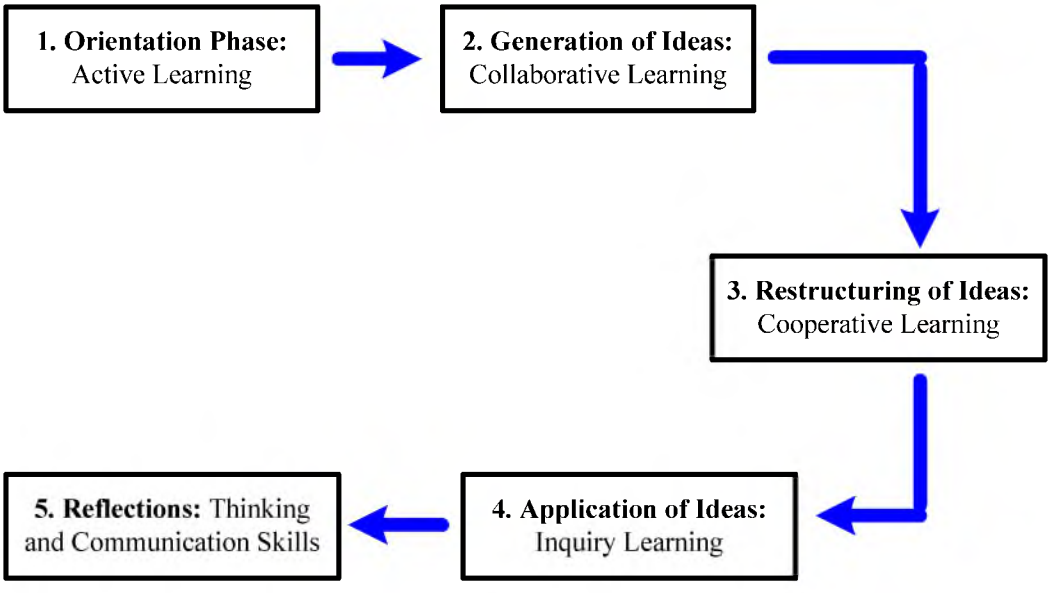

Figure 3.3 The block diagrams representing the three teaching plans

3.11 Data Analysis

In this study the data is gathered through the survey questionnaire, pretest and posttest, open-ended questionnaire, field group report, group work assignment and semi-structured interview. The survey questionnaire, pretest and posttest were analysed quantitatively using the Statistical Package for the Social Sciences (SPSS) version 22. The finding of the survey questionnaire is to determine the awareness of sustainable development among engineering students. The scores of the pretest and posttest were analysed to determine the students' knowledge gap on sustainable development.

The open-ended questionnaire, field group report, group work assignment and semi-structured interview were analysed qualitatively. The open-ended questionnaire and semi-structured interview in the form of sentences need to be transcribed (Harrell & Bradley, 2009) and considered to form descriptions and patterns (Taylor-Powell & Renner, 2003). The field-trip report and group assignment were evaluated using the rubric for the writing essay.

3.12 Summary

This chapter describes the methodology which was employed to achieve objectives of the research as stated in Section 1.4. The constructivist approach in classroom setting to was employed to incorporate the knowledge on sustainable development into the Civil Engineering Construction course.

The operation of the research is presented in the operational framework described in Section 3.2. The research employs qualitative and quantitative method and is explained in Section 3.3. This is followed by the research setting and population in Section 3.4. The research instruments used in the study are discussed in Section 3.5. The research procedure is described in Section 3.6 and the data collection is detailed in Section 3.7. The constructs for the awareness of sustainable development is given in Section 3.8, followed by the reliability and validity of the

constructs is presented in Section 3.9 and the application of Needham's Five Phase Constructivist Model (NFPCM) to teaching in Section 3.10. Lastly the data analysis is presented in Section 3.11.

CHAPTER 4

RESEARCH FINDINGS

4.1 Introduction

This chapter presents results and analysis of the data obtained from survey questionnaire, pretest, posttest, open-ended questions, field trip report, group work assignment, and semi-structured interview. The findings were based on the research questions as shown below.

a. What is the students' awareness toward sustainable development?
b. What is the knowledge that the students have on sustainable development through the pretest and posttest conducted?
c. What is the students' knowledge on sustainable development after using the Needham's Five Phase Constructivist Model (NFPCM) in the classroom setting?
d. What are the components of the guideline on teaching and learning approach in integrating knowledge on sustainable development into Civil Engineering Construction course based on the constructivist approach?

4.2 Demography Profile

There were 44 students from one of the local public universities as respondents for this research. However, only 36 respondents were considered

because the other eight had discrepancy in their responses. There were 20 male (55.6%) and 16 female (44.4%). They were third year Civil Engineering students with an average age of 20 years old. They had done the Civil Engineering Construction course without the sustainable development content. Out of 36 students, 17 stated that they came to know aboutthe term of sustainability or sustainable development through books, others claimed through the television, Government campaign and internet. The Table 4.1 below shows demography of the respondents including the gender, age, Cumulative Grade Progress Assessment CGPA of the students and some information regarding how they know about sustainable development

Table 4.1: Demography of respondents

Respondents	**Frequency**	**Percentage**
Male	20	55.6
Female	16	44.4
Total	36	100.0
Age	**Frequency**	**Percentage**
20 years old	35	97.2
21 years old	1	2.8
Total	36	100.0
Cumulative Grade Progress Assessment	Frequency	Percentage
3.5 – 4.0	13	36.1
3.0 – 3.49	15	41.7
2.5 – 2.99	6	16.7
2.0 – 2.49	2	5.6
Total	36	100.0
Know about sustainable development.	Frequency	Percentage
None	1	2.8
Through books	17	47.2
Through television	2	5.6
Through Government campaign	1	2.8
Through internet	9	25.0
Others	16	16.7
Total	36	100.0

4.3 Results

The results and analysis of the research is presented in the section below according to research questions.

4.3.1 Research Question 1: What is the Students' Awareness towards Sustainable Development among Engineering Students?

Table 4.2 shows the percentage of responses of the students for the survey questionnaire.

Table 4.2: Perception on sustainable development

	Strongly Agree	Agree	Slightly Agree	Disagree	Strongly Disagree
	Freq. (%)	Freq. (%)	Freq. (%)	Freq. (%)	Freq. (%)
Economic development, social development and environmental protection are all necessary for sustainable development.	11 (30.6)	18 (50.0)	7 (19.4)		
Sustainable development can balance the need for development and the need for environmental protection.	8 (22.2)	24 (66.7)	4 (11.1)		
Sustainable consumption includes using goods and services in ways that minimize the use of natural resources and toxic chemicals, and reduces waste.	12 (33.3)	19 (52.8)	4 (11.1)	1 (2.8)	
Sustainable development can be defined as fulfilment of human needs through simultaneous socio-economic and technological progress and conservation of the earth's natural systems.	11 (30.6)	19 (52.8)	6 (16.7)		
The concept of sustainable construction is derived from that of sustainable development.	6 (16.7)	19 (52.8)	10 (27.8)	1 (2.8)	

Table 4.2 shows the students' perception of sustainable development. 80.6% of the respondents agree that the considerations of economic development, social development and environmental protection are necessary for sustainable development. Majority of the respondents (88.9%) state that the sustainable development will act as balance for development and environmental protection. 86.1% think that sustainable consumption will minimize the use of natural resources and toxic chemicals, and reduces waste. 83.4% respondents answer that sustainable development can be defined as fulfillment of human needs through simultaneous socio-economic and technological progress and conservation of the earth's natural systems; and 69.5% of the response consider that the concept of sustainable construction is derived from sustainable development.

Table 4.3: Attitudes towards sustainable development

	Strongly Agree	Agree	Slightly Agree	Disagree	Strongly Disagree
	Freq. (%)	Freq. (%)	Freq. (%)	Freq. (%)	Freq. (%)
Every student should receive education that teaches the knowledge, perspectives, values, issues and skills for sustainable living in a community.	17 (47.2)	17 (47.2)	2 (5.6)		
The present generation should ensure that the next generation inherits a community at least as healthy, diverse and productive as it is today.	16 (44.4)	16 (44.4)	4 (11.1)		
Overuse of our natural resources is a serious threat to the health and welfare of future generations.	21 (58.3)	11 (30.6)	4 (11.1)		
We need stricter laws and regulations to protect the environment.	21 (58.3)	11 (30.6)	44 (11.1)		
There is no point in getting involved in environmental issues, since governments and industries have all the power and can do what they like.	3 (8.3)	5 (13.9)	44 (11.1)	24 (66.6)	

Table 4.3 gives a breakdown of the frequency and percentages of attitudes towards sustainable development. Majority of the respondents (94.4%) concerned that every student should have the knowledge, perspectives, values, issues and skills for sustainable living. 88.8 % think that the present generation has to ensure that the future generation inherits a healthy, diverse and productive community. 88.9% responds agree that the overuse of our natural resources is a risk to the health and welfare of future generations; and 88.9% agree that the stricter laws and regulations need to protect the environment. 66.6% of the respondents disagreed that there is no point in getting involved in environmental issues, since governments and industries have all the power and can do what they like.

Table 4.4: Environmental consciousness

	Strongly Agree	Agree	Slightly Agree	Disagree	Strongly Disagree
	Freq. (%)	Freq. (%)	Freq. (%)	Freq. (%)	Freq. (%)
Humans must live in harmony with nature in order to survive.	22 (61.1)	13 (36.1)	1 (2.8)		
We are approaching the limit of number of people the earth can support.	5 (13.9)	15 (41.7)	11 (30.6)	3 (8.3)	2 (5.6)
Serious and disruptive shortages of essential raw materials are likely if things continue.	6 (16.7)	20 (55.6)	9 (25)		
Lack of awareness and education – people just do not know what to do to protect the environment	9 (25.0)	19 (52.7)	7 (19.4)	1 (2.8)	
Government does not place enough emphasis on protecting the environment to be pace with the development.	4 (11.1)	20 (55.6)	12 (33.3)	4 (11.1)	

Table 4.4 shows an analysis of the frequency and percentages of environmental consciousness. Almost all of the respondents (97.2%) agreed that humans must live in harmony with nature in order to survive. More than half of the respondents (55.6%) believe that we are approaching the limit of number of people the earth can support. 72.3% think that serious and disruptive shortages of essential raw materials are likely to occur. More than three quarters of the respondents

(77.8%) state that polluted environment cannot be restored to its original state. 66.7 % think that more industrial development the more destruction will occur to the natural environment.

Table 4.5: Motivation to change

	Strongly Agree	Agree	Slightly Agree	Disagree	Strongly Disagree
	Freq. (%)	Freq. (%)	Freq. (%)	Freq. (%)	Freq. (%)
There is a lot that I as an individual can do to help protect the environment.	11 (30.6)	16 (44.4)	7 (19.4)	2 (5.6)	
I do what I can do to improve the quality of my country as it is going to inherited by my children	13 (36.1)	21 (58.3)	2 (5.6)		
We have a duty to look after things; human have no right to destroy natural systems, it's just the right thing to do.	20 (55.6)	14 (38.9)	2 (5.6)		
I am willing to have environmental problems solved even if this means sacrificing many goods.	7 (19.4)	19 (52.8)	10 (27.8)		
I think each of us can make a significant contribution to environmental protection.	14 (38.9)	17 (47.2)	5 (3.9)		

Table 4.5 shows an analysis of the frequency and percentages of motivation to change. Three quarters of the respondents (75.0%) agree that they as an individual would do to help protect the environment. Almost all the respondents (94.4%) think that they would do to improve the quality of the country before inherited to their children. Most of the respondents (94.5%) express that human have no right to destroy the natural systems. 72.2% state that they are willing to have environmental problems solved at the means sacrificing many goods. 86.1% respond that they can make a significant contribution to environmental protection.

Table 4.6: Personal views on incorporating knowledge on sustainable into Civil Engineering Construction course

	Strongly Agree	Agree	Slightly Agree	Disagree	Strongly Disagree
	Freq. (%)	Freq. (%)	Freq. (%)	Freq. (%)	Freq. (%)
Knowledge on concepts of sustainability, sustainable development and sustainable construction should be taught to the students.	15 (41.7)	19 (52.8)	2 (5.6)		
If future construction professionals are equipped with knowledge of sustainability, this could help improve the construction industry performance with regards to environmental protection.	19 (52.8)	14 (38.9)	3 (8.3)		
The most relevant of sustainability to students is to develop an understanding of the principles of sustainable development during the design and construction phases.	13 (36)	18 (50)	5 (13.9)		
Incorporating the principles of sustainability will change the undergraduates' attitude and thus they can make real changes to the industry in the future.	9 (25.0)	25 (69.4)	2 (5.6)		
Education is extremely important because it influences a person's attitudes, and attitudes in turn influences behaviours.	21 (58.3)	12 (33.3)	2 (5.6)	1 (2.8)	

Table 4.6 shows an analysis of the personal views on incorporating sustainable development into Construction course. Almost all the respondents (94.5%) agree that sustainable development should be taught to the students. 91.7% think that if future construction professionals are equipped with knowledge of sustainability, this could help improve the construction industry performance with regards to environmental protection. 86.0% state that to develop an understanding of the principles of sustainable development during the design and construction phases is very relevant. 94.4% respond incorporating the principles of sustainability into the curriculum will change the undergraduates' attitude who later on will change the

industry in the future. Most of the respondents (91.6%) agree that education is extremely important because it influences a person's attitude, and attitude in turn influence the behaviour.

4.3.2 Research Question 2: What is the Knowledge that the Students have on Sustainable Development through the Pretest and Posttest Conducted?

There were 17 questions in the pretest and posttest. The pretest was conducted before the class commence and posttest towards the end of semester.

Table 4.7: Question 1: Definition of sustainable development

Question 1 / Possible answers	In Brundtland's Report the definition of sustainable development is referred as_____									
	Pretest					Posttest				
	Factual Knowledge		Conceptual Knowledge			Factual Knowledge		Conceptual Knowledge		
	FK1	FK 2	CK 1	CK 2	CK 3	FK1	FK 2	CK 1	CK 2	CK 3
Sustainable development is development, which meets the needs of the present without comprising the ability of future generations to meet their own needs.	8.3% (3)					22.2% (8)				
Sustainable development refers to the fulfilment of human needs through simultaneous socio-economic, technological progress, and conservation of the earth's natural system.	33.3% (12)					22.2% (8)				
Sustainable development is a process which enables people to realize their potential and improve their quality of life in ways that	58.3% (21)					55.% (20)				

Question 1 / Possible answers	In Brundtland's Report the definition of sustainable development is referred as_____									
	Pretest					Posttest				
	Factual Knowledge		Conceptual Knowledge			Factual Knowledge		Conceptual Knowledge		
	FK1	FK 2	CK 1	CK 2	CK 3	FK1	FK 2	CK 1	CK 2	CK 3
simultaneously protect and enhance the Earth's life support systems.										
Total	100% (36)					100% (36)				

Table 4.7 shows that only 3 students (8.3%) got the correct answer. Majority of students (91.6%) are not able to identify the correct definition of sustainable development according to Brundtland's Report. They might have heard of the term sustainable development but no idea which is the correct definition. There are many definitions of sustainable development given by experts. The United Nations recognised the one define by Brundtland which first appeared in 1987 as "Sustainable development is development, which meets the needs of the present without comprising the ability of future generations to meet their own needs."

Table 4.8: Question 2: Concept of sustainable development

Question 2 / Possible answers	The concept of sustainable development is									
	Pretest					Posttest				
	Factual Knowledge		Conceptual Knowledge			Factual Knowledge		Conceptual Knowledge		
	FK1	FK2	CK 1	CK2	CK 3	FK 1	FK2	CK 1	CK2	CK 3
The concept of 'wants' and the concept of limits				5.6% (2)					8.3% (3)	
The concept of 'needs' and the concept of limits √				41.7% (15)					75.0% (27)	
The concept of 'protection'				52.8%					16.7%	

Question 2 / Possible answers	The concept of sustainable development is									
	Pretest					Posttest				
	Factual Knowledge		Conceptual Knowledge			Factual Knowledge		Conceptual Knowledge		
	FK1	FK2	CK 1	CK2	CK 3	FK 1	FK2	CK 1	CK2	CK 3
and the concept of limits				(19)					(6)	
Total				100% (36)					100% (36)	

Table 4.8 shows that less than half of the students (41.7%) got the right answer for Question 2. About 58.4% of the students are not able to choose the correct answer for the concept of sustainable development. Since majority of the students cannot identify the correct definition of sustainable development as shown in Table 4.7 for Question 1, consequently they could not ascertain the true concept of sustainable development.

Table 4.9: Question 15: Protecting the environment

Question 15 / Possible answers	Why is sustainable development so often associated with protecting the environment?									
	Pretest					Posttest				
	Factual Knowledge		Conceptual Knowledge			Factual Knowledge		Conceptual Knowledge		
	FK1	FK2	CK 1	CK 2	CK 3	FK 1	FK2	CK 1	CK 2	CK 3
a) In the 1980s, environmental groups raised the alarm about the boom in economic activity and the ceaseless exploitation of natural resources, which too often were damaging to the environment.		50.0% (18)					11.1% (4)			

Question 15 / Possible answers	Why is sustainable development so often associated with protecting the environment?									
	Pretest					Posttest				
	Factual Knowledge		Conceptual Knowledge			Factual Knowledge		Conceptual Knowledge		
	FK1	FK2	CK 1	CK 2	CK 3	FK 1	FK2	CK 1	CK 2	CK 3
b) In the 1970s, environmental groups raised the alarm about the boom in economic activity and the ceaseless exploitation of natural resources, which too often were damaging to the environment.		36.1% (13)					66.7% (24)			
c) In the 1960s, environmental groups raised the alarm about the boom in economic activity and the ceaseless exploitation of natural resources, which too often were damaging to the environment.		11.1% (4)					22.2% (8)			
Total		100.0 % (36)					100.0 % (36)			

Table 4.9 shows that only 13 students (36.1%) are able to identify the year sustainable development associated to protecting the environment. About 64% of the students answered incorrectly. They are unclear why is sustainable development often associated with protecting the environment. Sustainable development was created to address growing concern over the "accelerating deterioration of the human environment and natural resources and the consequences of that deterioration for economic and social development." Sustainable development was the solution to the problems of environmental degradation discussed by the Brundtland Commission in the 1987 report Our Common Future. The responsibility of the Brundtland Report is

to investigate the numerous concerns that had been raised in previous decades, namely, that human activity has severe and negative impacts on the planet, and that patterns of growth and development would be unsustainable if they continued unchecked.

Table 4.10: Question 16: Importance of sustainable buildings

Question 16 / Possible answers	Why is it important to have sustainable buildings?									
	Pretest					Posttest				
	Factual Knowledge		Conceptual Knowledge			Factual Knowledge		Conceptual Knowledge		
	FK1	FK2	CK 1	CK2	CK 3	FK 1	FK2	CK 1	CK2	CK 3
a) The building sector has a strong global potential to help protect the economy and increase life comfort and wellbeing.		50.0% (18)					2.8% (1)			
b) The building sector has a strong global potential to help protect the people and increase life comfort and wellbeing.		36.1% (13)					97.2% (35)			
c) The building sector has a strong global potential to help protect the environment and increase life comfort and wellbeing.		11.1% (4)								
Missing		2.8% 1								
Total		100% (36)					100% (36)			

Table 4.10, shows that only 13 students (36.1%) able to choose the correct answer. Majority of them are not sure why sustainable buildings are important.

Sustainable buildings are associated with reduce energy consumption, limit greenhouse gas emissions, minimize waste and pollution, can protect and restore ecosystem, promote skills development, direct and indirect jobs.

Table 4.11: Question 17: Buildings and construction works share in global resource and pollution emission

Question 17 / Possible answers	Buildings and construction works have the single share in global resource and pollution emission. The built responsible for approximately									
	Pretest					Posttest				
	Factual Knowledge		Conceptual Knowledge			Factual Knowledge		Conceptual Knowledge		
	FK1	FK2	CK 1	C K2	C K 3	FK 1	FK2	C K 1	C K2	CK 3
a) 40% of total energy use, 50% raw materials use, 40% of global greenhouse and 50% of solid waste generation		25.0% (9)					16.7% (6)			
b) 30% of total energy use, 40% raw materials use, 30% of global greenhouse and 50% of solid waste generation		50.0% (18)					69.5% (25)			
c) 25% of total energy use, 40% raw materials use, 50% of global greenhouse and 40% of solid waste generation.		25.0% (9)					13.9% (5)			
Total		100% (36)					100% (36)			

Table 4.11 shows that only half of the students, 50% are able to choose the correct answer for Question 17. About 50% of the students are unsure how much resource use and the pollution caused by building construction activity. Buildings are responsible for more than 40 percent of global energy use and one third of global

greenhouse gas emissions, both in developed and developing countries. The main source of greenhouse gas emissions from buildings is energy consumption, but buildings are also major emitters of other non-CO2 greenhouse emissions such as halocarbons. While historically the majority of emissions emanated from developed countries, it is expected that in the near future the level of emissions from buildings in rapidly industrializing countries will surpass emission levels from buildings in developed countries Buildings and Climate Change.

The questions in the pre and post tests were designed by the researcher and validated by the content experts. The main objective of these questions was to determine the students' knowledge on sustainable development. Hence, the nature of the questions reflects the students' knowledge on sustainable development and this has been validated by the content experts when they discussed the questions.

4.3.3 Research Question 3: What is the Students' Knowledge on Sustainable Development after Using the Needham's Five Phase Constructivist Model (NFPCM) in the Classroom Setting?

To answer the above research question several activities were conducted on the students. There were response to the open-ended questions in the classroom, field trip, group work, posttest and semi-structured interview.

4.3.3.1 Open Ended Questions during Class Intervention

At the end of every class session, the students were required to response to few open-ended questions. Below are few of the feedback given by the students where the written responses are categorized as shown in the Tables 4.12.

Table 4.12: What is most the important concept you have learnt today?

Category	Number of respondents
1. Conserve and minimise the usage of natural resources	13
2. Environment, social and economic	8
3. Minimise the negative impact to the earth	6

Table 4.12 is regarding the important concept that had just discussed in the classroom. The written responses were divided into three categories. Thirteen students mentioned about conservation and minimisation of the usage of natural resources. Eight students thought the concepts are related to environment, social, and economic elements; and six students relate it to minimising the negative impact of human activities to the earth. The responses of the students indicated they had acquired some knowledge but their understanding or perception of the concept was varied. These were reflected by the terms they used for their respective answers.

Table 4.13: What do you understand by sustainable construction?

Category	Number of respondents
1. Minimising waste, and the usage of recycling materials	21
2. Responsible management – protect the environment, minimise resource consumption, and reduce energy use	18
3. A subset of sustainable development, and preserve and balance the ecosystem, economic, social and environmental aspects	13

Table 4.13 is concerning the importance of sustainable construction. Twenty one students relate importance of sustainable construction with minimising waste, and the usage of recycling materials. Eighteen students associate it with responsible management that is the protection of the environment, minimise resource consumption, and reduce energy use. Thirteen students relate the importance of sustainable construction to a subset of sustainable development, and preserve and balance the ecosystem, economic, social and environmental aspects. Although the students' responses were varied it is acceptable from the viewpoints of sustainable construction. From the constructivist views of learning it is acceptable that the students have their own views and stances over any issues because constructivist

beliefs that students construct their knowledge and understanding based on their prior knowledge and experiences.

Table 4.14: What are the principal issues in sustainable construction?

Category	Number of respondents
1. Environmentally friendly construction.	30
2. Energy efficiency in buildings.	30
3. Transportation.	30
4. Construction and demolition, waste management.	29
5. Water conservation.	29
6. Health in building.	28
7. Sustainable architecture.	28
8. Urban sustainability.	27
9. Social impacts arising from construction and built environment.	27

Table 4.14 is about the principal issues in sustainable construction. Thirty students cite environmentally friendly construction materials, energy efficiency in buildings, and transportation are principal issues in sustainable construction. This is followed by construction and demolition, waste management and water conservation. Health in buildings, and sustainable architecture were coded by twenty eight students. Twenty seven students think that urban sustainability, and social impacts arising from construction and the built environment are the principal issues in sustainable construction. The responses implied that almost all the students thought the same principal issues involved around sustainable construction.

4.3.3.2 Marks of Field Trip Report

From the constructivist learning point of view a field trip is another form of learning strategy. It is considered as active and collaborative learning. Once return from the trip the students were to ask to write regarding what they had learned from the field trip. They were required to relate the visit with the classroom learning and

the real life situation. These could help the students to achieve certain objectives, which cannot be achieved as well by using other means. The report is the work of individual effort. Their marks were not that impressive however from the view of learning the students had the opportunity to practice their writing skills.

The students had acquired some knowledge on sustainable development in the field trip. This was indicated in the content report. However the students had some difficulty in explaining their personal views in their writing skills but they have the potential in writing good report. In constructivist learning point of view communication skills both written and verbal are very pertinent.

4.3.3.3 Marks of Group Work Assignment

This group work assignment is another form of learning strategy. It is highly recommended from perspective of constructivist view of teaching and learning. There are many benefits gain from the group work or task. Few of the advantages are students were encouraged to become active rather than passive learners by developing collaborative and co-operative skills, and lifelong learning skills. It encourages the development of critical thinking skills. It requires the establishment of an environment of support, trust and co-operative learning can be nurtured. In this class the students were ask to write essays.

The rubric of the marks is given in Appendix H and marks for both report and assignment are shown in Appendix K respectively. The marks scored base on the rubric show that the students had acquired some knowledge and understanding on sustainable development. However they do have problems in communicating the ideas effectively and convincingly. Eventually with more and rigorous practicing they will improve.

4.3.3.4 Semi-structured Interview after the Pretest

A semi-structured interview after the pretest was conducted on 11 students to investigate their knowledge and understanding on sustainable development and sustainable construction. The questions employs in the semi-structured interview were almost similar to the pretest. All students responded that they had heard the terms of sustainable development and sustainable construction however they were not able to define the term in their words or understanding. Almost of them think that sustainable development is related to 3R, that is reduce, reuse and recycle and some thought it has to with the solid waste management and wetland. Few of them mentioned that they ever heard the term of sustainable development and sustainable construction through social media but they never try the take any initiative to find the meaning of the terms. Since all of them gave inadequate and unsure responses the researcher make the conclusion that the students had no or limited knowledge on sustainable development and sustainable construction. So after the interview conducted the researcher justified that in reality the students' knowledge on sustainable development and sustainable construction were very basic and minimal. This implies that there was a need to incorporate the knowledge on sustainable development in the Civil Engineering Construction course.

4.3.3.5 Semi-structured Interview after the Posttest

As part of gathering data on the students' knowledge and understanding of sustainable development a semi-structured interview was conducted again on eleven students. They voluntarily wanted to do the Semi-structured interview. The information gathered from the interview was to support the responses obtained from the open-ended questions and posttest. The interview was able to give the researcher an opportunity to further probe the statements given in the open-ended questions and posttest. The researcher thought it would be more appropriate to speak directly to the students as the researcher sometimes got the impression that the students did not fully understand a question asked in the open-ended questions and posttest. Table 4.15 shows brief responses of students from the semi-structured interview.

Table 4.15: Semi-structured interview

Statements	Responses	Number of respondents
Q1. Where did you hear / learn about the term sustainability / sustainable development / sustainable construction?	1.Lecturer	11
	2.Television	3
	3.Internets	4
	4.Books	3
	5.Medianewspaper	3
	6.Friends	9
Q2. What do understand about the term sustainability / sustainable development?	1.Economic, social and environment	7
	2.To prepare the environment for destroyed	1
	3.The Government method including sustainable development and at the time to serve the environment	2
Q3. After you attended a few lectures on sustainability / sustainable development / sustainable construction what did you understand about the concept of sustainability / sustainable development?	1. Social, economic and environment	3
	2. Limits of capacity of environment	5
	3. Reduce natural resources usage	4
	4. Conserve energy consumption	2
	5. Reduce pollution	1
Q4. Why is sustainability / sustainable development / is important?	1. Better life for current and next generation	7
	2. Environmental protection	2
	3.Balancing the nature	1
Q5. Why do you think of the concept of sustainability / sustainable development be incorporated into construction course?	1. Responsible	1
	2.Awareness to undergraduate	10

Statements	Responses	Number of respondents
Q6. How important is the issues of sustainability/ sustainable development in construction course?	1. Use less material	4
	2. Benefits for future generation	2
	3. Future construction	1
	4. Reduce pollution	3
Q7. Malaysia is trying to reduce the carbon footprint 40% by the year 2050. How to minimise the carbon footprint?	1. Sustainable construction	6
	2. Not to waste energy	1
	3. Play a major role in protecting nature	1
	4. Campaign	1
Q8. What is your suggestion about sustainability/ sustainable development in the university education?	1. Sustainable development as part of the syllabus	6
	2. Sustainable development subject as compulsory to students	5

In Q1 the students were asked where did they hear about sustainable development. This was to investigate how the students acquired their basic knowledge and understanding of sustainable development. The students stated that they heard about the term sustainable development through the lecturers, media and friends.

In Q2 the students stated what they understood by the meaning of sustainable development. This was to find out what did the students understand of the meaning prior to they attended a few lectures. Seven out of eleven students stated that sustainable development is related to economic, social and environment and the rests acknowledged that to help the environment for not to being destroyed. It is the government initiative to consider sustainable development into the project as to protect the environment.

In Q3 the students were asked about the concept of sustainable development. This was to investigate the understanding of the concept of sustainable development of the students after they had attended a few lectures on sustainable development.

Seven out of eleven students answered that they relate it to reduce the consumption of natural resources.

In Q4 the students realized the importance of sustainable development because it gives better life for the next generation in terms of environmental protection and balancing the nature. All students believe that sustainable development is important whereby the people have to do something about the environment and save the earth for the future generation.

In Q5 all the students feel / think the concept of sustainable development should be incorporated into construction courses because it create awareness and responsible to the undergraduates. All the students agreed that incorporating sustainable development into the courses is important.

In Q6 the students realized how important is the concept of sustainable development in construction and design is because in sustainable construction and design it will use less material. All the students agreed it will give a great benefit to the construction industry and will able to protect the environment.

In Q7 Malaysia is trying hard to reduce the carbon footprint 40% by the year 2050 and construction industry is of one the ways to minimise the carbon footprint. Six out of eleven students think that sustainable construction is the most appropriate activity and should be implemented by the construction industry.

In Q8 the students suggested / proposed that the university should make sustainable development as part of the syllabus and also consider as a compulsory subject. All the students perceived that sustainable development should be incorporating in the course. This shows the students were concerned about the benefit of studying sustainable development.

4.3.4 Research Question 4: What are the Components of the Guideline on Teaching and Learning Approach in Integrating Knowledge on Sustainable Vevelopment into Civil Engineering Construction Course based on the Findings of this Research?

Table 4.16 shows components of the guideline on teaching and learning approach based on the findings of this research. These are teaching and learning approach which had been executed by the researcher in the classroom in order for the constructive approach to be effectively and to produce positive effective impacts on the students' learning.

Table 4.16: The components of the guideline on teaching and learning approach based on the findings of this research

Phases according to Needham's model	Choice of content	Learning approach	Teaching approach	Evaluation	Suggestion
1.Orientation To excite interest and attract attention of students	Posed a problem	**Active** The students discuss the problem within their respective group members.	The teacher presents a problem to the class. The students are asked to discuss their understanding of problem within their respective groups.	Observation - oral	Suitable to be applied
2.Generation of ideas To be aware of the students' prior knowledge.	How to solve the given problem?	**Collaborative** The students continue with their discussions and come out with possible answers to the question posed by the teacher.	The teacher inquires the students for possible solutions to the problem. The students are asked to work within their respective groups.	Discussion - oral	Suitable to be applied
3.Restructuring of ideas To recognize the existing of alternative ideas and to replace these ideas with scientific ideas.	Introduce knowledge related to the problem	**Cooperative** Each group of students presents the results of their group discussion to the class. Other students in	The teacher instructs each group of students to make a presentation to the class. The teacher opens the floor to other students to challenge the answers presented.	Discussion - oral	Quite challenging to be applied because it is not easy to make one to accept new idea.

Phases according to Needham's model	Choice of content	Learning approach	Teaching approach	Evaluation	Suggestion
		the class actively participate by challenging ideas presented by their colleagues.			
4.Application of ideas To apply the new ideas to different situation.	Application of knowledge related to the problem	**Inquiry** The students make further inquiry to know more details of knowledge and its application towards the problem.	The teacher guides the students in understanding the knowledge and its application towards the problem. The teacher will elaborate further when inquiries are made.	Writing of individual 's report on the project work.	Suitable with some challenges, such as students having difficulties applying the knowledge in solving problems given to them.
5.Reflection To investigate students' construction of knowledge and understanding	Open ended questions	**Thinking and communication skills** The students individually answer the written open-ended questions, before leaving the class.	The teacher gives out open-ended questions in written form in order to gage the students' understanding for that particular session.	Written responses as feedback	Suitable with some challenges such as students find it hard to express their reflection and teacher could not gage into the students understanding on the problem studies.

Table 4.16 illustrates the components of the proposed guideline on teaching and learning in classroom based on NFPCM. There are six components in this guideline. The first component consists of the phases based on NFPCM. The second component is the choice of content and the third component is the learning approach. These three components have been put in the teaching plans as described in Section 3.10.2, Chapter 3. The fourth column is the teaching approach; it explains the role of the teacher and the activities conducted. This component should observe and followed closely by the teacher so that effective learning among the students can be achieved. The role of the teacher and activities conducted are carefully selected

based on the literature review done among the work carried out by the local researchers as depicted in Table 2.9 in Chapter 2. The fifth column shows the evaluation that can be conducted. The evaluation refers to assessed activities that the students have to undergo. This assessment is to measure the knowledge construction among students and to ensure effective learning process has taken place. This component refers to the suitability of the activity to be carried out at each phase. Thus, the proposed guideline will hopefully assist the incorporation of the knowledge on sustainable development in Civil Engineering Construction course.

Figure 4.1 shows the block diagram for developing guideline for integrating sustainable development into Civil Engineering Construction course. The stages are:

i. identifying the constructivist approach,
ii. select Needham's Five Phase Constructivist Model (NFPCM),
iii. identify challenges based on prior studies,
iv. develop teaching plan for the class intervention,
v. carry out appropriate assessment in class interventions,
vi. identify the components for teaching and learning guideline, and
vii. develop the guideline

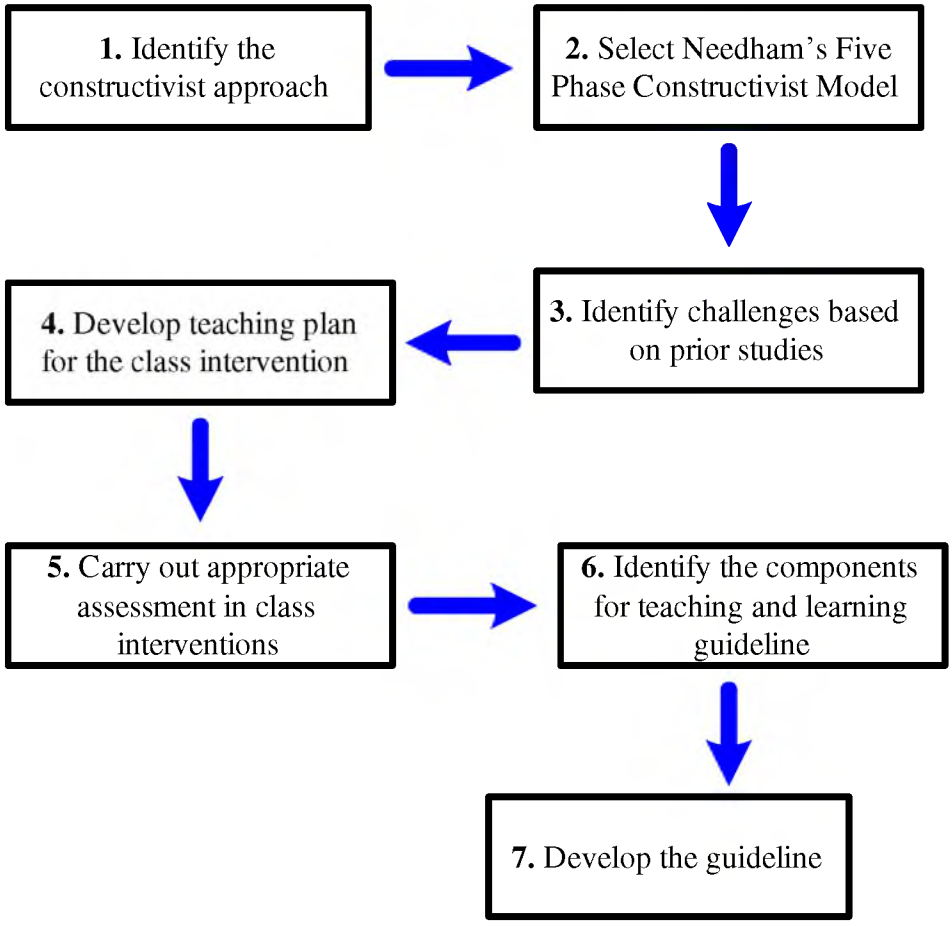

Figure 4.1 Block diagram for developing guideline for integrating sustainable development into Civil Engineering Construction course

4.4 Summary

This chapter reports and analyses the data from the survey questionnaire, pretest, posttest, semi-structured interview, open-ended questions, field trip report and group work assignment. The data has been analysed using both the quantitative and qualitative methods as shown in Table 4.17. The analysis of the data was organized according to the research questions.

The data for the first research question (RQ) is shown in Section 4.3.1. It is collected through the survey questionnaire and the data is analysed by quantitative

method using Statistical Package for the Social Sciences (SPSS) version 22. The second research question (RQ) as presented in Section 4.3.2 is to determine the knowledge gap on sustainable development through the pretest and posttest conducted. The analysis was done quantitatively using Statistical Package for the Social Sciences (SPSS) version 22. The third research question (RQ) depicted in Section 4.3.3 is the students' knowledge about sustainable development after using the Needham's Five Phase Constructivist Model (NFPCM) in the classroom setting. The data is collected through open-ended questions, field trip report, group work assignment and semi structured interview. All these data are analysed qualitatively. The fourth research question (RQ) as shown in Section 4.3.4 is to produce components of the guideline on constructivist approach in teaching and learning of knowledge on sustainable development based on the findings of this research. The development of the guideline and its components is explained in Section 4.3.4.

Table 4.17: Analysis of data

Qualitative	Quantitative
1. Open-ended questions	1. Survey questionnaire
2. Field trip report	2. Pretest
3. Group work assignment	3. Posttest
4. semi-structured interview	

CHAPTER 5

DISCUSSION, CONCLUSION AND RECOMMENDATION

5.1 Introduction

This chapter provides results and conclusion for the findings of the research. It starts by concluding the findings obtained as per Chapter 4 to answer the different research objectives. The conclusion will be made based on the findings, on how it was able to achieve the research objectives. Contributions as well recommendations for future research will also be mentioned in this chapter.

5.2 Discussion of the Research Findings

In the following section of this chapter, the main findings are reviewed for each of the questions followed by a detailed discussion. The four formulated questions are:

RQ1. What is the students' awareness toward sustainable development?

RQ2. What is the knowledge that the students have on sustainable development through the pretest and posttest conducted?

RQ3. What is the students' knowledge on sustainable development after using the Needham's Five Phase Constructivist Model (NFPCM) in the classroom setting?

RQ4. What are the components of the guideline on teaching and learning approach in integrating knowledge on sustainable development into Civil Engineering Construction course based on the constructivist approach?

5.3 Research Questions 1: What is the Students' Awareness toward Sustainable Development?

The findings showed that the students are aware of environmental issues and their attitude and perception towards sustainable development are generally positive. Majority of the students understand and can associate the terms, phrases and definitions with the knowledge on sustainable development. The findings reveal that the students understand the state of the current environmental problems and generally perceive sustainable development as one of the possible ways to overcome the problems. Consequently, their responses imply that they are willing to take on an active role in activities and efforts in overcoming issues facing the environment.

Table 5.1 shows the summary of findings for constructs: Perception on sustainable development, Attitude towards sustainable development, Environmental consciousness, Motivation to change, and Personal views on incorporating knowledge on sustainable development into Civil Engineering Construction course.

Table 5.1: Summary of findings

Construct	Comments
1. Perception on sustainable development	More than 80% of students agreed with items 1 to 4 except for item 5 where 69.5% was not sure of the derived concept of sustainable construction. In conclusion, the students have positive perception on sustainable development.

Construct	Comments
2. Attitude towards sustainable development	Majority of the students agreed with items 1 to 4 except for item 5 where they disagree and this implied that they wanted to be involved in activities. As a conclusion, this shows that the students have positive attitude towards sustainable development.
3. Environmental consciousness	97.2% of the students agree that we should live in harmony with nature and 55.6% agreed that the earth can still survive. In a nutshell, the students are conscious about the importance of the environment.
4. Motivation to change	Overall, majority of the students are motivated to change their attitude and feeling regarding the environment because they believe that they can contribute toward a better environment.
5. Personal views on incorporating knowledge on sustainable development into Civil Engineering Construction course	In general, majority of the students agreed to incorporate knowledge on sustainable development into Civil Engineering Construction course

Based on the summary given, it can concluded that the students have high level of awareness toward sustainable development, they have ample consciousness on the environment, they are motivated and believe that they can contribute toward a better environment and they agreed on the incorporation of knowledge on sustainable development into Civil Engineering Construction course.

Many research findings in literature showed that there is a correlation between knowledge, awareness and attitude to environmental practices. This indicates that to improve sustainable development 1 practices, students should be equipped with sustainable development knowledge and awareness as well as develop the positive attitude toward the environment and its conservation. Hence, it is

suggested that knowledge on sustainable development should be taught to all engineering students. The university should play a proactive role in preparing the students as future decision makers capable of affecting or even improving the state of the environment, as stated by Lee (2007).

5.4 Research Question 2: What is the Knowledge that the Students have on Sustainable Development through the Pretest and Posttest and the Types of Knowledge Students Conducted?

There are 17 multiple choice questions for the pretest. The same set applied to the posttest. The questions were divided into two levels of knowledge. The knowledge is factual and conceptual knowledge.

Overall, the score of the pretest shows that the students have some sustainable development, based on the correct answers given. An assumption can be made, from 12 out of 17 questions answered, the pretest can be said to have low difficulty level. The difficulty level of the test was measured by the score ranging from 0 for incorrect answer to 1 correct answer. The five questions which students did not correctly were Q1, Q2, Q15, Q16 and Q17. This might due to the students not having sufficient knowledge on sustainable development.

In the posttest, generally the score was almost the same as in the pretest. However, an improvement was observed whereby the students could answer correctly questions Q2, Q2, Q15, Q16 and Q17. This shows that after going through the class intervention, the students were able to increase their knowledge on sustainable development.

Based on the pretest and posttest scores, it can be concluded that little knowledge on sustainable development has been acquired by the students. Although, the knowledge is little, the attitude toward sustainable development is positive and thus, the learning process is said to have a great potential in developing the knowledge and awareness on sustainable development.

5.5 Research Question 3: What is the Students' Knowledge on Sustainable Development after using the Needham's Five Phase Constructivist Model (NFPCM) in the Classroom Setting?

The data for this research question were gathered from the open-ended questions in the classroom, field trip report, group work assignment, posttest, and semi-structured interview. The open-ended questions, field trip report and group work assignment and the posttest were analyzed through qualitative and quantitative methods respectively.

At the end of every class session the students were given a set of open-ended questions. The questions are related to the subject matter that had just done in the class. The students had to answer individually and hand in their written responses to the teacher at the end of the class period. The main aim of the open-ended questions is to obtain deep, meaningful, and thoughtful answers. It is helpful in finding out more about the student or a situation since there is no right or wrong answer in the open-ended question.

The students were required to answer the questions based on their own knowledge, understanding, thinking and opinions. They were encouraged to give complete sentences answers. Subsequently the students were exposed to critical and creative thinking and consequently this enhanced their written communication skills. From the constructivist view point of learning, responses of the open-ended questions will show that construction of knowledge and learning had taken place among the students. The written responses could also act as a feedback to the teacher.

A field trip was arranged for the students to GEO building and returning from the field trip the students had to write a brief report showing what they had learned or gained from the visit. The field trip report acts like a bridge of relevancy between the theoretical concepts learned in the classroom and the practice of actually doing the work. It also facilitate the students to understand how theory applies to real world situations and are also an opportunity to obtain evidence through methods of

observing professional practice that contribute to or challenge existing theories. From the view of learning the process of writing the report is an opportunity for the student to practice their thinking in written and communication skills.

Group work is one of the learning strategies which always recommended by constructivist. The constructivist theorists believe that learning take place during interaction. If the work is properly structured group projects can reinforce skills that are relevant to both group and individual work.. According to Caruso & Woolley (2008) group work can help students develop a host of skills that are increasingly important in the professional world (Caruso & Woolley, 2008; Mannix & Neale, 2005). Moreover, positive group experiences have been shown to contribute to student learning, retention and overall college success (Astin, 1997; Tinto, 1998; National Survey of Student Engagement, 2006). In the group work assignment the students had to write three essays. They had to cooperate and collaborate with each other. They were given the time and opportunity to complete the task by themselves. They could bring the assignment home and had to hand in to the teacher a week before the semester end. This, there are many benefits of working in the group.

In constructivist learning environment collaboration and exchange of ideas is pertinent. This is because the students learn about learning not only from themselves, but also from their peers. During the learning process they can pick up strategies and methods from one another. This also promotes social and communication skills of the students.

The field trip report and group work assignment are considered additional task to scaffold the students apart from learning in the classroom setting. One of the main purposes of the field trip and group work is to develop the learning potentials, skills and abilities which the classroom could not be able to accommodate because of time constraints, space and other limitations. As sustainable development issues are always being mentioned to be ill-structured, complex and ambiguous problems, many literature mentioned that this could not be solved only in very technical and straight manner as in engineering education but it requires creative and critical and higher thinking skills to solve or find the possible answers to the issues. Thus the

required skills and capabilities have to be developed effectively in the students besides providing the knowledge in the classroom.

The marks for the field trip report and group work assignment are almost the same for all students. This is due to the same references or sources that the students use in answering the questions. Their reports and essays are marked according to the rubric given in the Appendix H. Their work fulfill only the basic essentials and specification, however they lacked critical thinking and argumentative skills in their work. They had no sufficient information and facts to support their main idea. However with more guidance and practice the students will be able to acquire good report and essay writing. The students have some written and verbal communication potentials, as they had portrayed some good and acceptable writing in their open-ended questions and also presentation in the class.

The findings of posttest did not show any significant changes from the pretest. This might due the questions had low difficulty level. However, there are some improvements in the five questions mentioned in the pretest. Overall it can be concluded that the students had some prior knowledge and understanding of sustainable development.

The semi-structured interview was the last activity of the semester and was conducted on eleven students. In the interview, the students revealed that they had grabbed the knowledge and understanding of sustainable development. During the interview session, they could answer the questions, deliver their ideas and thoughts, and argued very well and confidently as compared to earlier interview at the beginning of the semester. In the previous semi-structured interview the students' knowledge and understanding were very minimal and basic. At the earlier semi-structured interview the students could not converse well. This might due to be lacking in knowledge and understanding on sustainable development. The outcomes of post semi-structured interview were very positive encouraging. It was a surprise to the researcher because they were same students who did the interviews earlier on. This indicates that the students had gained some knowledge and understanding on sustainable development. During the semi-structured interview they could explain and give the ideas very well and sound like an expert.

A number of the students had some critical, creative and good writing skills. These were shown in their open-ended questions responses. The open-ended questions responses and semi-structured interview are the strongest point for reason that learning and construction of knowledge had occurred among the student. The rationale is when they did both activities they were being impromptu.

Thus, the classroom intervention had assisted the students' to construct knowledge and understanding of sustainable development, developed their social and communication skills and advanced their potentials such as critical and creative thinking. These are some potentials, skills and capabilities required in order to be able to solve complex issues in sustainable development problems as stated by Preissinger (2015).

Finally after going through the five phases of the Needham's Five Phase Constructivism Model (NFPCM), the evaluations and the suggestions, the findings show that the students have constructed the knowledge and understanding on sustainable development in the Construction course. This is shown in their written responses in the open-ended questions. The students were able to comprehend how the knowledge on sustainable development can be applied in real life situations. During the semi-structured interview after posttest, they discussed sustainable development problems and issues very well as compared to their performance during the semi-structured interview before the class intervention. Their communication skills both oral and written had vastly improved. This is shown in the quality of the class presentations. Thus, the learning skills and techniques they had acquired through the constructivist learning approach will help them in furthering their studies in sustainable development areas or apply sustainable development knowledge in their future workplace.

5.6 Research Question 4: What are the Components of the Guideline on Teaching and Learning Approach in Integrating Knowledge on Sustainable Development into Civil Engineering Construction Course based on the Constructivist Approach?

The developing of the teaching and learning components is to execute effectively the Needham's Five Phase Constructivist Model (NFPCM). However, these details are not sufficient enough in the model. From the findings of the journal articles most stated that the teaching and learning activities are pertinent components in achieving the efficiency of Needham's Five Phase Constructivist Model (NFPCM) in the classroom. Thus based on these findings the researcher developed the appropriate components for the teaching and learning. With these components, the difficulties and challenges for the teachers especially who are inexperience in using constructivist approach in teaching can be overcome.

A guideline with its components for teaching and learning approach on sustainable development in Construction course is developed from the findings as depicted in Table 4.16, Chapter 4. The development of this guideline is explained in Section 2.11 and Section 4.3.4. Thus, Figures 5.1 and 5.2 show the diagrammatic block for the guideline and its components for teaching and learning approach on sustainable development in Construction course. Taking Needham's Five Phase Constructivist Model as its core, both the learning and teaching approaches are used in this knowledge acquiring process. It is then the task and responsibility of the teacher and the learner respectively, as stipulated in the Figure 5.1. Figure 5.2 explains in details how the guideline in Figure 5. 1 shall be implemented.

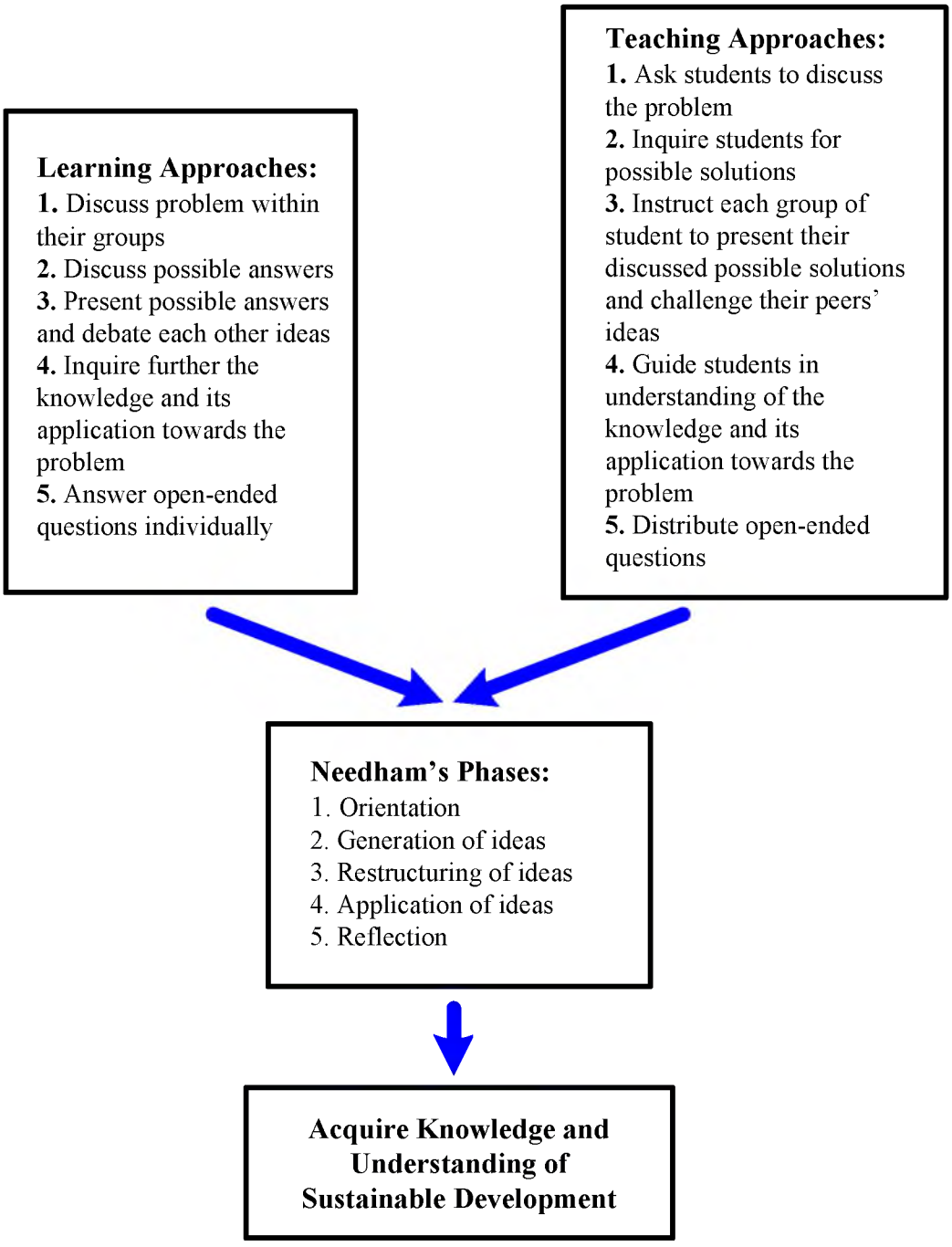

Figure 5.1 Teaching and learning approach guideline for integrating sustainable development into Civil Engineering Construction course

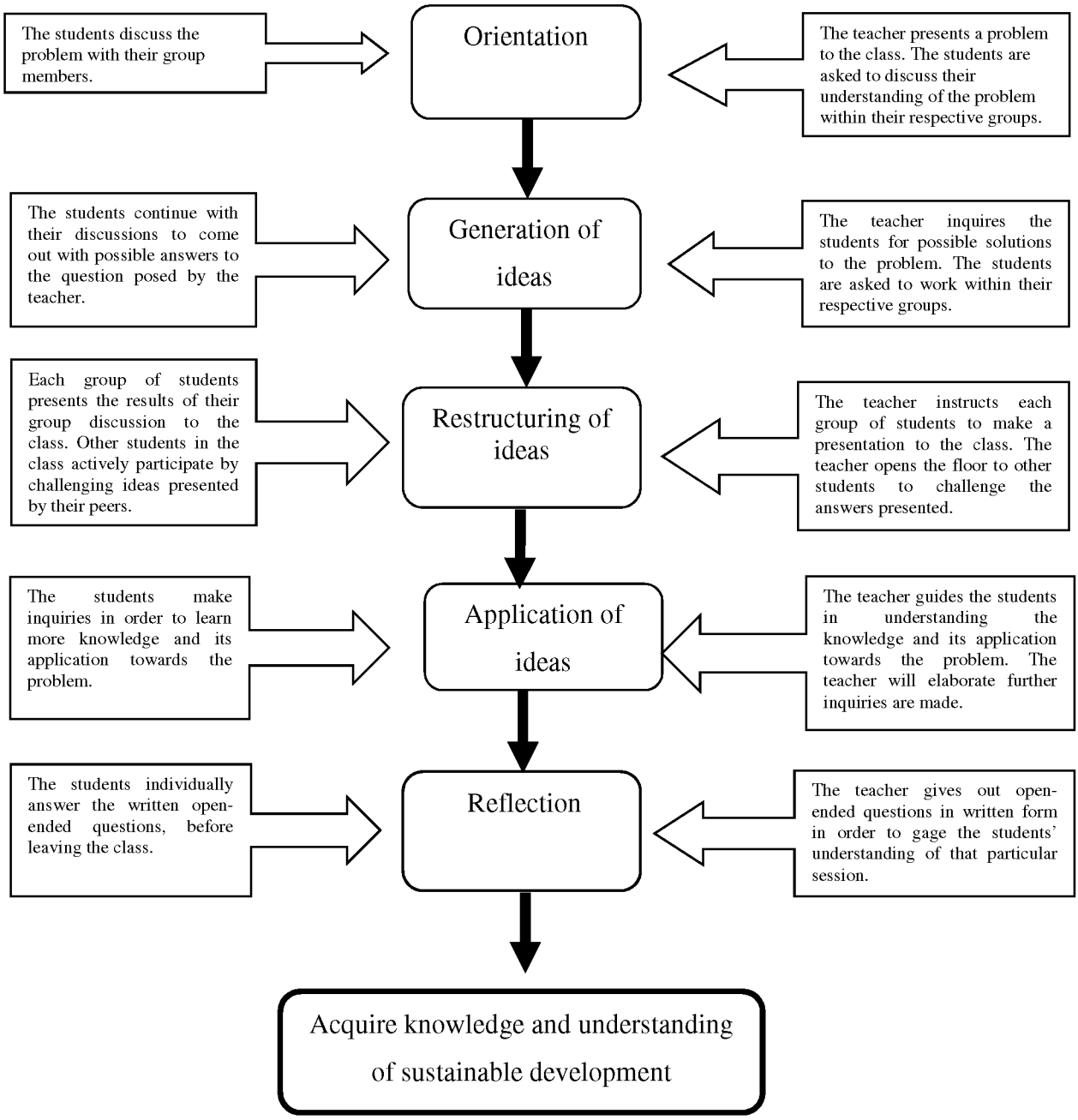

Figure 5.2 Teaching and learning approach guideline components for integrating sustainable development into Civil Engineering Construction course

The first phase of the Needham's model is orientation. The aim of orientation is to create interest, gain attention or raise curiosity of the students. The first step of constructivist learning is to set a scene. This scene could be in the form of either a

case, a problem, a video show, or an article for reading. This scene which shall begin with a question, will curiosity among the students (Bhattacharjee, 2015).

This research begins with setting a scene that includes issues and questions, presented to a group of students. They were given ample time to digest the issues, and were encourage to discuss the problems with their group members. Keeping in line with the constructivist learning model, the teacher limited his/her role to only prompting and facilitating student discussions. Since the classroom was meant to be student-centred, where learning was focused on the learner, students were required to actively participate in the class discussion. This is in accordance to the constructivist view of learning, where students work on a problem and the teacher intervenes only as required to guide them in the appropriate direction. This learning process has been proven to create common understanding of the issues among participants, a dynamic process of problem solving and above all a high sense of ownership of the conclusion reached (Bhattacharjee, 2015).

The second phase is known as generating of ideas. In the constructivist teaching and learning approach class discussion is considered as one of the most important distinctions from the traditional method of teaching and learning. At this stage the teacher inspires the students to think and find possible solutions to the given problem. Through these discussions it was observed that students developed connection to the topic, learned to respect other students' opinions and experiences, affirmed themselves as co-creators of knowledge, developed appreciation of clear communication of ideas as well as the habits of collaborative learning. Considered as one of the benefits of constructivist classroom, these group discussions have created an active and engaging environment for students. Through discussions and collaborations, engagements in active thinking and understanding, students learned to teach themselves. It is indeed in line with the constructivist teaching belief that effective learning occurs as learners are actively involved in the process of meaning and knowledge construction (Gray, 2007).

The third phase is known as restructuring of ideas. The purpose of this phase is to provide a platform for the exchanging of ideas. The process includes improvements of ideas, finding alternatives, critical assessments of ideas and

opinions and finally testing and validating different thoughts and ideas. The teacher requested the students to present their possible suggestions, opinions and thoughts to the classroom. Consequently the teacher triggered a challenging sessions where students argued and debated on each of the ideas presented. Academic research has proven that debate provides environment that are conducive to cognitive learning, and improves one's presentational skills. Throughout the process the teacher also created situations in which the students will question their own and each other's assumptions. This created a cooperative learning process, whereby students were encouraged to help and support each other in the class when their colleagues are being questioned. The cooperative learning theory, an offshoot of constructivism, incorporates the idea that the best learning occurs when students are actively engaged in the learning process and working in collaboration with other students to accomplish a shared goal. While constructivism focuses on personal experiences as the foundation for learning new material, cooperative learning utilizes not only the student's own experience to solidify knowledge, but also uses the experiences of others to further enhanced knowledge acquisition(Gray, 2007).

The fourth phase is application of ideas. The aim of this phase is to facilitate students' understanding of respective concepts, principles and its application for that particular session. After the students were done with their discussions and presentations, the teacher started to explain the concepts and principles of the subject matter which are related to the earlier introduced problem stated in scene at the first phase. The students were given opportunities to explore and ask questions to clarify certain matters which were not clear to them. The students were encouraged to actively inquire their colleagues or teacher for further knowledge and understanding. In this few rounds of dialogues, the teacher merely guided the students to construct new knowledge. Students acquired techniques in asking questions, and were introduced to variety of resources in finding solutions and answers.

The fifth and final phase is the reflection phase. Reflection plays a significant role in the constructivism. In this phase the teacher evaluated the students' understanding of the acquired knowledge. The students were given open-ended questions related to what they have learned in the classroom. They had to answer the questions and submit the written responses to the teacher in the class at the end of

given time. From the students' written response the teacher would be able to assess the students' learning progress and learning skills acquired. The reflection process could serve as a window to the learner's mind, and hence the teacher would be able to identify student's level of understanding of the concepts(Ong, 2000). Additionally this reflection process promotes social and communication skills by creating a classroom environment that emphasizes collaboration and exchanging of ideas.

In this research a number of evaluations were carried out. Firstly before the class commenced, a survey questionnaire, a pretest and a semi-structured interview were administered to the students. The survey questionnaire is used to determine the students' awareness on sustainable development. The pretest and semi-structured interview were conducted on the students to examine their knowledge on sustainable development. During the class intervention, open-ended questions were given to the students to determine their level of understanding of the particular lesson. Students were also required to submit their group project and field trip reports. At the end of the semester, a posttest and a semi-structured interview were again conducted on the students to examine their knowledge and understanding of sustainable development after the students had undergone the learning process.

5.7 Implications of the Study

Based on the research findings, the researcher suggests that constructivist approach should be adopted in teaching and learning sustainable development. It is one of an effective approaches could be employed in educating the future engineers on knowledge and understanding of sustainable development. The constructive approach encourages active and meaningful learning and promotes responsibility among the students. It is valuable teaching strategy that can assist the teacher in achieving desirable educational goals or objectives of the lesson. However, teacher should be prepared themselves with the knowledge and skills to enable the successful of teaching and learning of sustainable development. Thus it is recommended that the teachers should be provided with opportunities, resources and support from the management of the university to create incentives and encouragement to implement

constructivist teaching and learning approach. The constructivist approach could also be used in other engineering courses.

Through observation it shows that, the students are highly motivated and attracted to during the learning process. The constructivist approach ensures that the students engage and participate actively during the learning process. Self-awareness, responsibility, independent, collaboration and cooperation will drive student learn much better. It is an effective strategy to prepare students to the working environments and the real- life situation.

5.8 Conclusion and Contribution of the Study

The main objective of the research is to employ constructivist approach in teaching and learning of sustainable development into Civil Engineering Construction course. Based on the findings of the study it can be concluded that the constructivist teaching and learning approach had assisted students' in learning sustainable development knowledge and simultaneously trying to develop their potentials in critical thinking and communication skills.

Teachers who are going to implement the proposed constructivist approach have to make significant changes in the way they teach because in this approach the students are encourage to be active in the classroom whereby in the traditional teaching the students are passive receiver of information. In addition to understanding the constructivist philosophy of teaching and learning the teachers and all other personnel involved and responsible in implementing the proposed approach need to understand the kinds of changes the teachers need to undertake as they make the transition from traditionalist form of instruction to constructivist. They have to consider the learning approaches to be implemented in the classroom as well as how they make these changes. This teaching transformation can be greatly assisted and supported by the faculty and university to allow teachers to change their own personal behavior towards teaching and learning.

From the findings, students appreciated doing an activity compared to traditional way of learning. Furthermore, students tend to be self-autonomous by making discussion; sharing ideas and preparing students work cooperatively. The researcher believes that the findings of this research will encourage other teacher to consider the possibilities of using the constructivist approach. Teaching and learning using constructivist approach should be practiced and promoted to ensure the enhancement of knowledge and understanding of sustainable development in Civil Engineering construction course.

This study has the potential in adding knowledge to teaching and learning process in engineering education. When this happens, both students and teachers will be aware of the importance of sustainable development and thus, they can be expected to be more accountable in their actions in the future. Besides, this study has also added valuable knowledge on constructivism in engineering education. This knowledge will be certainly be useful for those who are interested in pedagogy and syllabus or curriculum development.

5.9 Recommendations for Future Research

Based on the findings the following recommendations are presented as for future work. Since the use of constructivist teaching approach proves to assists students' learning on sustainable development, it is highly recommended to be used as one of the main approaches for teaching the subject in a construction course, In addition to enhancing students' knowledge acquisition and understanding, the approach has also seemed to motivate students throughout the learning process

It is suggested that the teacher should try to change their pedagogical approach from a teacher-centred to a student-centred approach. The teacher is recommended to use the guideline which is proposed from this research as an alternative for teaching and learning approach. As an encouragement to the teacher the university management should try to sponsor or conduct seminars and training on

constructivism using experts in the field as a part of their faculty and staff development.

Constructivist teaching and learning is based on the belief that learning occurs as learners are actively involved in a process of meaning and knowledge construction as opposed to passively receiving information in teacher-centred learning. Another great benefit of constructivist teaching and learning is it fosters critical thinking, and creates motivated and independent learners. The constructivist approach should be adopted to assist students to build their full potentials, skills and competencies.

Constructivist teaching is based on the belief that learning occurs as learners are actively involved in a process of meaning and knowledge construction as opposed to passively receiving information in teacher-centred learning. Another great benefit of constructivist teaching is it fosters critical thinking, and creates motivated and independent learners. The constructivist approach should be adopted to assist students to build their full potentials, skills and competencies.

Since the constructivist teaching and learning approach as positive impact on students' learning, it should be extended to other courses and programs. Hence, further research work can be conducted to evaluate the effectiveness of the proposed guideline. In addition, based on this guideline, a more effective syllabus can be further developed as to cater to the dynamic world of engineering education in Malaysia especially.

5.10 Summary

Chapter 5 presents the discussion of the findings. It highlights the finding of each research questions which lead to identification of the components of the proposed guideline on teaching and learning sustainable development. This chapter also provides the implications of the study in Section 5.7, and in Section 5.8 is the conclusion and in Section 5.9 is the recommendation for the future research.

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APPENDIX A

Course Outline

COURSE OUTLINE

Department of Civil Engineering	Page : 1 of 6
Course Code: Civil Engineering Construction(DDA2132) Total Lecture Hours: 28 hours	Semester: II Academic Session: 2009/20010

Lecturer	:	*Dinar bt Md. Nurdin*
Room No.	:	*V310B*
Telephone No.	:	*03-26154631 / 012-3506421*
E-mail	:	*dinar@ic.utm.my*
Synopsis	:	This subject consists of construction activities. Introduction to substructure: foundation and piles. Introduction to temporary works: scaffolds and formworks. Introduction to superstructure: Floors, Walls, Internal Fixtures and Fittings and Roofs. Introduction to external works.

LEARNING OUTCOMES

By the end of the course, students should be able to:

No.	Course Learning Outcome	Programme Learning Outcome(s) Addressed	Assessment Methods
1.	*Describes the construction activities and practices*	PO1	Assig, T1
2.	*Explain the integration of building construction components*	PO2	Assig, T1, F
3.	*Explain and relates the construction methods and technology*	PO3	Assig, PR, T2, F
4.	*Make justifications as to the design and materials used in construction.*	PO5	Assig, PR, T2
5.	*Apply professional practice and ethics.*	PO6	PR (T1 & T2 – Test ; PR – Project ; Assig – Assignment; F – Final Exam)

Prepared by: Name: Signature: Date:	Certified by: Name: Signature: Date:

COURSE OUTLINE

Department of Civil Engineering	Page : 2 of 6
Course Code: Civil Engineering Construction(DDA2132) Total Lecture Hours: 28 hours	Semester: II Academic Session: 2009/20010

STUDENT LEARNING TIME

Teaching and Learning Activities	Student Learning Time (hours)
1. Lecture	28
2. Independent Study - self learning - information search - library search - reading - group discussion	28
3. Assignment (5x) - self learning - information search - library search - reading - group discussion	20
4. Test (2x)	2
5. Exam (1x)	
Total	80

TEACHING METHODOLOGY

Lecture and Discussion, Co-operative Learning, Independent Study, Group Project,

COURSE OUTLINE

Department of Civil Engineering	Page : 3 of 6
Course Code: Civil Engineering Construction(DDA2132) Total Lecture Hours: 28 hours	Semester: II Academic Session: 2009/20010

WEEKLY SCHEDULE

Week 1

1.0 INTRODUCTION TO CONSTRUCTION IN CIVIL ENGINEERING

1.1 Construction Activities

1.2 Site Preparations.

1.3 Definition of Substructure

1.4 Definition of superstructure and external works

1.5 Integration construction's components

Week 2

2. SUBSTRUCTURE/FOUNDATION

2.1 Introc sub-structure

2.2 Foun...

2.3 Classification of foundation

-Types of foundation

2.4 Designs of foundation

2.5 Construction process of foundation

2.7 Piles Construction and Test

2.7.1 Functions of piles

2.8 Classification of piles

2.9 Materials used for piles

2.10 Methods of pile driving

2.11 Load Tests

2.1

Weeks 3-4

3. SCAFFOLDS AND FORMWORKS

3.1 Scaffolds

3.2 Types of scaffolds

3.2.1 light duty scaffolds

3.2.2 heavy duty scaffolds

3.2.3 General purpose scaffolds

3.3 Formworks

3.4 Functions of formworks

3.5 Characteristics of good formworks

3.6 Design criterias of formworks

3.7 Construction process of formworks

3.8 Materials for formworks

3.9 Basic considerations in making formworks.

3.10 Other considerations – steps taken to avoid delay and to ensure good formwork construction and process.

COURSE OUTLINE

Department of Civil Engineering	Page : 4 of 6
Course Code: Civil Engineering Construction(DDA2132) Total Lecture Hours: 28 hours	Semester: II Academic Session: 2009/20010

Weeks 5-6	:	**4.0 SUPERSTRUCTURE**
Test 1		4.0 FLOORS 4.1 Classification of Floor 4.1.1 Ground Floor 4.1.2 Upper floor 4.2 Construction process of floors 4.3 Floor Finishes 4.4 Factors of selection of floor Finishes 4.4.1 Hard Flooring materials 4.4.2 :
		SEMESTER BREAK
Weeks 7-8	:	**5.0 Walls**
		5.1 Characteristics and Function of walls 5.2 Materials for wall construction 5.3 Walls Classification 5.3.1 Load and non load bearing walls 5.3.2 External and internal walls 5.4 Units of construction 5.4.1 Bricks 5.4.2 Blocks 5.4.3 Stone masonary 5.5 Opening in walls and curtain walls 5.6 Retaining Walls 5.6.1 Functions 5.6.2 Design Principles 5.6.3 Types of retaining walls 5.6.4 Construction of retaining walls 5.7 Walls finishing
Weeks 9-10		**6.0 INTERNAL FIXTURES AND FITTINGS**
		6.1 Doors 6.1.1 Design of door

COURSE OUTLINE

Department of Civil Engineering	Page : 5 of 6
Course Code: Civil Engineering Construction(DDA2132) Total Lecture Hours: 28 hours	Semester: II Academic Session: 2009/20010

6.1.2 Door frames construction

6.1.3 Door lining construction

6.14 Types of doors

6.2 Windows

6.3 Stairs

6.3.1 Principles to be observed while planning and designing stairs

6.3.2 Materials for stairs construction

6.4 Ironmongery

Week 11 - 12

7.0 ROOFS

7.1 Roof categorization, terminology and related terms to roofs

7.2 Roof Truss

7.3 Timber truss

Test 2

7.6 Steel truss

7.6.1 Points to be considered while constructing steel roof trusses.

Weeks 13 - 14

8.0 EXTERNAL WORKS

8.1 Drainage, manhole and septic tanks

8.2 Roads and pavings

8.3 Site Protection and reinstatement

8.4 Fencing and turfing

2

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COURSE OUTLINE

Department of Civil Engineering	Page : 6 of 6
Course Code: Civil Engineering Construction(DDA2132) Total Lecture Hours: 28 hours	Semester: II Academic Session: 2009/20010

GRADING

No.	Assessment	Number	% each	% total	Dates
1	Assignments	1	10%	10	
2	Project				
3	Quizzes				
4	Presentation				
5	Test	2	20%	40	
6	Final Exam	1	50%	50	
	Overall Total			100	

APPENDIX B

Pretest

PRETEST

Name:

Program:

Please tick one of the statements which best described the various items given.

Q1. **The definition of sustainable development (Brundtland's Report) is referred as**

No	Statements	Tick one
a	sustainable development is development which meets the needs of present without comprising the ability of future generations to meet their own needs.	
b	sustainable development refers to the fulfilment of human needs through simultaneous socio-economic, technological progress, and conservation of the earth's natural system.	
c	sustainable development is a process which enables to realise their potential and improve the quality of life in ways that simultaneously protect and enhance the Earth's life support systems.	

Q2. **The concept of sustainable development (Brundtland's Report) is based on two concepts.**

No	Statements	Tick one
a	The concept of 'wants', and the concept of limits	
b	The concept of 'needs', and the concept of limits	
c	The concept of 'protection', and the concept of limits	

Q3. **Sustainable development comprises three broad themes.**

No	Statements	Tick one
a	Social, environmental, and politics	
b	Social, technology, and economic	
c	Social, environmental, and economic	

Q4. **Environmentally sustainability is**

No	Statements	Tick one
a	to leave the Earth in good or better shape for future generations than how we found it for ourselves	
b	to leave the Earth in bad shape for future generations than how we found it for ourselves	
c	to leave the trees in good or better shape for future generations than how we found it for ourselves	

Q5. **Human activity is regarded as environmentally sustainable when it can be**

No	Statements	Tick one
a	performed or maintained indefinitely by depleting natural resources or degrading the natural environment.	
b	performed or maintained indefinitely without depleting natural resources or degrading the natural environment.	
c	performed or maintained indefinitely without decreasing energy efficiency	

Q6. **Sustainable construction is generally used**

No	Statements	Tick one
a	to describe the application of the latest technology to the construction industry.	
b	to describe the application sustainable development to the construction industry.	
c	to describe the application of the latest technique to the construction industry.	

Q7. **Sustainable construction aims at**

No	Statements	Tick one
a	increasing the environmental impact of a building over its entire lifetime, while optimising its economic viability and the comfort and safety of its occupants.	
b	increasing the energy use of a building over its entire lifetime, while optimising its economic viability and the comfort and safety of its occupants.	
c	reducing the environmental impact of a building over its entire lifetime, while optimising its economic viability and the comfort and safety of its occupants.	

Q8. **One of the principles of sustainable construction is**

No	Statements	Tick one
a	minimisation of resource consumption.	
b	minimisation of raw materials consumption.	
c	maximisation of energy consumption.	

Q9. **A green building places a high priority on**

No	Statements	Tick one
a	increasing the use of energy.	
b	increasing internal pollution and damage to health.	
c	reducing embodied energy and resource depletion.	

Q10. **Sustainable design, is the first step towards the sustainable construction and it requires innovative solutions which should include**

No	Statements	Tick one
a	cost less, conserve energy, and natural materials, reduce pollution while providing healthier, more comfortable internal environment.	
b	cost less, conserve energy, and natural materials, increase pollution while providing healthier, more comfortable internal environment.	
c	cost less, use more energy, and natural materials, reduce pollution while providing healthier, more comfortable internal environment.	

Q11. **Sustainable building is**

No	Statements	Tick one
a	a high carbon emission building.	
b	a low carbon emission building.	
c	a low oxygen emission building.	

Q12. **One of the checklists for environmentally responsible design and construction is**

No	Statements	Tick one
a	designing for potential health hazards.	
b	designing for water-efficient, low-maintenance landscaping.	
c	making it hard for occupants to recycle waste.	

Q13. **Malaysia is working towards to reduce the carbon emission as much as**

No	Statements	Tick one
a	30% by the year 2020	
b	40% by the year 2050	
c	40% by the year 2020	

Q14. **Is sustainable development necessary?**

No	Statements	Tick one
a	Yes, because the earth's resources are not unlimited.	
b	No, it is waste of time.	
c	Yes, because the economy is good.	

Q15. **Why is sustainable development so often associated with protecting the environment?**

No	Statements	Tick one
a	In the 1980s, environmental groups raised the alarm about the boom in economic activity and the ceaseless exploitation of natural resources, which often were damaging to the environment.	
b	In the 1970s, environmental groups raised the alarm about the boom in economic activity and the ceaseless exploitation of natural resources, which often were damaging to the environment.	
c	In the 1960s, environmental groups raised the alarm about the boom in economic activity and the ceaseless exploitation of natural resources, which often were damaging to the environment.	

Q16. **Why is it important to have sustainable buildings?**

No	Statements	Tick one
a	The building sector has a strong global potential to help protect the economy and increase life comfort and wellbeing.	
b	The building sector has a strong global potential to help protect the people and increase life comfort and wellbeing.	
c	The building sector has a strong global potential to help protect the environment and increase life comfort and wellbeing.	

Q17. **Buildings and construction works have the largest single share in global resource use and pollution emission. The built environment is responsible for around**

No	Statements	Tick one
a	40% of total energy use, 50% of raw materials use, 40% of global greenhouse gas emissions and 50% of solid waste generation.	
b	30% of total energy use, 40% of raw materials use,30% of global greenhouse gas emissions and 40% of solid waste generation.	
c	25% of total energy use, 40% of raw materials use, 50% of global greenhouse gas emissions and 40% of solid waste generation.	

APPENDIX C

Open-ended questions

Open-ended questions – 1

Name:

Program:

Q1. What was the most important concept you learn today?

Q2. What were the most difficult things you learn today?

Open-ended questions – 1

Q3. Malaysia is committed to reduce the carbon footprints as much as 40% by the year 2020. As a good citizen, list and briefly explain three ways you could like to make your contribution in reducing the carbon emission into the atmosphere.

Q4. Please express any concerns you have about Malaysian environment or people attitude towards environment.

Open-ended questions – 2

Name:

Program:

Q1. What do you understand by sustainable construction?

Q2. Why is sustainable construction important?

Open-ended questions – 2

Q3. How do buildings affect climate change?

Q4. What are the benefits of green building?

Open-ended questions 3

Name:

Program:

Q1. Briefly explain, how aware are you the role of engineers in creating an environmentally sustainable future?

Q2. As a good citizen, what are the positive action would you like to contribute to an environmentally sustainable future?

Open-ended questions – 3

Q3. As an engineer, what and how would you act and focus to create an environmentally sustainable future.

Q4. Educating engineers for sustainable development is important. What are your suggestions to develop the sustainability concerns and awareness among the undergraduates?

Open-ended questions – 4

Name:

Program:

Q1. What do you understand by the term sustainable construction?

Q2. What are the principal issues in sustainable construction?

Open-ended questions – 4

Q3. What improvement could sustainable construction provides?

Q4. Education and training for undergraduate engineers should incorporate sustainable concepts. Do you agree with the statement? What are you suggestion to increase the level of awareness among undergraduate engineers?

Types of Knowledge

Knowledge	Sub-Types
1. Factual Knowledge	Terminology (FK1) Specific Details and Elements (FK2)
2. Conceptual Knowledge	Classifications and Categories (CK1) Principles and Generalizations (CK2) Theories, Models, and Structures (CK3)
3. Procedural Knowledge	Subject-specific Skills and Algorithms (PK1) Subject-specific Techniques and Methods (PK2) Criteria for Determining When to Use Appropriate Procedures (PK3)
4. Meta-Cognitive Knowledge	Strategic Knowledge (MCK1) Knowledge about Cognitive Tasks (MCK2) Self-Knowledge (MCK3)

Question 4 / Possible answers	Environmental sustainability is									
	Pretest					Posttest				
	Factual Knowledge		Conceptual Knowledge			Factual Knowledge		Conceptual Knowledge		
	FK1	FK2	CK1	CK2	CK3	FK1	FK2	CK1	CK2	CK3
a) To leave the Earth in good o better shape for generations tha how we found it for ourselves.	91.7% (33)					88.9% (32)				
b) To leave the Earth in bad shape for future generations than how we found it for ourselves.										
c) To leave the trees in as good or better shape for future generations than we found it for ourselves.	8.3% (3)					11.2% (4)				
Total	100% (36)					100% (36)				

Question 3 / Possible answers	The three broad themes of sustainable development are									
	Pretest					Posttest				
	Factual Knowledge		Conceptual Knowledge			Factual Knowledge		Conceptual Knowledge		
	FK1	FK2	CK1	CK2	CK3	FK1	FK2	CK1	CK2	CK3
a) social, environment, and politics										
b) social, technology, and economic		8.% (3)								
c) social, environment, and economic		91.7% (33)					100% (36)			
Total		100% (36)					100% (36)			

Question 6 / Possible answers	Sustainable construction is generally used to describe the application of									
	Pretest					Posttest				
	Factual Knowledge		Conceptual Knowledge			Factual Knowledge		Conceptual Knowledge		
	FK1	FK2	CK1	CK2	CK3	FK1	FK2	CK1	CK2	CK3
a) The latest technology to the construction industry	5.6% (2)									
b) Sustainable development to the construction industry	88.9% (32)					100% (36)				
c) The latest technique to the construction industry	25.6% (2)									
Total	100.0% (36)					100.0% (36)				

Question 5 / Possible answers	Human activity is regarded as environmentally sustainable when it can be									
	Pretest					Posttest				
	Factual Knowledge		Conceptual Knowledge			Factual Knowledge		Conceptual Knowledge		
	FK1	FK2	CK1	CK2	CK3	FK1	FK2	CK1	CK2	CK3
a) Performed or maintained indefinitely by depleting natural resources or degrading the natural environment.		2.8% (1)					5.6% (2)			
b) Performed or maintained indefinitely without depleting natural resources or degrading the natural environment.		94.4% (34)					88.9% (32)			
c) Performed or maintained indefinitely without decreasing energy efficiency.		2.8% (1)					5.6% (2)			
Total		100% (36)					100% (36)			

Question 8 Possible answers	One of the principles of sustainable construction is									
	Pretest					Posttest				
	Factual Knowledge		Conceptual Knowledge			Factual Knowledge		Conceptual Knowledge		
	FK1	FK2	CK1	CK2	CK3	FK1	FK2	CK1	CK2	CK3
1. minimisation of resource consumption.				88.9% (32)					100.0% (36)	
2. Maximisation of raw materials consumption.				8.3% (3)						
3. Maximisation of energy consumption				2.8% (1)						
Total				100.0% (36)					100.0% (36)	

Question 7 / Possible answers	The aim of sustainable construction is to									
	Pretest					Posttest				
	Factual Knowledge		Conceptual Knowledge			Factual Knowledge		Conceptual Knowledge		
	FK1	FK2	CK1	CK2	CK3	FK1	FK2	CK1	CK2	CK3
a) Increase the environmental impact of a building over its entire lifetime, while optimizing its economic viability and the comfort and safety of its occupants.		13.9% (5)				5.6% (2)				
b) Increase the energy use of a building over its entire lifetime, while optimizing its economic viability and the comfort and safety of its occupants.		5.6% (2)				2.8% (1)				
c) Reduce the environmental impact of a building over its entire lifetime, while optimizing its economic viability and the comfort and safety of its occupants.		80.6% (29)				91.7% (33)				
Total		100.0% (36)				100.0% (36)				

Question 10 / Possible answers	Sustainable design, is the first step towards the sustainable construction and it requires innovative solutions which should be include									
	Pretest					Posttest				
	Factual Knowledge		Conceptual Knowledge			Factual Knowledge		Conceptual Knowledge		
	FK1	FK2	CK1	CK2	CK3	FK1	FK2	CK1	CK2	CK3
a) cost less, conserve energy, and natural materials, reduce pollution while providing healthier, more comfortable internal environment.		97.2% (35)					94.4% (34)			
b) cost less, conserve energy, and natural materials, increase pollution while providing healthier, more comfortable internal environment.							5.6% (2)			
c) cost less, use more energy, and natural materials, reduce pollution while providing healthier, more comfortable internal environment.		2.8% (1)								
Total		100.0% (36)					100.0% (36)			

Question 9 / Possible answers	A 'green' building places a high priority on									
	Pretest					Posttest				
	Factual Knowledge		Conceptual Knowledge			Factual Knowledge		Conceptual Knowledge		
	FK1	FK2	CK1	CK2	CK3	FK1	FK2	CK1	CK2	CK3
a) increasing the use of energy							2.8% (1)			
b) increasing internal pollution and damage to health.		8.3% (3)								
c) reducing embodied energy and resource depletion.		91.7% (3)					97.2% (35)			
Total		100.0% (36)					100.0% (36)			

Question 12 Possible answers	One of the checklists for environmentally responsible design and construction is									
	Pretest					Posttest				
	Factual Knowledge		Conceptual Knowledge			Factual Knowledge		Conceptual Knowledge		
	FK1	FK2	CK1	CK2	CK3	FK1	FK2	CK1	CK2	CK3
a) Designing for potential health hazards.				22.2% (8)						
b) Designing for water-efficient, low-maintenance landscaping.				77.8% (28)					94.4% (34)	
c) Making it hard for occupants to recycle waste									5.6% (2)	
Total				100.0% (36)					100.0% (36)	

Question 13 Possible answers	Malaysia is working towards to reduce the carbon emission as much as									
	Pretest					Posttest				
	Factual Knowledge		Conceptual Knowledge			Factual Knowledge		Conceptual Knowledge		
	FK1	FK2	CK1	CK2	CK3	FK1	FK2	CK1	CK2	CK3
a) 30% by the year 2020.		41.7% (15)					41.7% (15)			
b) 40% by the year 2050.		5.6% (2)					8.3% (3)			
c) 40% by the year 2020.		52.8% (19)					50.0% (18)			
Total		100.0% (36)					100.0% (36)			

APPENDIX E

Validation– Survey Questionnaire

SURVEY QUESTIONNAIRE

Dear Students,

I am conducting a research in Sustainability. This questionnaire is designed to incorporate the conc of sustainability into construction and design course.

This survey questionnaire consists of five parts:

Section A :	8 questions on students' demographic data
Section B :	5 questions on Knowledge of sustainable development
Section C :	5 questions on attitudes on sustainable development
Section D :	5 questions on Environmental Consciousness / Awareness – the relationship between environmental and development
Section E :	21 questions on students' views and understanding on sustainable building and construction
Section F :	5 questions on list of possible causes/ perceptions of Malaysia's environmental problems
Section G :	5 questions on motivation to change
Section H :	5 questions on personal views on incorporating sustainable concept and principles in Construction and Design course

You are kindly invited to participate in the survey.
The data collected would be a great help incorporating sustainability concepts and principles into Construction and design course in Civil Engineering programme. All information will only be used for academic purposes and research.

Thank you for your time and your cooperation.

Yours sincerely,

Dinar Bt Md Nurdin
Department of Civil Engineering,
UTMSPACE, INTERNATIONAL CAMPUS,
Universiti Teknologi Malaysia,
Kuala Lumpur.

ON A : DEMOGRAPHIC DATA

tick the appropriate box / fill in the data.

Q1. Course of Programme _____

Q2. Gender

1. Male
2. Female

Q3. Age 54 years

Q4. Year of study

1. First
2. Second
3. Third

None concerned.

Q5. Have you taken the construction course in your programme of study?

1. Yes
2. No

Not valid (NV)

Q6. Have you taken the design course in your programme of study?

1. Yes
2. No

NV

Q7. What is your current CGPA (Cumulative Grade Progress Assessment) ?

1. 3.5 – 4.0
2. 3.0 – 3.49
3. 2.5 – 2.99
4. 2.0 – 2.49

NV

Q8. From where do you know about sustainability?

1. Through books.
2. Through magazines.
3. Through television.
4. Through Government campaign.
5. Through internet.
6. Others. Please specify ..... Practicing

* Include : (1) Location of Hometown Rural Suburba Urban
(2) Socio-Economy Parents' Income (salary/month)
(a) 0 – 1500 (b) 1501 – 3000
(3) Father & Mother level of education

Section B

Review :

Table 1 Knowledge of sustainable development ? understanding of Meaning

Please indicate your level of agreement on the scale provided.

|Strongly Agree 5, Agree 4, Slightly Agree 3, Disagree 2, Strongly Disagree 1|

No	Items	SA 5	A 4	SLA 3	D 2	SD 1	Comments
K1.	Economic development, social development and environmental protection are all necessary for sustainable development.	✓					
K2.	Sustainable development can balance the need for development and the need for environmental preservation.	✓					
K3.	Sustainable consumption includes using goods and services in ways that minimize the use of natural resources and toxic chemicals, and reduces waste.	✓					
K4.	Sustainable development can defined as fulfillment of human needs through simultaneous socio-economic and technological progress and conservation of the earth's natural systems.		✓				0.74
K5.	The concept of sustainable construction is derived from that of sustainable development.		✓				

Section C

Table 2 Attitudes towards sustainable development ✓

Please indicate your level of agreement on the scale provided.

|Strongly Agree 5, Agree 4, Slightly Agree 3, Disagree 2, Strongly Disagree 1|

No	Items	SA 5	A 4	SLA 3	D 2	SD 1	Comments
A1.	Every students should receive education that teaches the knowledge, perspectives, values, issues and skills for sustainable living in a community.		✓				
A2.	The present generation should ensure that the next generation inherits a community at least as healthy, diverse and productive as it is today.		✓				0.54
A3.	Overuse of our natural resources is a serious threat to the health and welfare of future generations.		✓				
A4.	We need stricter laws and regulations to protect the environment.	✓					

A5.	There is no point in getting involved in environmental issues, since governments and industries have all the power and can do what they like.						

Section D

Table 3 Environmental Consciousness / Awareness – the relationship between environmental and development

Please indicate your level of agreement on the scale provided.

[Strongly Agree 5, Agree 4, Slightly Agree 3, Disagree 2, Strongly Disagree 1]

No	Items	SA 5	A 4	SLA 3	D 2	SD 1	Comments
EA1.	Humans must live in harmony with nature in order to survive.						
EA2.	W e are approaching the limit of number of people the earth can support.						0.426
EA3.	Serious and disruptive shortages of essential raw materials are likely if things continue.						
EA4.	A polluted environment cannot be restored to it's original state.						
EA5.	The more industrial development, the more destruction of the natural environment will take place.						

Separate Section E on separate sheet break up items, remove comments

Section E **Students' views and understanding on sustainable building and construction**

Table 4 Student's level of understanding of the rationale for using sustainable concepts on construction projects.

Choose and tick the statement best describes the above topics only one

Table 4a Every one ton of cement results in

No	Items		Comments
SU1.	One ton of CO_2 emission.	1	
SU2.	Minor effects on the environment.	2	
SU3.	Large consumption of raw material.	3	

Table 4b Students reasonable level of understanding of environmental concerns in construction.

The environmental concerns or impacts in the construction industry.

No	Items		Comments
SU4.	Rapid depletion of natural resources.	1	Both are applicable
SU5.	Energy and power savings.	2	
SU6.	Environmental impacts and construction industry are not related.	3	

Table 4c Students' awareness of the benefits of sustainable development

Results of sustainable development as applied in Engineering

No	Items		Comments
SU7.	High performance buildings and infrastructure.	1	
SU8.	High initial costs but less life cycle cost.	2	
SU9.	Better energy related components such as lighting, cooling, heating ,power generation systems.,water efficiency systems, and wastewater treatment and reuse.	3	

Table 4e Students' understanding of key elements of sustainable design as well as some of the terminology commonly used.

A sustainable building project is also called

No	Items		Comments
SU10.	A green building project.	1	
SU11.	A high performance building project.	2	
SU12.	A clean building project.	3	

Table 4f Students link sustainable design with the concepts of reducing, reusing, and recycling resources

Major principles of sustainable design

No	Items		Comments
SU13.	Reduce, reuse and recycle resource consumption.	1	
SU14.	Ignore additional cost, but assure better quality..	2	
SU15.	Reduce, reuse but not recycle resource resources.	3	

able 4g Students associate sustainability principles with ecological (or green) design.

An ecological design, also called green design

No	Items		Comments
SU16.	Describes the application of sustainability principles into building design.	1	
SU17.	In an improvement over the convectional design.	2	
SU18.	Undergoes continuous upgrading and modification in order to reach the optimal goal of achieving a full sustainable building system.	3	

Table 4h Students associate sustainability principles construction.

The principles of the sustainable construction

No	Items		Comments
SU19.	Minimization of resource consumption.	1	
SU20.	Use of renewable and recyclable resources.	2	
SU21.	Protect the natural environment.	3	

Section F

Table 5 List of possible causes/ perceptions of Malaysia's environmental problems ✓

Please indicate your level of agreement on the scale provided.

|Strongly Agree 5, Agree 4, Slightly Agree 3, Disagree 2, Strongly Disagree 1|

No	Items	SA 5	A 4	SLA 3	D 2	SD 1	Comments
P1.	Lack of awareness and education – people just do not know what to do to protect the environment.					✓	
P2.	Lack of enforcement of existing law.		✓				
P3.	Government does not place enough emphasis on protecting the environment to be pace with the development.		✓				
P4.	Malaysians can no longer afford to ignore environmental problem as hard earned economic growth will be spent on correcting the environment, that provide the resources for economic growth.				✓		0.439
P5.	Government services such as waste management is very inefficient.			✓			

Section G

Table 6 Motivation to change

Please indicate your level of agreement on the scale provided.

|Strongly Agree 5, Agree 4, Slightly Agree 3, Disagree 2, Strongly Disagree 1|

No	Items	SA 5	A 4	SLA 3	D 2	SD 1	Comments
M1.	There is a lot that I as an individual can do to help protect the environment.		/				0.772
M2.	I do what I can do to improve the quality of my country as it is going to inherited by my children.		/				
M3.	We have a duty to look after things; human have no right to destroy natural systems, it's just the right thing to do.		/				0.761
M4.	I am willing to have environmental problems solved even if this means sacrificing many goods.			/			
M5.	I think each of us can make a significant contribution to environmental protection.		/				

Section H

Table 7 **Personal views** on incorporating sustainable concept and principles in **Construction and Design course**

Please indicate your level of agreement on the scale provided.

[Strongly Agree 5, Agree 4, Slightly Agree 3, Disagree 2, Strongly Disagree 1]

No	Items	SA 5	A 4	SLA 3	D 2	SD 1	Comments
PV1.	Knowledge on concepts of sustainability, sustainable development and sustainable construction should be taught to the students.	/					
PV2.	If future construction professionals are equipped with knowledge of sustainability, this could help improve the construction industry performance with regards to environmental protection.	/					
PV3.	The most relevant aspect of sustainability to students is to develop an understanding of the principle of sustainable construction during the *design* and *construction* phases.		/				
PV4.	Incorporating the principles of sustainability will change the undergraduates' attitude and thus they can make real changes to the industry in the future.		/				
PV5.	Education is extremely important because it influences a person's attitudes, and attitudes in turn influences behaviours.	/					0.715

SUGGESTIONS:

COMMENTS:

Some of the questions are not clearly stated.

SURVEY INSTRUMENT VALIDATION FORM

Title of Survey Instrument: **Learning strategies for sustainability in Civil Engineering Program for Construction and Design Courses.**

I hereby acknowledge that the above mentioned survey instrument adapted/developed by Dinar Bt Md Nurdin UTMspace, International Campus, Universiti Teknologi Malaysia, Kuala Lumpur has been checked. The outcome is as follows: (Please tick your answers).

No	Items	Comments	
1.	The objective of the instrument is stated clearly	Yes ✓	No
2.	The instrument format is appropriate.	Yes ✓	No
3.	The font size is appropriate.	Yes ✓	No
4.	The meaning of every item is clear.	Yes	No ✓ (Section E – unclear)
5.	The instructions are clear.	Yes ✓	No
6	The measurement is appropriate.	Yes	No ✓

1. Section E – The ~~[illegible]~~ choice of answers given for Table 4, cannot be represented by just one, because they are encompassing and complementing each other. This section should be improvised for a clearer response, by the participant to reflect ~~the~~ his/her understanding ~~of the~~ ~~of him/her~~ on Sustainable Construction

2. Overall comment: Sustainable development is ~~the~~ very broad in scope ~~[illegible]~~. The survey should have focused on Sustainable Construction, which is more applicable to Engineering application.

Comments:
The current survey is meant for students, and should be distributed to students only. Others should be surveyed using ~~the~~ another set of questionnaire.

Thank you.

Signature:

Full Name: DR. FARIDAH SHAFII

Working Experience: Sustainable Building & Construction Specialist

Designation: Head, Sustainable Construction & Green Technology
ISI, UTM

Name and Address of Employer:
Institute Sultan Iskandar
UTM

Stamp of Employer:

Date: 1st July 2

APPENDIX F

Validation form – Survev Instrument

VALIDATION FORM

(Survey Instrument)

Title of Research: A constructivist framework to enhance knowledge and understanding of sustainable development in construction course.

I hereby acknowledge that the survey instrument developed by Dinar Binti Md Nurdin from Universiti Teknologi Malaysia has been checked.

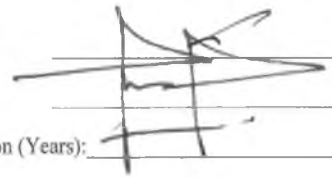
The outcome is as follows: (Please tick your answer).

PRETEST				
		YES	NO	Need modification
1.	The objective of the instruments is stated clearly.	✓		
2.	The instrument format is appropriate.	✓		✓
3.	The font size is appropriate.	✓		
4.	The instructions are direct and clear. Students can understand the instructions easily.	✓		
5.	The instructions are relevant to the content of sustainable development in construction course.	✓		

Comments:

1. FORMAT :
2. LEVEL OF QUESTION ↑ LOW HIGH

Thank you.

Signature: 

Full name:

Experience in Engineering Profession (Years):

Designation:

Name and address of employer:

YUSMADY BIN MD. JUNUS
Ketua Jabatan Alam Bina
Pusat Pengajian Diploma SPACE
Universiti Teknologi Malaysia
Jalan Sultan Yahya Petra
54100 Kuala Lumpur

Stamp of Employer:

VALIDATION FORM

(Survey Instrument)

Title of Research: A constructivist framework to enhance knowledge and understanding of sustainable development in construction course.

I hereby acknowledge that the survey instrument developed by Dinar Binti Md Nurdin from Universiti Teknologi Malaysia has been checked.

The outcome is as follows: (Please tick your answer).

PRETEST				
		YES	NO	Need modification
1.	The objective of the instruments is stated clearly.	/		
2.	The instrument format is appropriate.	/		
3.	The font size is appropriate.	/		
4.	The instructions are direct and clear. Students can understand the instructions easily.	/		
5.	The instructions are relevant to the content of sustainable development in construction course.	/		

Comments:

The choice of answers are closed each other and it will be tricky to the students/respondents. they be need a variety of answers statement.

Thank you.

Signature:

Full name: DR. RAHIMAH MUHAMAD

Experience in Engineering Profession (Years): 16 YEARS

Designation: SENIOR LECTURER

Name and address of employer:

DR. RAHIMAH MUHAMAD
Senior Lecturer
Engineering Department
UTM RAZAK School of Engineering & Advanced Technology
Universiti Teknologi Malaysia, 54100 Kuala Lumpur
HP No: +6012-6012205
Office No: 03-21805241

Stamp of Employer:

VALIDATION FORM

(Survey Instrument)

Title of Research: A constructivist framework to enhance knowledge and understanding of sustainable development in construction course.

I hereby acknowledge that the survey instrument developed by Dinar Binti Md Nurdin from Universiti Teknologi Malaysia has been checked.

The outcome is as follows: (Please tick your answer).

PRETEST				
		YES	NO	Need modification
1.	The objective of the instruments is stated clearly.	✓		
2.	The instrument format is appropriate.	✓		
3.	The font size is appropriate.	✓		
4.	The instructions are direct and clear. Students can understand the instructions easily.	✓		
5.	The instructions are relevant to the content of sustainable development in construction course.	✓		

Comments:

Subjective questions will be good as well.

Thank you.

Signature: 

Full name: Dr MOHAMMAD SYAZLI FATHI

Experience in Engineering Profession (Years): 16 YEARS

Designation:

Name and address of employer:

DR. MOHAMAD SYAZLI FATHI
Senior Lecturer
Razak School of Engineering & Advanced Technology
Universiti Teknologi Malaysia
Jalan Sultan Yahya Petra, 54100 Kuala Lumpur

Stamp of Employer:

VALIDATION FORM

(Survey Instrument)

Title of Research: A constructivist framework to enhance knowledge and understanding of sustainable development in construction course.

I hereby acknowledge that the survey instrument developed by Dinar Binti Md Nurd from Universiti Teknologi Malaysia has been checked.

The outcome is as follows: (Please tick your answer).

PRETEST				
		YES	NO	Need modification
1.	The objective of the instruments is stated clearly.	✓		
2.	The instrument format is appropriate.	✓		Should use "item" instead of "No"
3.	The font size is appropriate.	✓		
4.	The instructions are direct and clear. Students can understand the instructions easily.	✓		
5.	The instructions are relevant to the content of sustainable development in construction course.	✓		

Comments:

maybe should highlighted the important terms/ ans/answer which are different from another in same question.

Thank you.

Signature: _____

Full name: WAN MOHD KAMIL WAN AHMAD

Experience in Engineering Profession (Years): 15

Designation: LECTURER / HEAD OF DEPART.

Name and address of employer:

WAN MOHD KAMIL BIN WAN AHMAD
Ketua Jabatan Kejuruteraan Awam
Pengurusan Harta Tanah dan Ukur Tanah
Pusat Penggajian Diploma SPACE
Universiti Teknologi Malaysia
Jalan Sultan Yahya Petra
54100 Kuala Lumpur

Stamp of Employer: _____

APPENDIX G
Validation form

Title of Research: A constructivist framework to enhance knowledge and understanding of sustainable development in construction course.

I hereby acknowledge that the teaching and learning plan developed by Dinar Binti Md Nurdin from Universiti Teknologi Malaysia has been checked. The outcome is as follows: (Please tick your answer).

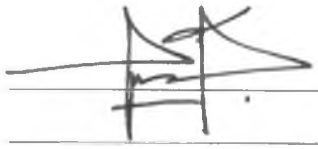
Sustainable Development				
		Suitable	Not Suitable	Need modification
1.	Objective of the teaching and learning plan.	✓		
2.	Choice of content	✓		
3.	Learning process	✓		
4.	Phases of teaching and learning plan	✓		
5.	Role of teacher as guide and facilitator	✓		
6.	Open-ended question as feedback and evaluation	✓		

Sustainable Construction				
		Suitable	Not Suitable	Need modification
1.	Objective of the teaching and learning plan.	✓		
2.	Choice of content	✓		
3.	Learning process	✓		
4.	Phases of teaching and learning plan	✓		
5.	Role of teacher as guide and facilitator	✓		
6.	Open-ended question as feedback and evaluation	✓		

The role of engineers in creating an environmentally sustainable future				
		Suitable	Not Suitable	Need modification
1.	Objective of the teaching and learning plan.	✓		
2.	Choice of content	✓		
3.	Learning process	✓		
4.	Phases of teaching and learning plan	✓		
5.	Role of teacher as guide and facilitator	✓		
6.	Open-ended question as feedback and evaluation	✓		

Comments:
SUITABLE FOR 3 AREAS.

Thank you.

Signature: 

Full name:

Experience in Engineering Profession (Years):

Designation:

Name and address of employer:

YUSMADY BIN MD. JUNUS
Ketua Jabatan Alam Bina
Pusat Pengajian Diploma SPACE
Universiti Teknologi Malaysia
Jalan Sultan Yahya Petra
54100 Kuala Lumpur

Stamp of Employer:

VALIDATION FORM

Title of Research: A constructivist framework to enhance knowledge and understanding of sustainable development in construction course.

I hereby acknowledge that the teaching and learning plan developed by Dinar Binti Md Nurdin from Universiti Teknologi Malaysia has been checked. The outcome is as follows: (Please tick your answer).

Sustainable Development				
		Suitable	Not Suitable	Need modification
1.	Objective of the teaching and learning plan.	✓		
2.	Choice of content	✓		to add current issues in SD.
3.	Learning process	✓		
4.	Phases of teaching and learning plan	✓		
5.	Role of teacher as guide and facilitator	✓		
6.	Open-ended question as feedback and evaluation	✓		

Sustainable Construction				
		Suitable	Not Suitable	Need modification
1.	Objective of the teaching and learning plan.	✓		
2.	Choice of content	✓		- what activities? - list specific activities.
3.	Learning process	✓		
4.	Phases of teaching and learning plan	✓		
5.	Role of teacher as guide and facilitator	✓		
6.	Open-ended question as feedback and evaluation	✓		

The role of engineers in creating an environmentally sustainable future				
		Suitable	Not Suitable	Need modification
1.	Objective of the teaching and learning plan.	✓		
2.	Choice of content	✓		
3.	Learning process	✓		
4.	Phases of teaching and learning plan	✓		
5.	Role of teacher as guide and facilitator	✓		
6.	Open-ended question as feedback and evaluation	✓		

Comments:

Thank you.

Signature: _____

Full name: Dr Mohamad Syazli Fathi

Experience in Engineering Profession (Years): 16 years

Designation: _____

Name and address of employer:

DR. MOHAMAD SYAZLI FATHI
Senior Lecturer
~~Razak School of Engineering & Advanced Technology~~
Universiti Teknologi Malaysia
Jalan Sultan Yahya Petra, 54100 Kuala Lumpur

Stamp of Employer: _____

VALIDATION FORM

Title of Research: A constructivist framework to enhance knowledge and understanding of sustainable development in construction course.

I hereby acknowledge that the teaching and learning plan developed by Dinar Binti Md Nurdin from Universiti Teknologi Malaysia has been checked. The outcome is as follows: (Please tick your answer).

Sustainable Development				
		Suitable	Not Suitable	Need modification
1.	Objective of the teaching and learning plan.	✓		
2.	Choice of content	✓		or need to discuss some current issue
3.	Learning process	✓		student should show individual communicator skill as well before formed a group
4.	Phases of teaching and learning plan	✓		
5.	Role of teacher as guide and facilitator	✓		
6.	Open-ended question as feedback and evaluation	✓		

Sustainable Construction				
		Suitable	Not Suitable	Need modification
1.	Objective of the teaching and learning plan.	✓		
2.	Choice of content	✓		add some safety and health problems
3.	Learning process	✓		individual communicator skill as well
4.	Phases of teaching and learning plan	✓		
5.	Role of teacher as guide and facilitator	✓		
6.	Open-ended question as feedback and evaluation	✓		

The role of engineers in creating an environmentally sustainable future				
		Suitable	Not Suitable	Need modification
1.	Objective of the teaching and learning plan.	✓		
2.	Choice of content	✓		
3.	Learning process	✓		
4.	Phases of teaching and learning plan	✓		
5.	Role of teacher as guide and facilitator	✓		
6.	Open-ended question as feedback and evaluation	✓		Questions ~~must~~ perhap should be narrow down to the level of students knowledge.

Comments:

Topics should not too general, perhap should focus on hot ~~topic~~ issues or small issues. Student should show their skill on critism other group's discussion to open the become more excited.

Thank you.

Signature: [signature]

Full name: WAN MOHD KAMIL B WA

Experience in Engineering Profession (Years): 15

Designation: LECTURER / HEAD OF DEPART.

Name and address of employer:

WAN MOHD KAMIL BIN WAN AHMAD
Ketua Jabatan Kejuruteraan Awam
Pengurusan Harta Tanah dan Ukur Tanah
Pusat Pengajian Diploma SPACE
Universiti Teknologi Malaysia
Jalan Sultan Yahya Petra
54100 Kuala Lumpur

Stamp of Employer:

VALIDATION FORM

Title of Research: A constructivist framework to enhance knowledge and understanding of sustainable development in construction course.

I hereby acknowledge that the teaching and learning plan developed by Dinar Binti Md Nurdin from Universiti Teknologi Malaysia has been checked. The outcome is as follows: (Please tick your answer).

Sustainable Development				
		Suitable	Not Suitable	Need modification
1.	Objective of the teaching and learning plan.	✓		
2.	Choice of content	✓		
3.	Learning process	✓		
4.	Phases of teaching and learning plan	✓		
5.	Role of teacher as guide and facilitator	✓		
6.	Open-ended question as feedback and evaluation	✓		

Sustainable Construction				
		Suitable	Not Suitable	Need modification
1.	Objective of the teaching and learning plan.	✓		
2.	Choice of content	✓		
3.	Learning process	✓		
4.	Phases of teaching and learning plan	✓		
5.	Role of teacher as guide and facilitator	✓		
6.	Open-ended question as feedback and evaluation	✓		

The role of engineers in creating an environmentally sustainable future				
		Suitable	Not Suitable	Need modification
1.	Objective of the teaching and learning plan.	/		
2.	Choice of content	/		
3.	Learning process	/		
4.	Phases of teaching and learning plan	/		
5.	Role of teacher as guide and facilitator	/		
6.	Open-ended question as feedback and evaluation	/		

Comments:

good ~~qu~~ open-questions for basic knowledge of sustainable construction. Respondents need to have a ~~ba~~basic knowledge of construction before answering the ~~go~~ open questions.

Thank you.

Signature:

Full name: DR. RAHIMAH MUHAMAD

Experience in Engineering Profession (Years): 16

Designation: SENIOR LECTURER

Name and address of employer:

DR. RAHIMAH MUHAMAD
Senior Lecturer
Engineering Department
UTM RAZAK School of Engineering & Advanced Technology
Universiti Teknologi Malaysia, 54100 Kuala Lumpur
HP No: +6012-6012205
Office No: 03-21805241

Stamp of Employer:

APPENDIX H

Rubric for group work project

Rubric for group project

	Excellent (9 – 10)	Good (7 – 8)	Average (4 – 6)	Poor (0 – 3)
Green building	• Precise and sufficient explanation of the term green buildings • Facts are of sufficient number to provide highly effective support • Facts are consistently detailed/precise and very relevant • Excellent variety of resources used and highly effectively blending of resources	• Sufficient explanation of the term green buildings which includes: • Facts provide substantial support • Facts are detailed/precise and relevant • Good variety of resources used and good blending of sources	• Insufficient explanation of the term green buildings which includes: • Facts provide some support • Lacking details and examples to support arguments • Some variety of sources used but more bleeding of sources needed	• Do not explain term green buildings • Very facts provided • More specific details and examples needed to support opinions • Vague • Limited variety of sources used and very poor blending of sources.
Reasons for green building	• There is one clear well-focused topic • Main idea stands out and is supported by detailed	• Main idea is clear, but the supporting information is general • Almost all	• Main idea is somewhat clear, but there is a need for more supporting information • Most supportive	• The main idea is not clear. There is a seemingly random collection of information • No facts are reported

	information • All supportive facts are reported accurately • Well supported and justified reasons	supportive facts are reported accurately • Adequately supported and justified reasons	facts are reported accurately • Merely supported and justified reasons	or most are inaccurately reported • Poorly supported and justified reasons
Significance of green building	• Well explained and supported significance • Original idea, very well explained, justified and maturely presented	• Adequately explained and supported significance • Original idea and well executed and explained	• Merely explained and supported significance • Original idea and not well executed	• Poorly explained and supported significance • Merely listing or lifting from another source • Not original • Not acknowledging the source • Immature treatment of ideas

Rubric for Report on Field trip

Criteria	Excellent (2)	Good (1.5- 1.9)	Average (1-1.4)	Poor (0 – 0.9)
Introduction	• Very clearly highlights main points to follow (without providing details) • Very smooth flow between sentences	• Highlights main points to follow (without providing details) • Fairly smooth flow between sentences	• Some overview of main points presented • Poor flow between sentences	• Main points to follow not clearly presented • Choppy flow
	Excellent (4 - 5)	Good (3-3.9)	Average (2-2.9)	Poor (1-1.9)

Content	• Facts are consistently linked to topics with highly effective explanations • Contains examples of critical thinking • Complex understanding of topic demonstrated	• Facts are generally linked to topics with effective explanations • Solid understanding of topic demonstrated • Additional analysis in places would strengthen arguments	• Connections between ideas and facts not always made • More analysis/explanation needed • Facts may appear to be 'listed'	• Connections between ideas and facts not made • Depth to argument lacking/more explanation of facts needed
	Excellent (2-3)	Good (1.5- 1.9)	Average (1-1.4)	Poor (0 – 0.9)
Conclusion	• Clear summary of main points presented (with no new data added) • Thoughtful expansive application offered • Smooth flow of summary flows	• Clear summary of main points presented (with no new data added) • Expansive application offered • Fairly smooth flow of summary flows	• Summary of main points unclear or incomplete • Expansive application weak • Choppy flow between summary flows	• Summary of arguments not provided • Elements of concluding paragraph missing

APPENDIX I

Sample of students written responses to open-ended questions

Name :

Program: 3 DDA

Q1. What was the important concept you learn today?

Its the concept where we as people who live on this earth, should make a differences on how we use this earth. we should support the plan that how to save natural resources, by make the sustainability development. maybe the cost would be high, but the reflected action is really comfort with everyone. By saving the energy, or natural resources, we can also save peoples, and our lives. But, even we do make sustainability development. and there is no work by ourselves its nothing worth. so, the important thing while during the development, we should care about the environment. do not waste anywhere, the current or keep the river and water clean from wastage. This the important concept on sustainability.

(To be discussed in group)

Q2. What was the most difficult things you learn today?

The attitudes of peoples that used to waste energy such as electricity, or throw rubbish to the river, that will make this natural resources or environment is no longer clean as before. By this bad attitude, it will cause bad effects to us also. This the most difficult things to make a changes.

Q3. Malaysia is committed to reduce the carbon footprints as much as 40% by the year 2020. As a good citizen, list and briefly explain three ways you could like to make your contribution in reducing the carbon the carbon emission into atmosphere.

first thing, for those using ar own car or motorcycle, should less use it so, use public transportation to less the carbon dioxide that have been carried out by the vehicles. me, as student, will concerned about the usage of air cond in class. Switch off the air cond when leaving the class and turn of the light when its not to be used. we also can planting trees or maybe flowers nearer to our house and do not make a open burning, such as burn the rubbish. we can make a recycling on our garbage.

Q4. Please express any concerns you have about the Malay nent or people attitude towards environment.

Malaysian's people are still not cautious about the environment now, especially in Malaysia by own. People always wanted the urbanizations in all things, but they dont realised that mostly it affects to environment and will also cause effects to us. for example, people wants the cold air so the developer or building designer mostly desire an air cond building for every and each of the rooms in the building. By this request, people's do not realised it will cause the ozone layer getting thin, and eventually it let UV ray reached towards to the earth. Rather than that, all this bad attitudes cause Malaysian environment itself not clean and uncomfortable. These will decreased the market of foreign money.

Exercise 2

Name:

Program: 3DDA

Q1. What do you understand by sustainable construction?

The construction of the building that provide or use the sustainability work. It considers the protection of natural resources where it can be save on energy. This construction is to build a building that can save energy, less using of electricity or power supply. Other than that, mostly of the use is to make the building a comfortable building to everyone who will use the building. By saving the lights, water, it can reduce use of money to spend to pay the bill. But the disadvantages for the construction is quite using a big modal. The cost is worth because it will sustain the use of electricity or power or energy to the building.

Solo 4 or 5

Q2. Why is sustainable construction important?

His to maintain the natural resources from being used a lot. It is also will offects to all people because the using of electricity such as air cond, will make the ozone layer become thinner and the UV lights or ray will be directed to the people. This will causely disease or skin damage. Other than that, sustainable construction gives comfort to us by the environment of the building and save energy. Government will use lack of money to pay or maintain the resource to be treated or else.

Q3. How do buildings affect climate change?

Towards environment :
- the weather will not be so hot as now, or getting hot
- gives the environment beautiful appearance planting.
- less using of aircond, that can make the ozone layer maintain and not damaging skin or other things.

Towards people :
- less illness that come from the wheater
- more comfortable and can save money for sickness treatment.

Towards natural resources :
- the resources that we always use to make for construction can be maintain.
- less use of resources and in other way it gives us benefits.

Q4. What are the benefits of green building?
- Lack using of electricity and power
- Save energy
- give comfortable environment for the building and people who will use the building.
- save money (for paying the bills)
- no need to work on for watching the building where need to be lights off because the building will automatically controls the environment.

Exercise 3

Name:

Program: 3DDA

Q1. Briefly explain, how aware are you the role of engineers in creating an environmentally sustainable future?

I just aware about creating an environmentally sustainable future by engineers by the building development where as they've started build a sustainability buildings. While the construction, the engineers should take role and care about the effects to environment, otherwise towards the natural resources, construction site, or the publics. They've should be aware in dealing with the air pollution, on how to control the pollution and waste once created and in remediating. Mostly of them, I believe that they have played their role for environmental in the future.

Q2. As a good citizen, what are the positive action would like to contribute to environmentally sustainable future?

The positive action that I would take or to contribute to environmentally sustainable future, started with saving the electrical energy at home or as students, at the college or other place. Whenever the class is or anymore the building or room, I'll s electrical supply to save the energy. Next, I'll start saving water, where as not wasting water while taking bath or using the toilet, Better use basin or pail then filled up it with water, so people can use the water only in the basin without wasting water from the pipe. Other than that, I can contributeby reused or recycle things that can be reused. All this type of action, can save the energy or distribution of natural resources for the future of development.

Q3. As an engineer, what and how would to act and focus to create an environmentally sustainable future?

I, as engineer should be aware and concerned on the environmental while doing or involving in building development. I also should use the natural resources wisely and think of the consequences on the construction of building or others. other than that, I need to carry out how much do i need to use the resources on eareh such as timber, water, electricity for each building that I will construct. To focus to create an environmentally susteinable future, I should encourage the public about the advantages on the sustainability building, and how do I will encourage them, by spread it in the newspapers or on television. this will make more easier to cooperate for the building construction.

Q4. Educating engineers for sustainable development is important. What are your suggestions to develop the sustainability concerns and awareness among the undergraduate?

Educating engineers for sustainable development is important. If we are to achieve a sustainable future, institutions of higher education must provide the awareness / knowledge, skills, that to make individuals pursue life goal in manner that sustains human and non-human being. And since higher education should be given the knowledge, the profesionals needs to develop, manage and teach for giving the influence society's institutions. other than that, profesionals also should develop the knowledge to schools so they can be aware early about this sustainable future development.

Exercise 4

Name:

Program: 3DDA

Q1. What do you understand by the term sustainable construction?

Sustainable construction is the way for the industry of building to achieve environmentally friendly. ~~to the nature~~ while achieving sustainable development, the economic issues also should be taken. This construction involved how to save the natural resources while giving the development in industry. For example, sustainable construction will save the energy of electricity in a building. when there were a lot of buildings that have been constructed with the sustainable development construction, it can save the cost while saving the energy and lack use of it. Other than that, this building will provide more environmental friendly, Furthermore gives beautiful environment to us.

Q2. What are the principal issues in sustainable construction?

The principal issues in sustainable construction should involve the environmentally friendly construction materials As much as 50% of all materials extracted from the earth's crust are transformed into construction materials and also including energy in use. when installed in a building, they account for the energy used. Other than that, energy efficiency should be the principal issues where as the potential for reducing gas emissions buildings can be upgraded. water management also one of the principal issues in a sustainable construction, where the operation of building places a strain on raw water reserves while waste water and sewage needs to be treated before being returned to water courses.

Q3. What improvement could sustainable construction provides?

The improvement of sustainable construction should provides the reducing of gas ~~emm~~ emissions includes greenhouse gas and others. It also should provide on reducing the use of electricity and water while reducing also the use of natural resources.

Q4. Education and training for undergraduate engineers should incorporate sustainable development concepts. Do you agree with the statement? What are your suggestions to increase the level of awareness among undergraduate engineers?

Yes, education and training for undergraduate engineers should incorporate sustainable development concepts and made it well known and accepted by all people. It is important in promoting sustainable development and improving the capacity of the people to address environment issue. This will increase the level of awareness both among undergraduate engineers in the entire construction process. The understanding about sustainable construction can be stood through common definitions and languages. while the understanding, they also should know and consider the environmental issues as one aspect of productivity.

Name :

Program: 3 DDA

Q1. What was the important concept you learn today?

From what I had learnt today, sustainable development is important to human kind and its generations. From the aspect of construction, designing, operating, human daily lifes, what we use or how we use does effects our nature. Therefore, sustainable development helps to conserves energy usage and resources from wastage. It also helps to improve mankind, nature, through social, environment and economics.

Q2. What was the most difficult things you learn today?

Agenda 21. From what I understand, it is a plan to be taken either globally or locally to maintain and preserve our environment through sustainable development. There are many plans to be considered in emphasizing agenda 21.

Q3. Malaysia is committed to reduce the carbon footprints as much as 40% by the year 2020. As a good citizen, list and briefly explain three ways you could like to make your contribution in reducing the carbon ~~the carbon~~ emission into atmosphere.

a) use public transportation as an alternative to move from one place to another.

- Instead of driving a car, we can use public transport. It may helps reducing burning of fuels and carbon emmissions.

educe the use of cfc equipments.
cfc gas can be found in aerosol etc. Therefore, y reducing the usage of cfc, it may helps ~~the~~ to reduce e emmission of carbon into atmosphere.

c) ~~Reduce~~ Recycle waste instead of open burning.

by open burning, a high percentage of carbon are release to the atmosphere. Therefore as a citizens, recycle or reuse the waste materials are one of the way to reduce carbon emmissions.

Q4. Please express any concerns you have about the Malaysian environment or people attitude towards environment.

From my perspective, malaysian should be more ~~aware~~ aware towards this issues. The attitude of throwing rubbish into the river channels, high energy usage, waste in raw materials and others should be changed into more possitive manners. Malaysians should think wisely if we want our country to be successfully develop by 2020. Our government also should play their role in encouraging people to be more alert in conserving our nature. we should think how to minimise the cost and wastage and maximise the ~~quality~~ creation of anything we do. So, lets do our job in protecting our mother earth! :)

Exercise 2

Name:

Program: 3DDA

What do you understand by sustainable construction?

Sustainable construction is the application of sustainable development in construction industry. It consists of creating ther and maintain the environment starting from pre-construction phase, construction phase and post constructions phase. In sustainable construction, it is important to minimise the resource consumption, maximise the resoured usage, use renewable energy, protect natural surrounding, creating healthy environment and improving quality in creating built environment.

Q2. Why is sustainable construction important?

It is important because by holding with the principles in sustainable construction, it may help in creating healthy and improved environment to mankind. It also helps in reducing energy usage and wastage. In terms of climate factor, it helps to balance the climate changes to prevent natural destruction such as global warming. It also may help in protecting the natural environment and balance the ecosystem. Pollutions also will be reduce and non-toxic environment may be created.

Q3. How do buildings affect climate change?

During the construction phase, it is important to take the precaution and implementing the sustainable developme principles. Pollution from the construction may increase the toxic emmission that jeoperdize our natural environment. For industry building, a factory for example, emmits high toxic content of gaseous in to the air and it may effect our ozone layer. Building with high energy usage may emmit high percentage of heat that can cause global warmig. Acid rains due to pollutions from burnig of fuels and petroleums, emmission of toxic gas may lead to corrossion to building and harm us. Building with uncontrolled energy wastage lead and affect climate change.

Q4. What are the benefits of green building?

By constructing green building, it comprises the element of protecting the nature. To tone, minimum energy usage from the green building helps in protecting our surroundig. The materials and method use from the phase of construction and after the construction, helps in moving better earth and save our planet. It minize the energy usage and reduce renewable sources wastage.

Exercise 3

Name:

Program: 3DDA

Q1. Briefly explain, how aware are you the role of engineers in creating an environmentally sustainable future?

Engineers play important role in applying sustainable development. As an engineer, they have to concern in preserving nature and maintain the ecosystem. Environmental engineers need to be educated in dealing with environmental probles such as pollution, hazardouse waste etc. They have to be expertise in activities that involve human needs such as good health and good quality of life.

Q2. As a good citizen, what are the positive action would like to contribute to environmentally sustainable future?

As a citizen, i can contribute by reduce the pollution either air, water or any kind of pollution that may harm the environment. This can be done by reduce waste, recycle all things that still can be used and reuse waste into new product. I will support green technology development in Malaysia by installing all the elements of green technology at my home.

Q3. As an engineer, what and how would to act and focus to create an environmentally sustainable future?

As an engineer, we need to focus on maintaining the nature and ecosystem. We have to start to think about applying all sort of green building technology in our daily life. We should have to introduce and make people aware about the effect to our ~~earth~~ earth if don't ~~have~~ take a good action now. We also need to focus on increasing human quality of life and provide them with sustainable future. For environmental engineers, they have to be proactive by joining the force of chemist, physicist etc.

Q4. Educating engineers for sustainable development is important. What are your suggestions to develop the sustainability concerns and awareness among the undergraduate?

In my opinion, for undergraduate, we have to apply and introduce to student about the importance of nature and preservation. This can be done by organizing campaign about green building and what they can do to preserve our nature. Other than that, we can develop sustainable concerns by giving talk and speech to them about the importance of sustainability awareness.

Exercise 4

Name:

Program: 3 DDA.

Q1. What do you understand by the term sustainable construction?

Sustainable construction is move taken to achieve sustainable development. It has to consider environment, socio-economic & cultural issue. It is important to construct sustainable, healthy, affordable and innovative structure for human.

Q2. What are the principal issues in sustainable construction?

Principal issues in sustainable construction :

a) environmentally friendly construction materials.
b) energy effiency in buildings.
c) construction and demolitions waste management.
d) water conservation.
e) Health in buildings
f) Transportation.
g) urban sustainability.
h) sustainable architechture
i) Social impacts arising from construction and the built environment.

Q3. What improvement could sustainable construction provides?

a. Healthy and safer construction
b. Reduce land degradration maximise the use of land.
c. Reduce the depletion of non-renewable resources. Through sustainable construction, we can reduce wastage of resources.
d. Lessen the material wastage and shortage.
e. Preserve the environment and balance the ecosystem.

Q4. Education and training for undergraduate engineers should incorporate sustainable development concepts. Do you agree with the statement? What are your suggestions to increase the level of awareness among undergraduate engineers?

Yes. It can be done through educate all the undergraduate engineers about the importance of sustainable and promoting the sustainable development. Other it can be done by improving the capacity that can address the development issue.

Name :

Program: 3 DDA

Q1. What was the important concept you learn today?

The important concept that I learned today is that every achievement about something starts from ourself. To achieve a major success that helps the environment and sustainability towards the Earth, every individual have to take their own action and put responsibility to help save the Earth. Eventhough a simple actions such as recycling things and make use of saving electrical appliances electricity, does really helps to sustain the Earth a lot. And as an engineer, the sustainability development and sustainability construction should be done as to help this program that helps / the Earth quality.

Q2. What was the most difficult things you learn today?

The most difficult things that I learned today are to gives awareness to those who are not beware of the benefits towards the Earth and even ourself and also to our generations. Many people argue about the effects on the economical aspects because by constructing a sustainable buildings that cost highly however the benefits that we gained after are the one that we must be aware of.

Q3. Malaysia is committed to reduce the carbon footprints as much as 40% by the year 2020. As a good citizen, list and briefly explain three ways you could like to make your contribution in reducing the carbon the carbon emission into atmosphere.

We can use less energy for electrical appliances such as air-conditioner and refrigerator. Other than that by using car pooling ~~not~~ compared to using one car for each people. Avoid smoking are also one of the actions that gives the contribution we can also plant many small trees that gives oxygen to people. We must also stop open burning that cause many carbon exposed.

Q4. Please express any concerns you have about the Malaysian e attitude towards environment.

Based on what I observed, there are some Malaysian people who awave about the importants of sustainability that take actions that supports towards the environmental sustainability But however, those who lives in urban area are more concerned about this awareness compared to those who live in rural area. Actions that people normally did are such as recycling things and saves energy

Exercise 2

Name:

Program: 3DDA

Q1. What do you understand by sustainable construction?

Sustainable construction means the people who involve in many kinds of way to build a healthy construction or building. People who involved are such as the engineers, the users and event the owner of the project. Sustainable construction should have the concepts of minimising waste and recycling materials. Sustainable construction should protect the environment to create a healthy environment by aspects of electricity, water and others

Q2. Why is sustainable construction important?

Sustainable construction is important because by doing it it helps to improve the quality of the nature and environment. Sustainable construction that keeps healthy environment helps to reduce pollution and moreover gives healthier life for human and benefits towards people who maintains healthy way of life and lifestyle. Eventhough it may cause higher cost of constructing it, but the benefits after it, overcome the high cost. Moreover sustainable construction is easier and cheaper to maintain.

Q3. How do buildings affect climate change?

As the building are built, the soil structure changes and cause landslide. Moreover high rise building that uses many energy change the climate condition such as increasing the thinning of ozone layer. Air pollution from construction cause air to be polluted that cause acid rain to be produced. This causes higher earth temperature and effects the earth condition.

Q4. What are the benefits of green building?

Green building gives reduction of human exposure towards noxious or toxic materials. It also conserved of non-renewable energy and materials that are used. Green building also protects and restore local air, water, soils, plants and even animals. Green building minimise the ecological life-cycle impact of energy. Green building gives better environment such as less pollution either air, water and others.

Exercise 3

Name:

Program: 3DDA

Q1. Briefly explain, how aware are you the role of engineers in creating an environmentally sustainable future?

The role of engineers in creating an environmentally sustainable future is by developing better water supplies, municipal sewer systems, wastewater treatments plants to the design of buildings to protect us from natural hazards and provide health care, to improved agriculture through water resource development and distribution projects to rapid and dramatic changes in transportation systems.

Q2. As a good citizen, what are the positive action would like to contribute to environmentally sustainable future?

The basic action that can be done by the citizen in normal everyday life is recycle. Not just recycling things such as glass paper, bottle and aluminium but also water. For an example the rain water can be collected and use again for outdoor purpose such as car wash and others. Our action by reducing the use of plastic bag at the supermarket also contributes a lot to environmentally sustainable future. Other than that we can also plant and grow trees around the houses to maintain green nature environment and it also helps gives better oxygen for our respiration system. Moreover less use of electricity will also supports towards environmentally sustainable future.

Q3. As an engineer, what and how would to act and focus to create an environmentally sustainable future?

As an engineer, we must build a sustainable building and constuction that has good water system, waste system, electrical system and others. The design of the building should be based on environmentally sustainable future. The materials that are used for the outdoor and indoor should be correctly used that won't effect our environment for an example rather that caused reduce deforestation

Q4. Educating engineers for sustainable development is important. What are your suggestions to develop the sustainability concerns and awareness among the undergraduate?

My suggestion to develop the sustainability concerns and awareness among the undergraduate are by putting this type of subjects as a compulsory for the students to learn and must be aware of. Those subjects must be about sustainability and those that will contribute to environmentally sustainable future. Other than that, government should provide campaign about this awareness since the kids were at primary school.

Exercise 4

Name:

Program: 300A

Q1. What do you understand by the term sustainable construction?

Sustainable construction is a construction that holds the specification that environmental friendly. The construction must maintain a dynamic balance between + demands of people for equity, prosperity and quality of life which is ecologically possible. Sustainable construction must take into account the factors of environmental, socio-economic and cultural issues.

Q2. What are the principal issues in sustainable construction?

The principal issues in sustainable construction are environmentally friendly construction materials, lower energy efficiency in buildings that potentially can reduce greenhouse gas emissions, construction and demolition waste management, water conservation, health in buildings, transportation, urben sustainability, sustainable architecture, and the social impacts arising from construction and the built environment.

Q3. What improvement could sustainable construction provides?

The improvement from sustainable construction are reducing the emissions of toxic gasses. Includes greenhouse gas and others. It can also reduce the use of electricity and water. It also improves in the reducing of the use of materials such as wood, steel and others.

Q4. Education and training for undergraduate engineers should incorporate sustainable development concepts. Do you agree with the statement? What are your suggestions to increase the level of awareness among undergraduate engineers?

Yes, because the study of sustainable development among the students are important. Way to increase the level of awareness among undergraduate engineers is by making this subject as one of the major subjects that must be pass by each students. Campaign about benefits of sustainable development should be aware by each students. We can also make a visit to buildings that apply the sustainable concepts to give more awareness to the students.

Exercise 2

Name:

Program: 3 DDA

Q1. What do you understand by sustainable construction?

Sustainable construction is construction that involves many aspects where the major are economics, social and environmental effects to the present and future generation. It is not only let the economics aspect as the main aspect of the construction but it also look through the social impact to the human being as to maintain and respect their welfare ~~of and~~ As the environmental impact to the surroundings, ~~this~~ this sustainable construction ensure that there are no resources left for the next generation.

Q2. Why is sustainable construction important?

I

It is strongly ~~agg~~ agreed that sustainable construction is very important as it really helps human to develop economic growth as well as maintaining the resources and does not produce pollution that will affect human's health. All of these ~~will~~ can be continued without any bad effects affecting any aspect.

Q3. How do buildings affect climate change?

As constructing buildings needs too many resources as well as timber, deforestration will occur. This may lead to many disaster. But the only thing that people always forgot is that the climate also can change due to deforestation as there are no longer medium to stabilize the earth's temperature. In fact, as the buildings are readily constructed, they will also contribute to the climate change. The gas emmission from factories are the major source of climate change to happen.

Q4. What are the benefits of green building?

Green buildings help to maintain the use of resources on earth as well as avoiding climate change. As a result, there will be more resources for future generation and also the human's health can be in a very good condition. In fact, there will be less disaster as landsliding and flood when the resources are limited in order to construct any building.

Exercise 3

Name:

Program: 3 DDA.

Q1. Briefly explain, how aware are you the role of engineers in creating an environmentally sustainable future?

As the engineer in future, I have to realize the importance of the sustainable environment for the mankind. I ~~possibly~~ probably should reduce the use of the non-renewable resources in order to build up a construction. In other hand, the construction also should consider the bad effect produced to the environment and the health of mankind. Despite from that, the construction to be built have to be in a very good condition although many resources have been reduced. Thus, the presence of technology nowadays have to be improved in order to achieve the goal of creating an environmentally sustainable future.

Q2. As a good citizen, what are the positive action would like to contribute to environmentally sustainable future?

First of all, it starts from home. We as a good citizen should reduce the use of plastic bag as we know that this material takes thousands of years to decompose. We also have to recycle things in order to save our natural resources. Electricity is one of the main things that contribute to pollution and others. Hence, saving electricity such as switch off any appliances while not in use and prevent from wasting it could be really helpful in order to maintain and to achieve the goal of having an environmentally sustainable in the future.

Q3. As an engineer, what and how would to act and focus to create an environmentally sustainable future?

I would start the concept of sustainable environment in my project first If I am to be hiring the workers, I would then ask them to apply the same concept as I hold onto. when the clients satisfied with the work I would then suggest to them the same concept and it will be used widely among the engineers. I would try to explain ~~and~~ in fact, shows everyone ~~on~~ about how good and the very good impact will be brought to them.

Q4. Educating engineers for sustainable development is important. What are your suggestions to develop the sustainability concerns and awareness among the undergraduate?

This topic of sustainable development should be taught in classrooms where the ~~a~~ undergraduates will have the awareness of developing the future with a very harmonize way where the environment can be maintained. Other than that, campaigns of this awareness should be held by government as well as the NGO's ~~that~~ will gathered all kind and level of man from ~~the~~ children to the elders to make them understand on how important the Sustainable development is.

Exercise 4

Name:

Program: 3DDA

Q1. What do you understand by the term sustainable construction?

Sustainable construction is a way ~~of~~ for the building industry to move towards achieving sustainable development, taking into account environmental, socio-economic and cultural issues.

Q2. What are the principal issues in sustainable construction?

The principal issues in sustainable construction are ① using environmentally friendly construction materials, ② energy ~~effen~~ efficiency in buildings, ③ construction and demolition waste management, ④ water conservation, ⑤ health in buildings, ⑥ transportation, ⑦ urban sustainability, ⑧ sustainable architecture and ⑨ social impacts arising from construction and the built environment.

Q3. What improvement could sustainable construction provides?

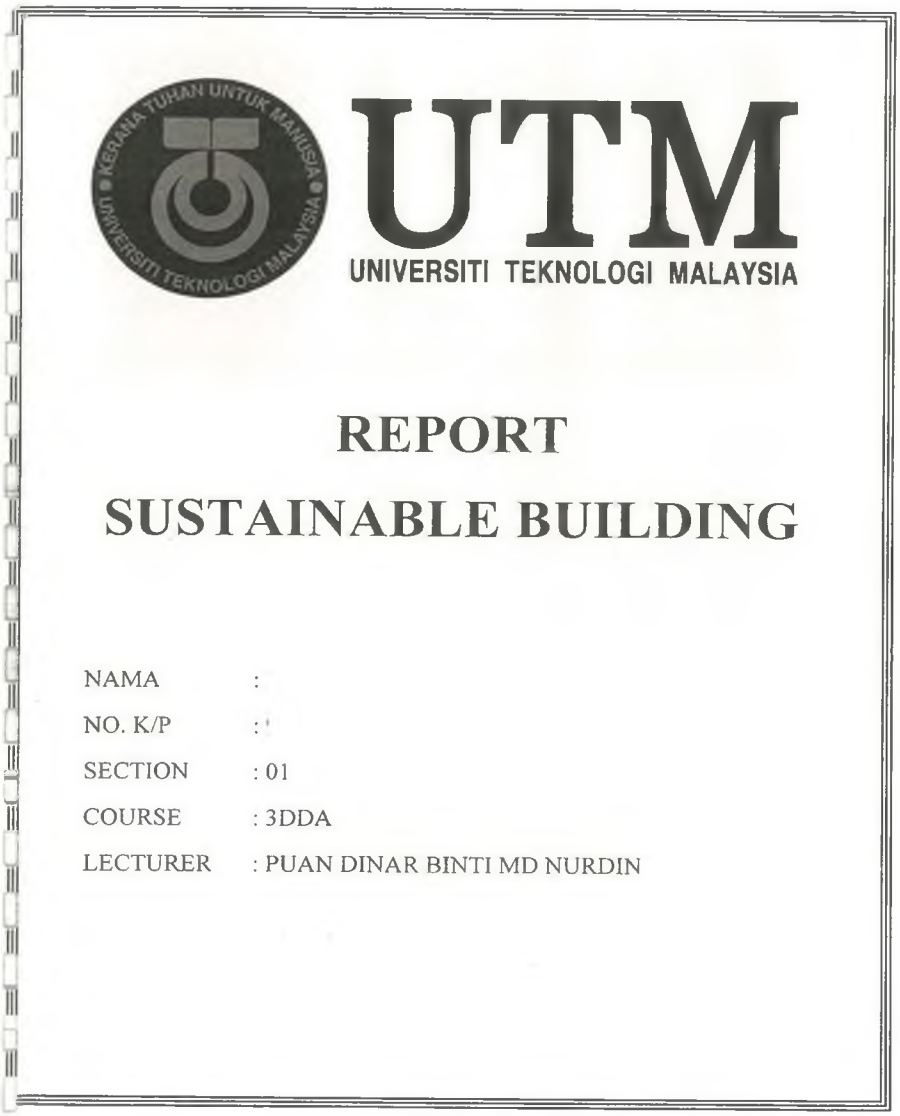
Sustainable construction may provides improvement such as ecological damage and waste minimisation during construction, site design to maximise passive solar, hydrological, ecological and other features, selection of sustainable and low impact materials, integrated design ~~building~~ of site, bilding structure, insulation, lighting, HVAC systems to minimise running cost, heat losses and energy use.

Q4. Education and training for undergraduate engineers should incorp... development concepts. Do you agree with the statement? What are y... increase the level of awareness among undergraduate engineers?

Yes, I agree with the statement. It ~~must~~ should be incorporated sustainable development concepts as education is seen as an important tool in promoting sustainable development and improving the capacity of the people to address environment and development issue. Therefore, I ~~think~~ would like to suggest that there must be a compulsory subject for the undergraduate engineers that will teach and promote on how important the sustainable development concepts is to be applied in our daily lives for the sake of better future.

APPENDIX J

Sample students' report



UTM

UNIVERSITI TEKNOLOGI MALAYSIA

REPORT

SUSTAINABLE BUILDING

NAMA :

NO. K/P :

SECTION : 01

COURSE : 3DDA

LECTURER : PUAN DINAR BINTI MD NURDIN

Introduction

Green building (also known as **green construction** or **sustainable building**) refers to a structure and using process that is environmentally responsible and resource-efficient throughout a building's life-cycle: from siting to design, construction, operation, maintenance, renovation, and demolition. This practice expands and complements the classical building design concerns of economy, utility, durability, and comfort

Although new technologies are constantly being developed to complement current practices in creating greener structures, the common objective is that green buildings are designed to reduce the overall impact of the built environment on human health and the natural environment by:

- Efficiently using energy, water, and other resources
- Protecting occupant health and improving employee productivity
- Reducing waste, pollution and environmental degradation

A similar concept is natural building, which is usually on a smaller scale and tends to focus on the use of natural materials that are available locally. Sustainability may be defined as meeting the needs of present generations without compromising the ability of future generations to meet their needs.[3] Green building does not specifically address the issue of the retrofitting existing homes

Reducing environmental impact

Green building practices aim to reduce the environmental impact of buildings, and the very first rule is, do not build in sprawl. No matter how much grass you put on your roof, no matter how many energy-efficient windows, etc., you use, if you build in sprawl, you've just defeated your purpose. Buildings account for a large amount of land.. The International Energy Agency released a publication that estimated that existing buildings are responsible for more that 40% of the world's total primary energy consumption and for 24% of global carbon dioxide emissions

Energy efficiency

Green buildings often include measures to reduce energy consumption – both the embodied energy required to extract, process, transport and install building materials and operating energy to provide services such as heating and power for equipment.

To reduce operating energy use, high-efficiency windows and insulation in walls, ceilings, and floors increase the efficiency of the building envelope, (the barrier between conditioned and unconditioned space). Another strategy, passive solar building design, is often implemented in low-energy homes. Designers orient windows and walls and place awnings, porches, and trees to shade windows and roofs during the summer while maximizing solar gain in the winter. In addition, effective window placement (daylighting) can provide more natural light and lessen the need for electric lighting during the day. Solar water heating further reduces energy costs.

Onsite generation of renewable energy through solar power, wind power, hydro power, or biomass can significantly reduce the environmental impact of the building. Power generation is generally the most expensive feature to add to a building.

Sustainable Building in Malaysia

The Pusat Tenaga Malaysia building houses the government's Green Energy Office and is the first GBI rated building in Malaysia.

Prime Minister Najib Tun Razak is chair of the council and said the move was one of five strategic thrusts under the National Green Technology Policy. The policy incorporates energy, environment, economy and social perspective. The additional strategic thrusts are:

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PUSAT TENAGA MALAYSIA'S ZERO ENERGY OFFICE

Necessity—the mother of all inventions—lends her mark of approval to Pusat Tenaga Malaysia's (PTM) new Zero Energy Office (ZEO). While buildings play a fundamental role in providing the recreational and work structures that people work, play and live in, it is also impossible to ignore the negative effects they can have, especially when a sustained amount of massive energy is needed to power them.

Heeding the call to best manage energy resources, PTM's ZEO rises to the occasion by capitalising on energy efficient measures implemented through various facets of the overall design. Construction work on the building started in March 2006, which was followed by the successful installation and commission of the four solar building integrated photovoltaic (BIPV) systems in June 2007, leading to the completion of PTM's ZEO in October last year.

Fashioned after the Low Energy Office (LEO) building initiated by the Ministry of Energy, Water and Communications (MEWC) in Putrajaya, the PTM's ZEO building has placed Malaysia on the regional map as the first completely self-sustainable building in Southeast Asia. Spread over a 5-acre site in Bandar Baru Bangi, Selangor, the building, located 40 kilometres south of the city centre of Kuala Lumpur, operates on the dynamics of both passive and active techniques and onsite renewable energy generation, as exemplified in the solar BIPV system.

The building is seen as a feasible and timely solution to growing concerns surrounding the pressing issues of global warming and energy security. Figures point to the alarming reality that in developed nations, buildings tend to take up a third of total energy consumption.

The business of sustainability is big news, by any standards. The PTM's ZEO building serves as a pilot project that provides a platform for proof of concept in driving forward the goals of the Malaysian building industry (developers, consultants, architects, local professionals and academia at large) in the subject of sustainable building design. This is great news as most buildings in Malaysia are energy inefficient—most of them record higher Building Energy Index (BEI) beyond the benchmark for Energy Efficient Buildings (EEB) set at 135 kWh per square metre per year (the kWh per square metre of the BEI is derived based on dividing the total kWh or electricity used per year by the building area based on metre square calculations).

Energy efficient architecture

Pre-programmed into the building's DNA are energy efficient features and the BIPV system—they make up the backbone of this self-sufficient, fully sustainable landmark. As such, PTM's ZEO building does not use fossil fuels, driving home the point that an office building need not consume electricity derived from this source. Instead, all electricity needed by the building is being generated by its own solar BIPV systems.

In all, four different solar BIPV systems utilising four different technologies have been installed into PTM's ZEO. The first and biggest component features the 47.28 kWp polycrystalline BIPV system on the main roof; the second component lies with the 6.08 kWp amorphous silicon BIPV system incorporated into the second main roof; the third system stored in the atrium of the building highlights the use of the 11.64 kWp monocrystalline glass-glass BIPV system; and lastly, the car park roof is fitted with 27 kWp monocrystalline BIPV system.

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Looking at the example of a total BIPV capacity of 92 kWp, the anticipated target for annual electricity generated from solar BIPV systems stands at 102 MWh. To date, the BIPV systems have produced about 103 MWh/year average, based on actual output over three months. Buildings that are not energy efficient would need more than 92 kWp as compared to PTM's ZEO. This is because the super energy efficient (EE) features of ZEO reduces the energy consumption of the building and complements the 92 kWp solar BIPV to make the total payback time for the whole systems to be less than 22 years. And this is based on current subsidised electricity tariff and technologies that are mostly imported today. It is acknowledged that the

costs of future electricity would increase and the EE as well as the solar technologies would reduce. Furthermore, it is important to bear in mind that there is no payback price for the environment.

To achieve the super EE outputs, the building incorporates features utilising passive techniques as well as orientation and vegetation, balanced with active features seen in efficient lighting systems, floor slab cooling, double-glazed windows as well as a thermal wall at its east- and west-facing façades.

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Emphasis on holistic design approach

The critical approach towards ZEO is the holistic design involving all consultants, led by the architect, working together in order to achieve the client's zero energy vision. The initial architectural concept of the building was enhanced with super EE features, followed by the solar BIPV capacity to offset the remaining energy demand. The usage of solar BIPV technology not only displaced conventional building materials, but also adds value to the architecture of the building.

Today, PTM's ZEO continues to function as a showcase building to facilitate and explore the concept of sustainability in buildings, while assisting to create opportunities for the involvement of other relevant industries. The building is exemplifying the use of energy efficiency, with solar BIPV setting a new standard for sustainable building in the ASEAN region.

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Monocrystalline PV modules (27kWp) on the carpark roof

Polycrystalline modules (47.28kWp) on the main roof

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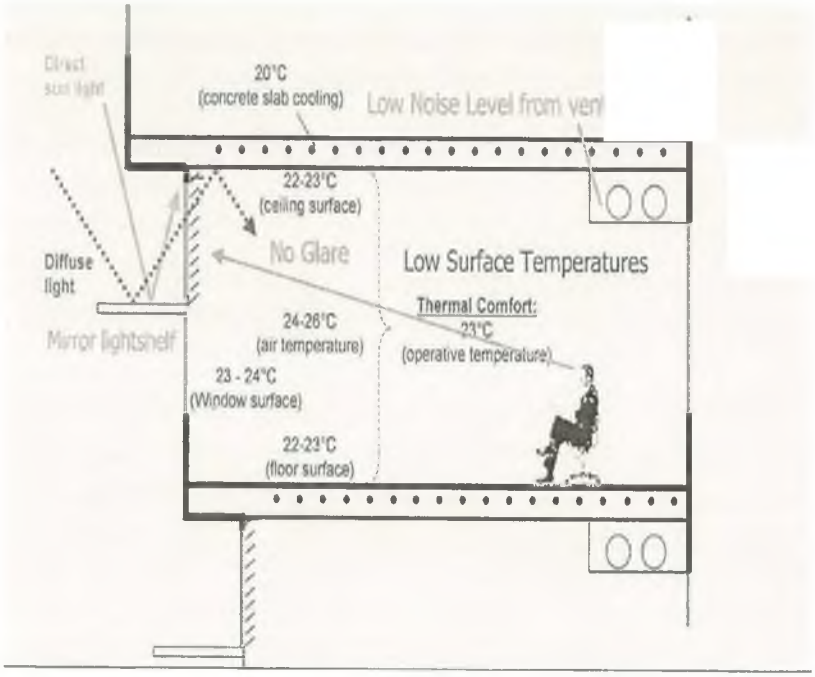
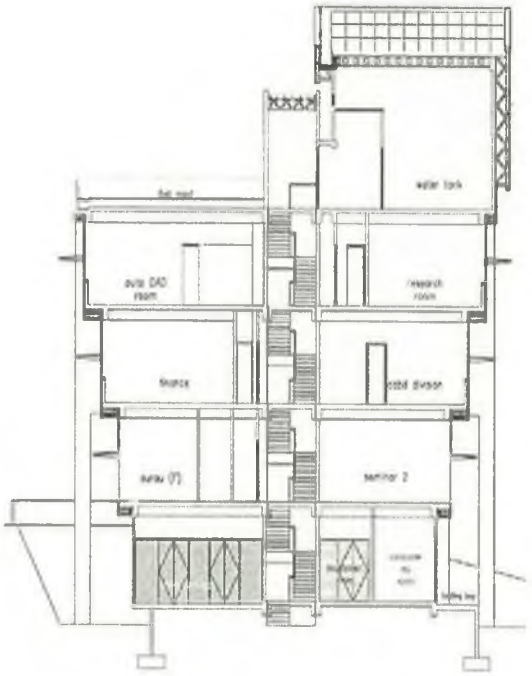


Typical section

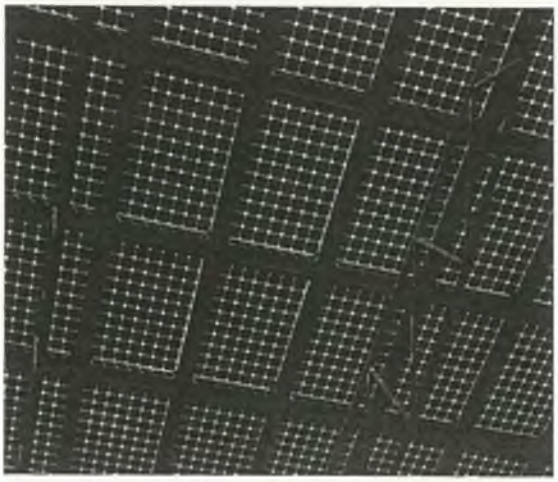


Step-in design (self-shading

Colour of office interior reflects light

Colour of building exterior minimises heat gain

Maximising daylighting



Glass semi-transparent PV modules (11.64kWp)

UTM
UNIVERSITI TEKNOLOGI MALAYSIA

REPORT SUSTAINABLE BUILDING

DDA 3153

LECTURER :

PUAN DINAR MOHD NURDIN

SUSTAINABILITY

Sustainability is the capacity to endure. For humans, sustainability is the long-term maintenance of well being, which has environmental, economic, and social dimensions, and encompasses the concept of stewardship, the responsible management ofresource use. In ecology, sustainability describes how biological systems remain diverse and productive over time, a necessary precondition for human well-being. Long-lived and healthy wetlands and forests are examples of sustainable biological systems.

Healthy ecosystems and environments provide vital goods and services to humans and other organisms. There are two major ways of managing human impact on ecosystem services. One approach is environmental management; this approach is based largely on information gained from earth science, environmental science, and conservation biology. Another approach is management of consumption of resources, which is based largely on information gained from economics.

Human sustainability interfaces with economics through the social and ecological consequences of economic activity. Moving towards sustainability is also a social challenge that entails, among other factors, international and national law, urban planningand transport, local and individual lifestyles and ethical consumerism. Ways of living more sustainably can take many forms from reorganising living conditions (e.g., ecovillages, eco-municipalities and sustainable cities), to reappraising work practices (e.g., using permaculture, green building, sustainable agriculture), or developing new technologies that reduce the consumption of resources.

DEFINITION

The word sustainability is derived from the Latin *sustinere* (*tenere*, to hold; *sus*, up). Dictionaries provide more than ten meanings for *sustain*, the main ones being to "maintain", "support", or "endure". However, since the 1980s *sustainability* has been used more in the sense of human sustainability on planet Earth and this has resulted in the most widely quoted definition of sustainability and sustainable development, that of the Brundtland Commission of the United Nations on March 20, 1987: "sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

At the 2005 World Summit it was noted that this requires the reconciliation of environmental, social and economic demands - the "three pillars" of sustainability. his view has been expressed as an illustration using three overlapping ellipses indicating that the three pillars of sustainability are not mutually exclusive and can be mutually reinforcing.

Scheme of sustainable development: at the confluence of three constituent parts

The UN definition is not universally accepted and has undergone various interpretations. What sustainability is, what its goals should be, and how these goals are to be achieved are all open to interpretation. For many environmentalists the idea of sustainable development is an oxymoron as development seems to entail environmental degradation. Ecological economistHerman Daly has asked, "what use is a sawmill without a forest?" From this perspective, the economy is a subsystem of human society, which is itself a subsystem of the biosphere, and a gain in one sector is a loss from another. This can be illustrated as three concentric circles.

A universally accepted definition of sustainability remains elusive because it is expected to achieve many things. On the one hand it needs to be factual and scientific, a clear statement of a specific "destination". The simple definition "sustainability is improving the quality of human life while living within the carrying capacity of supporting eco-systems", though vague, conveys the idea of sustainability having quantifiable limits. But sustainability is also a call to action, a task in progress or "journey" and therefore a political process, so some definitions set out common goals and values. The Earth Charter speaks of "a sustainable global society founded on respect for nature, universal human rights, economic justice, and a culture of peace."

To add complication the word *sustainability* is applied not only to human sustainability on Earth, but to many situations and contexts over many scales of space and time, from small local ones to the global balance of production and consumption. It can also refer to a future intention: "sustainable agriculture" is not necessarily a current situation but a goal for the future, a prediction. For all these reasons sustainability is perceived, at one extreme, as nothing more than a feel-good buzzword with little meaning or substance but, at the other, as an important but unfocused concept like "liberty" or "justice". It has also been described as a "dialogue of values that defies consensual definition".[23]

Some researchers and institutions have pointed out that these three dimensions are not enough to reflect the complexity of contemporary society and suggest that culture could be included in this development model.

OBJECTIVE OF GREEN BUILDING

There are a number of motives to building green, including environmental, economic, and social benefits. However, modern sustainability initiatives call for an integrated and synergistic design to both new construction and in the retrofitting of an existing structure. Also known as sustainable design, this approach integrates the building life cycle with each green practice employed with a design-purpose to create a synergy amongst the practices used.

Green building brings together a vast array of practices and techniques to reduce and ultimately eliminate the impacts of buildings on the environment and human health. It often emphasizes taking advantage of renewable resources, such as using sunlight through passive solar, active solar, and photovoltaic techniques and using plants and trees through green roofs, rain gardens, and for reduction of rainwater run-off. Many other techniques, such as using packed gravel or permeable concrete instead of conventional concrete or asphalt to enhance replenishment of ground water, are used as well.

While the practices, or technologies, employed in green building are constantly evolving and may differ from region to region, there are fundamental principles that persist from which the method is derived: Sitting and Structure Design Efficiency, Energy Efficiency, Water Efficiency, Materials Efficiency, Indoor Environmental Quality Enhancement, Operations and Maintenance Optimization, and Waste and Toxics Reduction. The essence of green building is an optimization of one or more of these principles. Also, with the proper synergistic design, individual green building technologies may work together to produce a greater cumulative effect.

Environmental Dimension

Healthy ecosystems provide vital goods and services to humans and other organisms. There are two major ways of reducing negative human impact and enhancing ecosystem servicesand the first of these is environmental management. This direct approach is based largely on information gained from earth science, environmental science and conservation biology. However, this is management at the end of a long series of indirect causal factors that are initiated by human consumption, so a second approach is through demand management of human resource use.

Management of human consumption of resources is an indirect approach based largely on information gained from economics. Herman Daly has suggested three broad criteria for

ecological sustainability: renewable resources should provide a sustainable yield (the rate of harvest should not exceed the rate of regeneration); for non-renewable resources there should be equivalent development of renewable substitutes; waste generation should not exceed the assimilative capacity of the environment.

Environmental management

At the global scale and in the broadest sense environmental management involves the oceans, freshwater systems, land and atmosphere, but following the sustainability principle of scale it can be equally applied to any ecosystem from a tropical rainforest to a home garden.

Atmosphere

In March 2009 at a meeting of the Copenhagen Climate Council, 2,500 climate experts from 80 countries issued a keynote statement that there is now "no excuse" for failing to act on global warming and that without strong carbon reduction "abrupt or irreversible" shifts in climate may occur that "will be very difficult for contemporary societies to cope with". Management of the global atmosphere now involves assessment of all aspects of the carbon cycle to identify opportunities to address human-induced climate change and this has become a major focus of scientific research because of the potential catastrophic effects on biodiversity and human communities (see Energy below).

Other human impacts on the atmosphere include the air pollution in cities, the pollutants including toxic chemicals like nitrogen oxides, sulfur oxides, volatile organic compounds andparticulate matter that produce photochemical smog and acid rain, and the chlorofluorocarbons that degrade the ozone layer. Anthropogenic particulates such as sulfate aerosols in the atmosphere reduce the direct irradiance and reflectance (albedo) of the Earth's surface. Known as global dimming, the decrease is estimated to have been about 4% between 1960 and 1990 although the trend has subsequently reversed. Global dimming may have disturbed the global water cycle by reducing evaporation and rainfall in some areas. It also creates a cooling effect and this may have partially masked the effect of greenhouse gases on global warming.

Freshwater and Oceans

Water covers 71% of the Earth's surface. Of this, 97.5% is the salty water of the oceans and only 2.5% freshwater, most of which is locked up in the Antarctic ice sheet. The remaining freshwater is found in glaciers, lakes, rivers, wetlands, the soil, aquifers and atmosphere. Due to the water cycle, fresh water supply is continually replenished by precipitation, however there is still a limited amount necessitating management of this resource. Awareness of the global importance of preserving water for ecosystem services has

only recently emerged as, during the 20th century, more than half the world's wetlands have been lost along with their valuable environmental services. Increasing urbanization pollutes clean water supplies and much of the world still does not have access to clean, safe water. Greater emphasis is now being placed on the improved management of blue (harvestable) and green (soil water available for plant use) water, and this applies at all scales of water management.

Ocean circulation patterns have a strong influence on climate and weather and, in turn, the food supply of both humans and other organisms. Scientists have warned of the possibility, under the influence of climate change, of a sudden alteration in circulation patterns of ocean currents that could drastically alter the climate in some regions of the globe. Ten per cent of the world's population – about 600 million people – live in low-lying areas vulnerable to sea level rise.

Land use

Loss of biodiversity stems largely from the habitat loss and fragmentation produced by the human appropriation of land for development, forestry and agriculture as natural capital is progressively converted to man-made capital. Land use change is fundamental to the operations of the biosphere because alterations in the relative proportions of land dedicated to urbanisation, agriculture, forest, woodland, grassland andpasture have a marked effect on the global water, carbon and nitrogen biogeochemical cycles and this can impact negatively on both natural and human systems. At the local human scale, major sustainability benefits accrue from sustainable parks and gardens and green cities.

Since the Neolithic Revolution about 47% of the world's forests have been lost to human use. Present-day forests occupy about a quarter of the world's ice-free land with about half of these occurring in the tropics. In temperate and boreal regions forest area is gradually increasing (with the exception of Siberia), but deforestation in the tropics is of major concern. Food is essential to life. Feeding more than six billion human bodies takes a heavy toll on the Earth's resources. This begins with the appropriation of about 38% of the Earth's land surface and about 20% of its net primary productivity. Added to this are the resource-hungry activities of industrial agribusiness – everything from the crop need for irrigation water, synthetic fertilizers and pesticides to the resource costs of food packaging, transport (now a major part of global trade) and retail. Environmental problems associated with industrial agriculture and agribusiness are now being addressed through such movements as sustainable agriculture, organic farming and more sustainable business practices.

Energy

The Sun's energy, stored by plants (primary producers) during photosynthesis, passes through the food chain to other organisms to ultimately power all living processes. Since the industrial revolution the concentrated energy of the Sun stored in fossilized plants as fossil fuels has been a major driver of technology which, in turn, has been the source of both economic and political power. In 2007 climate scientists of the IPCCconcluded that there was at least a 90% probability that atmospheric increase in CO_2 was human-induced, mostly as a result of fossil fuel emissions but, to a lesser extent from changes in land use. Stabilizing the world's climate will require high-income countries to reduce their emissions by 60–90% over 2006 levels by 2050 which should hold CO_2 levels at 450–650 ppm from current levels of about 380 ppm. Above this level, temperatures could rise by more than 2°C to produce "catastrophic" climate change. Reduction of current CO_2 levels must be achieved against a background of global population increase and developing countries aspiring to energy-intensive high consumption Western lifestyles.

Reducing greenhouse emissions, is being tackled at all scales, ranging from tracking the passage of carbon through the carbon cycle to thecommercialization of renewable energy, developing less carbon-hungry technology and transport systems and attempts by individuals to leadcarbon neutral lifestyles by monitoring the fossil fuel use embodied in all the goods and services they use.

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Colour of office interior reflects light

Maximising daylighting

Glass semi-transparent PV modules (11.64kWp)

Daylighting

Colour of building exterior minimises heat gain

APPENDIX K

Marks – Field Trip Report and Group Work Assignment

Students	Introduction (2 marks)	Content (5 marks)	Conclusion (3 marks)	Total (10 marks)
1	1.5	2.5	1.0	5.0
2	1.5	2.5	1.0	5.0
3	1.5	2.5	1.0	5.0
4	1.5	2.5	1.0	5.0
5	1.5	2.5	1.0	5.0
6	1.5	2.0	1.0	4.5
7	1.5	2.5	1.0	5.0
8	1.5	2.5	1.0	5.0
9	1.5	2.5	1.0	5.0
10	1.5	2.5	1.0	5.0
11	1.5	2.5	1.0	5.0
12	1.5	2.5	1.0	5.0
13	1.5	2.5	1.0	5.0
14	1.5	2.5	1.0	5.0
15	1.5	2.5	1.0	5.0
16	1.5	2.5	1.0	5.0
17	1.5	2.5	1.0	5.0
18	1.5	2.5	1.0	5.0
19	1.5	2.5	1.0	5.0
20	1.5	2.5	1.0	5.0
21	1.5	2.5	1.0	5.0
22	1.5	2.5	1.0	5.0
23	1.5	2.5	1.0	5.0
24	1.5	2.5	1.0	5.0
25	1.5	2.5	1.0	5.0
26	1.5	2.5	1.0	5.0
27	1.5	2.5	1.0	5.0
28	1.5	2.5	1.0	5.0
29	1.5	2.5	1.0	5.0
30	1.5	2.5	1.0	5.0
31	1.5	2.5	1.0	5.0
32	1.5	2.5	1.0	5.0
33	1.5	2.5	1.0	5.0
34	1.5	2.5	1.0	5.0
35	1.5	2.5	1.0	5.0
36	1.5	2.5	1.0	5.0
37	1.5	2.5	1.0	5.0
38	1.5	2.5	1.0	5.0
39	1.5	2.5	1.0	5.0

Group	What is green building? (10 marks)	Why the world needs green building? (10 marks)	Significant of green building to Malaysian environment (10 marks)	Conceptual drawing (10 marks)	Total marks (40 marks)
1	4	8	3	8	23
2	4	7	7	8	27
3	4	8	9	6	27
4	9	8	6	8	31
5	5	7	8	6	26
6	5	6	7	5	23
7	4	5	4	5	18
8	4	5	4	6	19
9	6	8	4	6	24
10	4	4	4	6	18
11	4	5	4	7	20