INSTRUCTIONAL SCAFFOLDING IN ONLINE SOCIAL COLLABORATIVE LEARNING ENVIRONMENT FOR NURTURING ENGINEERING STUDENTS' KNOWLEDGE CONSTRUCTION LEVEL

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To my beloved students in Ungku Omar Polytechnic

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ABSTRACT

The purpose of this study is to evaluate the impact of Instructional Scaffolding (IS) on an online Social Collaborative Learning (SCL) environment upon engineering students' knowledge construction (KC) level. In addition, this study also investigate on how the IS cognitively steers engineering students towards KC and helps them reach a higher level of KC. This study then proposed a KC model in an online SCL environment integrated with IS that could nurture engineering students' knowledge construction level. A questionnaire, achievement test, posting scripts from Facebook discussions, and structured interviews were used for data collection. The methodology comprised two designs: a quasi-experimental for the quantitative approach, and a case study for the qualitative approach. The quasi-experimental involved the pre and post-test to be taken by 74 participants from one polytechnic in northern Malaysia to identify the improvement in their knowledge construction level. Meantime, the case study involved a process in providing the detail and depth of exploration in a real situation by obtaining the perceptions and perspectives of 10 engineering students. Content analysis and thematic analysis were used to identify the relationships between codes, themes, and between different levels of themes. A t-test indicated a significant increase in the mean score of the post-test in both of the learning environments, that is, the conventional collaborative learning (CCL) and the SCL environment supported by instructional scaffolding. Nevertheless, the engineering students in the SCL environment showed a significantly higher mean score if compared with those in the CCL environment (pre-test score; 3.05 vs post test score; 13.98). Simultaneously, comparing the combination of results in the percentage of knowledge construction level reveals that engineering students in the control group and in the experimental group demonstrated an increase for each level of knowledge construction whether they were in the CCL or in the SCL environment. They illustrated different percentages for scores of argumentative knowledge construction (such as CCL=84.21, SCL=86.11) and metacognitive knowledge construction (CCL=13.16, SCL=64.00) between control and experimental group. Through content analysis, eight answer themes that affect engineering students' knowledge construction were identified. Nine answer themes also were identified regarding on how SCL characteristics supported by IS enabled engineering students to reach a higher level of knowledge construction. Based on all these findings, the researcher then produced a holistic knowledge construction model. It comprised the 8 essential elements of impact factors, such as students' cognitive pre-engagement, motivation, engagement and enhancement, explanation and guide, encouragement and praise, determination, comfort and engagement, as well as ease of the learning process in the instructional scaffolding strategy model. As a result, it is concluded that IS plays a vital role in the knowledge construction processes in order to help engineering students' construct their knowledge and reach a higher level of thinking.

ABSTRAK

Tujuan kajian ini adalah untuk menilai kesan perancah pengajaran (IS) dalam persekitaran pembelajaran sosial kolaboratif (SCL) atas talian terhadap tahap pembangunan pengetahuan (KC) pelajar kejuruteraan. Di samping itu, kajian ini juga mengkaji bagaimana IS dapat merangsang kognitif pelajar kejuruteraan ke arah pembangunan pengetahuan pada tahap yang lebih tinggi. Kajian ini seterusnya mencadangkan satu model KC dalam persekitaran SCL secara talian bersepadu dengan IS yang boleh memupuk tahap pembangunan pengetahuan pelajar kejuruteraan. Soal selidik, ujian pencapaian, skrip perbincangan Facebook dan temubual berstruktur telah digunakan untuk pengumpulan data. Metodologi yang merangkumi dua reka bentuk: kuasi-eksperimen bagi pendekatan kuantitatif dan kajian kes bagi pendekatan kualitatif telah digunakan. Kuasi-eksperimen melibatkan ujian pra dan pasca yang perlu diambil oleh 74 peserta dari sebuah politeknik di utara Malaysia bagi mengenal pasti peningkatan dalam tahap pembangunan pengetahuan mereka. Sementara itu, kajian kes melibatkan proses penyediaan maklumat terperinci berdasarkan penerokaan situasi sebenar menerusi persepsi dan perspektif yang diperoleh daripada sepuluh orang pelajar kejuruteraan. Analisis kandungan dan analisis tematik telah digunakan untuk mengenal pasti hubungan antara kod, antara tema, dan di antara tahap yang berbeza tema. Ujian t menunjukkan bahawa terdapat peningkatan yang signifikan dalam skor min bagi ujian pasca bagi kedua-dua persekitaran pembelajaran, iaitu, pembelajaran kolaboratif secara konvensional (CCL) dan juga persekitaran SCL yang disokong dengan perancah pengajaran. Walau bagaimanapun, pelajar kejuruteraan dalam persekitaran SCL menunjukkan skor min yang lebih tinggi berbanding dengan mereka yang berada dalam dalam persekitaran CCL (ujian pra = 3.05, ujian pasca = 13.98). Pada masa yang sama, perbandingan kombinasi peratusan tahap pembangunan pengetahuan mendedahkan bahawa pelajar kejuruteraan dalam kumpulan kawalan dan kumpulan eksperimen menunjukkan peningkatan bagi setiap tahap pembangunan pengetahuan sama ada mereka yang berada dalam persekitaran CCL atau pun SCL. Didapati peratusan pembangunan pengetahuan pelajar adalah berbeza untuk pembangunan pengetahuan berhujah (CCL=84.21, SCL=86.11) dan pembangunan pengetahuan metakognitif (CCL=13.16, SCL=64.00) antara kumpulan kawalan dan eksperimen. Menerusi analisis kandungan, lapan tema jawapan yang memberi kesan kepada pembangunan pengetahuan pelajar kejuruteraan telah dikenal pasti. Sembilan tema jawapan berkaitan dengan bagaimana ciri-ciri SCL disokong oleh IS membolehkan pelajar kejuruteraan mencapai pembangunan pengetahuan pada tahap yang lebih tinggi juga telah dikenal pasti. Berdasarkan semua penemuan ini, penyelidik kemudiannya telah membangunkan sebuah model pembinaan pengetahuan secara holistik. Ia terdiri daripada lapan unsur penting yang memberi kesan seperti pra-penglibatan kognitif pelajar, motivasi, penglibatan dan penambahbaikan, penjelasan dan panduan, galakan dan pujian, keazaman, keselesaan dan penglibatan, dan juga memudahkan proses pembelajaran dalam model strategi perancah pengajaran. Secara keseluruhannya, dapat disimpulkan bahawa IS memainkan peranan yang penting dalam proses pembangunan pengetahuan bagi membantu pelajar kejuruteraan dalam pembangunan pengetahuan dan mencapai tahap pemikiran yang lebih tinggi.

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LIST OF ABBREVIATIONS AND ACRONYMS

ABET	*Accreditation Board for Engineering and Technology*
AOD	*Asynchronous Online Discussions*
APEC	*Asia-Pacific Economic Cooperation*
C3I	*Condition, Interaction, Immediacy, Intimacy*
CCL	*Conventional Collaborative Learning*
CGPA	*Cumulative Grade Point Average*
CL	*Collaborative Learning*
CoP	*Communities of Practice*
CSCL	*Computer-Supported Collaborative Learning*
CSLEs	*Computer-Supported Learning Environments*
F2F	*Face-To-Face*
FB	*Facebook*
HOT	*Higher Order Thinking*
IASs	*Industry Applications Societies*
ICT	*Information Communication Technology*
IEM	*Institution of Engineers Malaysia*
IS	*Instructional Scaffolding*
ISS	*Instructional Scaffolding Strategic*
IT	*Information Technology*
KC	*Knowledge Construction*
KCL	*Knowledge Construction Level*
KCM	*Knowledge Construction Model*
LCP	*Learner-Centered Practices*
LGC	*Learning or Learner-Generated Content*
LMS	*Learning Management System*

LMSs	*Learning Management Systems*
LOT	*Lower Order Thinking*
MCED	*Malaysian Council of Engineering Deans*
MEEM	*Malaysian Engineering Education Model*
MoE	*Ministry of Education*
NHESP	*National Higher Education Strategic Plan / Pelan Strategik Pengajian Tinggi Negara (*PSPTN)
OBE	*Outcome Based Education*
OERs	*Open Educational Resources*
OL	*Online Learning*
QAD	*Quality Assurance Department*
SCL	*Social Collaborative Learning*
SCLE	*Social Collaborative Learning Environment*
SLE	*Social Learning Environment*
SLEs	*Social Learning Environments*
SMT	*Social Media Technologies*
SNS	*Social Network Sites*
SPM	*Sijil Pelajaran Malaysia*
STPM	*Sijil Tinggi Persekolahan Malaysia*
T&L	*Teaching and Learning*
TS	*Thinking Skills*
TVET	*Technical and Vocational Education and Training*
WebCT	*Web Communication Technology*
ZPD	*Zone of Proximal Development*

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Students' knowledge construction requires "knowledge to be taught" (Tiberghien, 2007), especially during a teaching and learning (T&L) session. Moreover, it can be linked with acquiring knowledge instilled by educators effectively in the classroom. In other words, students structure their knowledge in the classroom. "Knowledge to be instructed" is distinguished scientific knowledge that depends on the teaching level. For instance, the subject of classical mechanics is taught differently at vocational schools and polytechnics, and is also different at the university level, although all of them refer to the same laws of the natural philosophical system. This knowledge differs with the application for the tasks given and contributes to "shaping" students' knowledge.

The conventional view of knowledge is that of acquisition through books or lectures. Knowledge is an asset of the individual mind, and the process of learning to construct knowledge. Nowadays, knowledge is a process of learning related to social activities. It emphasizes learning processes and the outcome of academic achievement (Williams, 2009). The issue needs to be recognized that knowledge construction is from the learning process and outcome of learning; it is integrated with the correlation between students and environment.

Thus, environment brings affect students' knowledge construction. Engineering students show very little gains in high knowledge construction level that allow them to integrate and apply in the real world, practicing notably to develop the competence and expertise in the engineering field (Tchoshanov, 2013; Streveler *et al.*, 2008; Donovan and Bransford, 2005). Moreover, industry complains that engineering students are deficient in skills and demonstrate low quality achievement in academic performance (Felder, 2012).

Recently, students including who study engineering field also need to construct their own knowledge through social constructivism (O'Neill, Geoghegan and Petersen, 2013). It provides learning strategies, such as active learning, which apply rational processes such as critical and creative thinking (Li, 2012).

Different approaches used will provide different learning outcomes for students. We may consider adopting explicit teaching to bring about students' construction of knowledge in the social constructivist theory of learning context. Rosenshine's (1986) essay on explicit teaching claimed that teachers can effectively teach concepts and skills explicitly, in graduated steps with the student-guided practice that promotes students' success in the learning process. Mayer (2012) stressed that discourse can be carried out in the form of teacher-led, student-led and teacher/student co-led learning process, depending on the authority granted to students. The learner-centered practices (LCP) approach provides insights into pedagogical practices, replacing the traditional teacher-centered classroom. Such of approach, the students may participate the discussion actively among them. Nonetheless, they do not know how to discuss the learning content in effectively due to construct their knowledge. Thereby, instructors need to scaffold a learning environment that supports the processes and learning outcomes of knowledge construction. Scaffolding is one way to minimize the problem.

However, that aim of teacher's scaffolding of students' learning is to maintain productive interaction with students. Scaffolding raises the importance of activating students' prior knowledge. Utilizing instructional scaffolding by teachers plays a vital role in encouraging students to be active in learning (O'Neill, Geoghegan and Petersen, 2013). This scaffolding can take the form of questions, prompts, rephrasing, demonstrations, explaining, and comprehension monitoring (Crawford, 2003). Teachers are seen as learning instructors for students. Scaffolding, questioning techniques and feedback (Walsh, 2006) are indispensable in their metacognitive activities, as it is unclear how teachers utilize different questioning techniques to scaffold students' new knowledge construction (King, 1994).

Students will find their learning environment meaningful to them through their prior learning, applied to new learning opportunities, as pointed out by Schuh (2003). She explained how student-centered instruction can be carried out in which students' views need to be understood by the teachers, who will in turn support students to accomplish their desired learning goals. Learning can be achieved through active collaboration between teachers and students, who together determine what learning means and how it can be enhanced by students' own unique talents, capabilities, and experience (McCombs, 1997). Students are seen as developing new knowledge and understanding through being actively engaged in the process of knowledge construction (Jenkins, 2000).

The use of scaffolding, which is implemented on the engineering students' knowledge construction has not been used to minimize the gap between students' prior knowledge and learning experience. Hence, teacher guidance is needed for students due to achieve the learning goals such as build up new knowledge (Schwarz *et al.*, 2004). There is good evidence to support teaching and LCP to enhance motivation and achievement for students (McCombs, 1997). Thus, in order for engineering students to achieve complex skills, the instructional scaffolding needs to be put into practice in the learning process. As such, it is timely for researchers to discuss the issue of scaffolding.

Nowadays, learners face numerous challenges in order to be successful: (a) know how to learn, (b) access changing information, (c) apply what is learned, and (d) address complex real-world problems (Larkin, 2002). These challenges are also faced by engineering students, who have a variety of problems in the engineering field. Hence, scaffolding is provided to facilitate and optimize student learning since they need to continue to learn independently and without support in the engineering classroom.

Conventionally, scaffolding is a continuous process in which there is the interaction between a parent and child, or between instructor and student (Bruner, 1975). Today, instructional scaffolding comprises of interactions between individuals with tools, resources, and environments. It is provided in paper-and-pencil tools (Puntambekar and Kolodner, 2005), technological resources (Bell and Davis, 1996; Jackson, Krajcik, and Soloway, 1998), peer interactions (Puntambekar *et al*. 1997) or instructor-led discussion (Tabak and Reiser, 1997). Kupers, Dijk and Geert (2014) considered how to set up appropriate scaffolding in the process of learning for students, which also involves engineering students. Thus, researcher discussion focuses on the interactions that specifically address the issue of instructional scaffolding, exploring students' learning process of knowledge construction.

1.2 Background of Problem

Nowadays, our environment and society are drastically changing into a knowledge-cum-network society. We see different products and get new information from widgets daily through which we acquire better knowledge about products. This is how knowledge is constructed. Importantly, people are beginning to have the option and capability to learn whenever, wherever, and however they wish (Mbendera, Kanjo and Sun, 2010). Even today, knowledge construction in engineering education is a major topic of concern.

1.2.1 Issues and Challenges in the Engineering Field

The engineering profession has become increasingly important globally, particularly in the 21st century (UNESCO Report, 2010). These changes have had a great impact on the profession. Thus, engineers need to be educated in a better way (Daniels *et al.* 2010; UNESCO Report, 2010).

However, there is no instruction of a cognitive, informational, or rational nature (Dai and Sternberg, 2004). Instruction can be enhanced by explicit attention to each professional field and academic course (Hardré, 2009, 2012). Low motivation, low retention rates, and existing skills gaps are critical in the engineering field (Hardré and Siddique, 2013). These are related to the engineering programs.

The report on 2015 and 2016 put forward the criteria for accrediting engineering programs (ABET, 2014) to prepare current and future engineers. There are six skills suggested for addressing global issues such as global warming and climate change in the engineering area (Daniels *et al.* 2010):

- ability to apply knowledge of mathematics, science, and engineering
- ability to function on multidisciplinary teams
- ability to communicate effectively
- the education necessary to understand the impact of engineering solutions in a global, environmental and societal context
- knowledge of contemporary issues

Hence, there is a need to transform teaching and learning (T&L) in response to the increasing globalization of workforces (UNESCO Report, 2010; Felder, 2012). There is a reasonable consensus over the skills required. However, questions remain on how to implement and create equilibrium in the curriculum in engineering field (Daniels *et al.* 2010; UNESCO Report, 2010; Felder, 2012).

Entry qualification (enrolment) for degree engineering programs in Malaysia are based on students need to have minimum 5 credits in Sijil Pelajaran Malaysia (SPM/Malaysia Certificate of Education) or O-levels inclusive of mathematics and 2 pure science course for entry in the Foundation in Science or Foundation in Engineering. Generally, art students would not be able to take science-related degree programs depending on which university. For those students after Sijil Tinggi Persekolahan Malaysia (STPM/Malaysian Higher School Certificate) or A-levels or matriculation may entry into the degree program at their particular university.

Universities in Malaysia offered a five-year engineering program in the past. This program period was reduced to three years in 1996 as a result of recommendations from the Ministry of Education in Malaysia (MoE). The rationale was to meet the growing demands of the workforce market in the engineering sector. Aziz *et al.* (2005) revealed that this was against the Institution of Engineers Malaysia (IEM)'s regulations and no research had been published to support the change. The performance of students across the country was subsequently greatly affected while there was an increase in the failure rate. The program also encountered problems with training accreditation (Aziz *et al.*, 2005).

The Malaysia as a member of the Washington Accord and the Engineering Accreditation Council (EAC). The outcome-based rather than prescriptive approach to assessment affected the country's institutions (Aziz *et al.*, 2005). Recently, engineering school programs have been centered on outcome-based modes. In fact, there are variations throughout the country in all fields of study, which are encouraged by the Quality Assurance Department (QAD) at the MoE, Malaysia.

Thereafter, the Malaysian Engineering Education Model (MEEM) led the way for engineering schools to adopt an outcome-based education (OBE) in 2000. However, the Engineering Accreditation criteria (attributes) was not fully understood or practiced by engineering education providers (Aziz *et al.*, 2005). Yet, it is without compulsory to follow the recommendations (Aziz *et al.*, 2005). Since early 2004, interest in OBE has started to appear with some providers of engineering education leading the way. Nonetheless, there was unshown the effectiveness of the learning process for engineering students, as is required by OBE approach.

In addition, Ismail and Abidin, (2014) cited that a huge challenge of technical and vocational education and training (TVET) providers to attract more than 100,000 school-leavers further their education and training in TVET notably engineering field. They are join the labor market after 11 years of formal schooling in Malaysia. This issue brings together the most obvious problems education or training in TVET Malaysia due to school-leavers lack of participation in technical and vocational streams (Ismail and Abidin, 2014).

Moreover, another issue of engineering curriculum development is the requirement to meet the relevant minimum credit/contact hours of study for engineering courses. The curriculum may seem to be well designed on paper, but there is no indication that it will be well delivered (Aziz *et al.*, 2005). Apart from that, Marjoram and Zhong (2010) of UNESCO Report revealed that a degree in engineering should be associated with skills such as design and drawing. The engineering education need seeks to develop a logical, practical, problem-solving methodology and approach that comprises technical (hand-on) skills which is related to real-world engineering experience on how to solve the society issues. These include motivation, the ability to perform, rapid understanding, communication and leadership, and social-technical skills in training and mentoring (UNESCO Report, 2010).

Nowadays, engineers need to face complex problems in the engineering field, which they need to solve by themselves (National Academy of Engineering, 2004, 2005; UNESCO Report, 2010). Engineering careers in the twenty-first century require a good understanding of the interface between natural and artificial in this rapidly changing world as a “hybrid world” (Sheppard *et al.*, 2009). However, there is a lack of well-prepared engineers for the next generation (National Academy of Engineering, 2004, 2005; UNESCO Report, 2010).

The factor that makes retention of engineering students is a major challenge in engineering education (Burtner, 2005; Felder, Shepard and Smith, 2005). There is a high dropout rate from engineering courses and programs (Grose, 2008; Marra, *et al.*, 2012). Notably, less than 10 % of students dropped out from engineering courses due to low grades (Kuh *et al.*, 2006). This clearly shows that there are other factors, such as negative motivation (Hardré and Siddique, 2013). Thereby, a researcher in engineering education should strive to increase instructional scaffolding towards knowledge construction for engineering students' learning process. Apply scaffolding to promote engagement for them participate the metacognitive activity. Simultaneously, optimize encourage engineering students to complete the engineering course in current university (Hardré and Siddique, 2013).

Conceptual knowledge is a key strength that needs to be constructed in engineering field (Streveler *et al.*, 2008). Such knowledge may assist engineering students in discovering their mistakes when solving problem. If students are unable to master this knowledge, they may face problems in knowledge construction.

Many engineering students in biomedical, mechanical and chemical, and other fields might find it difficult to construct knowledge, particularly conceptual knowledge (Streveler *et al*, 2008). Such students may have misconceptions in learning science (Tchoshanov, 2013; Duit, 2007). It is often a challenge for engineering students to learn science concepts (Tchoshanov, 2013). They are unable to understand concepts such as force, energy, moments, heat, current, stress, and other physical quantities of engineering science, which brings difficulties when mastering it (Tchoshanov, 2013; Streveler *et al.*, 2008; Donovan and Bransford, 2005). Ron Watermayer of UNESCO Report claimed that fundamentals knowledge (a combination of general and specialist engineering knowledge) not optimize the application in engineering field (UNESCO Report, 2010). In addition, these concepts knowledge are not engaged to their daily learning experience (Tchoshanov, 2013).

Several concepts are difficult for engineering students to learn in terms of knowledge construction (Streveler *et al.*, 2008). These may be differences in the concept between the various fields of engineering science. However, there is a very little study in the engineering field about learning conceptual knowledge in engineering science (Tchoshanov, 2013; Streveler *et al.*, 2008; Donovan and Bransford, 2005).

The six skills and competencies (global and strategic, industrial, humanistic, practical, professional and scientific) embedded in the Civil Engineering courses (Aziz *et al.*, 2005) can prepare next generation engineering students to have the competencies and meta-competencies in their work place and real-world practice. Hoyer *et al.*, of UNESCO Report revealed that performance requirement in globalization of the workforce market is driven by the quality; skills and flexibility of employee in the engineering sector (UNESCO Report, 2010). Hence, there is a need to have well-designed effective learning, such as (1) active learning and construction of knowledge, (2) teamwork learning and (3) learning through problem-solving (Alavi, 1994) to assist students to optimize knowledge construction.

1.2.2 Knowledge Construction Issues for Engineering Students Scenario

Knowledge construction is a complex cognitive process that is not easy to master and acquire (Wang *et al.*, 2013). Ericsson (2008) stressed that development and acquisition of knowledge is a complex process. Similarly, Kinchin, Baysan, and Cabot (2008) revealed that extending the knowledge base requires an underlying network of understanding. Students have low prior knowledge for learning higher knowledge construction to guide them through the process of knowledge construction (Moreno and Valdez, 2005).

Knowledge construction can occur in a number of ways (Du and Wagner, 2007). For instance, teachers giving effective explicit instruction using pedagogy beneficial to student learning (O'Neill, Geoghegan and Petersen, 2013), students' actively engaging in collaborative knowledge construction (Goodyear and Zenios, 2007), and learning with computer support to facilitate and enhance knowledge (Tarmizi *et al.*, 2012).

The traditional T&L approach, via teacher-centered classrooms has limitations for being able to foment development of personalized knowledge construction, as learning content has typically not been able to meet the individual's needs (Mbendera, Kanjo and Sun, 2010). This is similar with Scott's (2008) idea that, in a conventional lecture classroom, lecturers have strong autonomy in teaching students, and tend to focus on content and modules. The conventional telling-listening in T&L scenarios puts stress on the relationship between lecturer and students (Prawat,1992). These teaching methods do not cultivate and fully discover students' potential in knowledge construction at a higher level. The issue is how lecturers or instructors can guide students in knowledge construction (Schwarz *et al*, 2004).

In the conventional classroom learning environment, an instructor presents the same content in the same format. Meanwhile, the instructor hopes that students learn equally in the traditional classroom and face-to-face, which exemplifies the 'one content fits all' approach to T&L. However, research has shown that learning is subjective and different from person to person. Hence, it is vital to modify content based on students' needs and expectations to ensure effective learning (Mbendera, Kanjo and Sun, 2010). Kahiigi *et al*. (2008) define personalized learning as "…*a learning approach that facilitates and supports individualized learning, where each learner has a learning path that caters for learners' learning needs and interests in a productive and meaningful way*…" However, the onus is on the instructor. Instructors may be lacking the breadth and depth of explicit teaching embedded in a practical classroom that is beneficial to student engagement (O'Neill, Geoghegan and Petersen, 2013). Thus, how to bring about student-driven knowledge construction is the key issue.

On the other hand, Grapragasem, Krishnan and Mansor (2014) revealed Hrm ASIA Report in 2012 that unemployment Malaysian graduates was increase from 44,000 in 2011, 43,000 in 2010 and 41,000 in 2009. There is a gap between industry expectations and satisfaction of engineering graduates' skills in the area of employability (Eric, Serge and Karim, 2015). Thereby, from this issue can relate with the context of Malaysian students' issues such as (a) 57.90% final year engineering undergraduate has low academic achievement (means that low Cumulative Grade Point Average (CGPA) grades) from the study of graduate employability in University of Malaysia Perlis (UNIMAP) (Yusof and Jamaluddin, 2015), (b) lack of knowledgeable and skillful workforce to support industry demands (Ismail and Abidin, 2014) and (c) inadequate quality and skills possess by the students in the academic which is related with labor market needs (Ismail and Abidin, 2014). There is slightly gain research that looks into the issue at the undergraduate engineering students' knowledge construction level in the engineering education field.

There are contradictory views in T&L over the issues related to the learning environment. Researchers need to investigate the role of lecturers or instructors in the construction of knowledge (Schwarz *et al.* 2004) in different learning settings (Hershkowitz, Schwarz, and Dreyfus, 2001). These environments also integrate in educational engineering settings, which provide innovative and creative learning that reinforces competencies, capabilities, and skills that engineering and technology students are required to have (Santos, Escudeiro and Carvalho, 2013).

Bateson (2000) noted knowledge construction as '*...a difference that makes a difference...*', and Enosh, Ben-Ari and Buchbinder (2008) referred to knowledge construction as providing '*...a sense of differentness...*'. How can pedagogies be made more joyful and meaningful in knowledge construction for the students when implementing metacognitive activities in the classroom? It is difficult to define "joy" (Vujicic, 2014) in learning. Thus, "learning by doing" of Dewey can enhance students' experience and meaning of learning. It can also enhance opportunities for maximum engagement in active learning (Matthew, 2012). Santos, Escudeiro, and Carvalho (2013) emphasis that the process of learning over the product (knowledge) of Dewey. This can be expressed as: experience + reflection (feedback) = learning. This refers to reflection on students' joyful and meaningful learning.

This issue related with Cano-Garcia and Hughes (2000) cited that students have different paradigms of learning preference may influence their academic achievement. In other words, students may have variety ways to construct knowledge in order to achieve better academic performance particularly engineering students in Malaysia.

Recognition of differentness in knowledge emerges. Researchers become aware of an apparent incongruity that needs to be explored and understood. Researchers contend that such exploration and learning serve as the starting point for knowledge construction. What are the issues and challenges in the engineering field worldwide? Ron Watermayer of UNESCO Report (2010) revealed the engineering issues and challenges are those future engineers do not have the experience or expertise to apply fundamentals knowledge to solve complex problems even though they possess knowledge. Moreover, they unable to solve high level problem by using engineering knowledge and possess interpersonal skills.

In order to have a better learning approach for engineering students, it seems reasonable that researchers use a social constructivist approach, which may enhance their learning environment (Felder, 2012). Apparently, it may promote higher levels of thinking with quality knowledge construction. An active learning environment can provide opportunities for students to work in a team when conducting the discussion about learning content. With focus on knowledge construction, the UNESCO report (2010) has been produced in response to call to address what was perceived as a particular need for the engineering community to engage. Thereby, the SCL approach as an active cognitive engagement among engineering students is next topic.

1.2.3 Social Collaborative Learning Environment (SCLE)

To address the problem where students lack a higher level of knowledge construction in the classroom, constructivism should be included in the cognitive perspective. Both explicit teaching and student knowledge construction can be considered in the context of the social constructivist theory of learning (O’Neill. Geoghegan and Petersen, 2013). When students’ learning outcomes significantly improve, it is fair to assume that the nature of pedagogy in the classroom has also improved (Hardman *et al*., 2003). Hence, it is necessary to consider how pedagogy can be effectively implemented in traditionally instructivist cultures (Porcaro, 2011) when there are only lectures, memorization, and assessments embedded in the conventional classroom?

The constructivist approach argues that students construct their own concepts through active engagement, like personal experimentation and observation (Mbendera, Kanjo and Sun, 2010). With constructivism on the aspect of cognitive perspective, Beetham and Sharpe (2007) claimed that new ideas or concepts can be constructed based on students' current and past experience, which is the knowledge they already possess. In other words, students do not absorb knowledge from the external world (Mbendera, Kanjo and Sun, 2010). That is because they have different backgrounds, prior knowledge, and past learning experience. Thus, how should teachers support and facilitate students' learning and engagement in expanding and enriching their construction of knowledge? How much do students need to learn for knowledge construction?

Subsequently, the lecturer is an instructor in the learning process of students being involved in complex and challenging problems, working collaboratively to solve problems, and reflecting on their experiences (Wang *et al.*, 2013). Students can improve their knowledge based on practical experience. Moreover, collaborative knowledge construction is recognized as a vital part of a process in which students can equally integrate and share their knowledge (Takahito *et al.*, 2011).

Research has shown that collaborative learning affects student achievement. (De Hei *et al*., 2014). Hence, students engage in active thinking and flexible knowledge construction (Wang *et al*., 2013). In order to achieve this engagement, collaborative learning has been implemented effectively to improve students' learning and increase engagement in discussions to obtain higher-order thinking (Stump *et al*., 2011). However, not all collaborative activities are successful at simply putting students working together. This will not produce quality knowledge construction, nor will it increase academic achievement (Barron, 2003; Salomon and Globerson, 1989). Besides, there is a lack of studies that show students are engaged in cognitive processes such as identifying gaps in their existing knowledge and questioning each other's ideas through collaborative knowledge construction (Cobos and Pifarre, 2008).

Collaborative learning underpinned by Vygotsky's social constructivism (Vygotsky, 1978) stressed that the zone of proximal development (ZPD) is the distance between the actual development level and the potential development level. It is a social interaction that involves a society of instructors, and between students to share their experiences or knowledge. An experience is one that supports deep and meaningful learning among engineering students. They learn and construct knowledge through social interaction, which involves groups or pairs of students (Puntambekar, 2006). It also refers to instructional learning in which the instructor's role involves coaching, modeling, and scaffolding to help students acquire different levels of knowledge (Collins, Brown and Newman, 1989), a process from which engineering students cannot be excluded. How the kind of support offered by instructors can affect student learning outcomes differently remains unclear. Thus, further study is needed on this matter.

Studies have shown that collaborative learning can bring beneficial achievement and engagement to students working together (Williams, 2009). For instance, engineering students can offer new ideas when they work together in the group. This can lead them to seek new information to clarify misconceptions in the learning process, particularly across the various fields of engineering. In addition, students working together can generate new approaches to solve problems in engineering tasks set by instructors. The issue here is that students may not know how to work together (Williams, 2009). Apart from that, sufficient work in a collaborative learning environment will help to build up knowledge construction. On the other hand, appropriate pairing of peers is important, as differing background knowledge levels and peers characteristics can affect their performance (Kumar, 1996). Moreover, the group size needs to be considered on the requirement of the collaborative learning task. Thus, an appropriate number in a group in collaborative learning is one of the key issues (Kumar, 1996).

Popescu (2014) described collaborative learning as involving interaction among peers, with learning materials, and with the teacher. Students work together in small groups at various engineering performance levels to achieve an academic goal. They actively exchange ideas through collaborative learning. This shared learning gives them the opportunity to be engaged in the asynchronous online discussions (AOD) and take responsibility for their own learning (Totten *et al.*, 1991).

Consequently, active learning engagement takes place in a group, addressing the ‘one content fits all’ approach, particularly in the engineering classroom. Harasim *et al.* (1995) defined collaborative learning involving two or more people working as a team to create meaning, explore a topic, or improve skills in a learning process.

Research has been shown that AOD features in online learning. Guzdial and Turns (2000) emphasized the obstacles facing students: "*(a) unmotivated by discussion topic, (b) not knowing what issues to discuss, and (c) not knowing how to discuss them.”* The online learning may empower computer-supported collaborative learning (CSCL). Thus, the instructor plays an important role in effectively guiding the students in such an environment. On the other hand, it is a challenge for discovery and negotiate of meaning in learning content (Kumar, 1996) to construct knowledge, notably for students who explore knowledge through the internet in online learning.

CSCL comprises of the construction of meaning through interaction with others (Law and Wong, 2003). Engineering students can create and share information, practice critical reflection, negotiate meaning, and build consensus in AOD learning societies. Zhu (2012) claimed that collaborative written assignments, group discussions, debates, arguments, and critiques can all enhance knowledge construction through AOD. One of the pitfalls of CSCL is the lack of social interaction, which is needed to achieve a higher level of knowledge construction (Kreijns, Kirschner, and Jochems, 2003). This may affect the productivity of collaborative learning, either in a positive or negative learning environment.

CSCL is a dynamic and interdisciplinary method of learning (Resta and Laferriere, 2007). It consists of activities in which technology facilitates knowledge construction. There are a number of studies on knowledge construction (Zheng and Yin, 2012; Zhu, 2012; Cobos and Pifarre, 2008; Davenport and Prusak, 2000). This relate with technologies enable collaborative learning. It means that the engineering students construct knowledge via utilize SMT such as Web 2.0 supported by a CSCL environment that (a) can encourage them express their ideas and or opinions with peers during AOD, (b) enable them to share and compare with other resources (such as documents from Wikipedia) for accomplish the specific task given by instructor, and

(c) can discover and explore the new knowledge via YouTube videos in order to improve and enhance their participants' interaction in AOD. Furthermore, the instructor furnish assistance (scaffold) to the engineering students through multimedia/hypermedia environment due to suit their leaning preference that affect them construct a higher level of knowledge. The students learning process give high impact on their academic achievement. Thereby, in order to fill the vacuum of the transformative learning environment, this study looks into the knowledge construction issue among engineering students.

Nevertheless, most of them do not provide enough evidence to support the important role of CSCL among students' knowledge construction learning practices, in which engineering students are also involved. Knowledge can be constructed by sharing and creating new ideas through CSCL, and expertise through peer interaction and group learning. CSCL interactions take place among engineering students, using computer networks to enhance learning (Kreijns, Kirschner and Jochems, 2003) and facilitating collective learning (Pea, 1994). It involves the use of technology to support asynchronous and synchronous communication between students in both on and off-campus societies.

Eventually, questions are asked in engineering classroom interactions, synchronous and asynchronous, through computer-supported learning environment (CSLE). There are many different ways of interacting with each other, for instance, instructor interaction with students, peer-to-peer interaction, and computer interaction with students. The challenge for instructor is to ensure the efficiency and effectiveness of interaction for the engineering students' knowledge construction and process of learning in the engineering field. Constructing knowledge through CSLE is a complex process, and the process is not easily studied (Resta and Laferiere, 2007). Thus, faced with this problem, researchers need to propose instructional scaffolding in engineering classrooms to minimize the issue. How can engineering students' interaction with instructional scaffolding in learning process be nurtured?

Social media technologies (SMT) can be utilized for social collaborative learning (SCL) (Popescu, 2014). SMT tools such as Skype, Facebook, Twitter, YouTube, Instagram, Weblogs, WhatsApp, We Chat, and Line are used in the social learning environment to enhance learning spaces and provide value for both engineering students and instructors. Nowadays, students are “digital natives” or part of the “internet generation,” who can get information with ease with digital communication technologies supported by SCL environment. Hence, there are different paradigms of work, attention, and learning preferences (Popescu, 2014).

To understand and solve the topic discussed, as pointed out by Popescu (2014), students will be actively engaged in their learning process: discussing with peers, exchanging ideas, questioning beliefs, and providing feedback on the task. Roberts and McInnerney (2007) emphasized that CSCL issues are related to “… *student’ antipathy towards group work, problems in group selection, a lack of essential group-work skills, free-riders, possible inequality of student abilities, withdrawal of group members, and improper assessment of individuals within the groups*…” Newman, Griffin and Cole (1989) stressed that collaborative learning will be inadequate if students are simply appointed to groups. Moreover, CSCL studies show that dissatisfaction arises from shallow learning, ineffective collaboration, and lack of discourse and inter subjective knowledge construction, as noted by Porcaro (2011).

The social learning environment (SLE) fits within the social constructivist paradigm, which views the construction of new knowledge as a social and collaborative activity (Gadanidis, Hoogland and Hughes, 2008). Consequently, the challenge is how to construct knowledge in SLE, with engineering students needing effective interaction through online learning. Additionally, they lack the true companionship and can become more and more isolated resulting from frequent communication over the internet through emails, texts, and tweets (Vujicic, 2014).

There are various problems in conventional education in which students have low prior knowledge (Chen, Wu and Jen, 2013) on constructing knowledge on higher levels, such as argumentative and metacognitive knowledge. Utilization of the reproduction of knowledge in assessment in schools and universities is a common scenario occurring in the Malaysian educational sector. For instance, assessment of the content taught is very common in school and university examinations in the educational system. Exam-based learning does not seem to be effective, particularly in knowledge construction for engineering students (Leinhardt, Mccarthy Young and Merriman, 1995). Most of the time, they only achieve declarative (conceptual and factual) knowledge and procedural knowledge but lack enhanced learning satisfaction, knowledge gained, and learning efficiency (Popescu, 2014).

A variety of tools can be integrated into SLE. Tool support such as SMT (Web 2.0 tools like blog (Blogger), wiki (Media Wiki), social bookmarking (Delicious), microblogging (Twitter), and media sharing (YouTube, Picasa, SlideShare)) (Popescu, 2014) may affect the stimulation of knowledge construction (Van Boxtel, 2001). This has a negative impact on students lacking the initiative and responsibility to construct their knowledge if the tools are not used appropriately. Moreover, usage of these tools is one of the meta-skills to take the initiative and accept responsibility for learning (Popescu, 2014). Herder and Marenzi (2010) claimed that the burden on students is "*…too much freedom, lack of structure that can create chaos, and not choosing the right tools for collaborative work can hinder the learning process. Synchronization of work is difficult and time-consuming…*"

SMT can be used with various media to provide different types of communication in the process of knowledge construction. However, face-to-face communication is essential for human beings (Bilic, 2014). Bilic (2014) revealed that there has been a '*…shift into media through which knowledge is transmitted…*' From this statement, researchers can relate to engineering students' current learning behavior in the social learning environment. They prefer freedom and informal learning through surfing the internet. Engineering students can construct and negotiate knowledge integrated with different media approaches through which they achieve their learning goals. However, the efficiency and effective communication of peer-to-peer knowledge construction in the process of learning is an issue that needs to be addressed.

There has been a trend towards integrating SMT with collaborative learning which is a powerful learning tool that encourages collaboration, creativity, comments, feedback, linking, following up and sharing knowledge construction with each other

(Freed, 2012). Simultaneously, teachers have raised issues as to what knowledge to take, how and where they move in the mobility of knowledge (Van Oorschot, 2013). Consequently, teachers have ambiguity in resolving this issue of constructing students' knowledge in the proper way since social media have drastically modified our society.

Nowadays, engineering students have more choice over what to learn, how to learn, and when to learn, made possible through informal learning environments such as online also known as social learning (Yeo, 2013). They see and learn from each other through various SMT applications (Maloney, 2007) such as Web 2.0, which now forms the participatory and collaborative nature of students' 'learning by doing'. Another challenge is what students can do and how they learn better if they interact regularly in an online learning environment (Yeo, 2013).

There are inevitably, issues with using Weblogs and Facebook postings for learning from which engineering students are not exempt. They feel that the information and knowledge gained via SMT applications are not able to assist them much with formal homework. Thereby, students feel that information they get is too much to be credible and reliable for formal schoolwork-related learning (Yeo, 2013). Thus, the quantity of information is too much and does not assist in the learning content.

Learning is a complex cognitive process (Du and Wagner, 2007). Thus, quality of students' learning remains in doubt (Popescu, 2014). This leads us to question how it can be applied in today's classroom, due to the inexperience of constructing online SCL environment. Eventually, Jonassen, Carr and Yueh (1998) cited that the computer acts as a mind tool which needs to be applied in educational settings. It is also a mentor that leads engineering students into desirable learning tracks and improves their learning performance. It is a burden on the teacher, who needs to set up the learning space from scratch and then continuously monitors students' metacognitive activity (Popescu, 2014). However, the practical methods that lead us to create (design and build) effective technology-enhanced constructivist learning environments are not well described in the curriculum guidelines.

Hence, the challenge is how to organize class interaction in an online environment. How does the instructor organize AOD and deal with matters such as course learning content, evaluation practices, and their role as an instructor during the class? How can instructors use online teaching to support a collaborative learning environment? Instructors may use social networking services such as Facebook as an online teaching tool, forging a vastly different experience from conventional teaching in engineering classrooms.

On the other hand, studies have shown that there are other issues related to knowledge construction. They relate to the change in our view and practice of online education within an online environment. How do instructors guide construction of knowledge in the engineering classroom through SCL environment?

The concept of SCL environment is formed by integrating collaborative learning with a SCL to produce quality knowledge construction through online learning. What are the methods available to construct new knowledge among engineering students in today's SMT environment, a field subject to continuous innovation?

Previous literature reviews have not mentioned students' behavior in online collaborative learning in support group learning processes (Pea, 2004; Wallace, 2003; Weinberger, Fischer and Mandl, 2002). The online discussion does not promote higher acquisition of knowledge construction without instructional scaffolding that forms the role of instructor in engineering students' learning cycles. To address the issue, there is a need for instructional scaffolding to support students' knowledge construction, in which the learner controls the changing of scaffolding, with guidance and support provided by the instructor (Jackson, Krajcik and Soloway, 1998).

Since there are different issues found in different learning environment when constructing knowledge, SCL environment is created to address the problems discussed previously. With this in mind, the researcher will investigate instructional scaffolding in an online SCL environment that cognitively steer engineering students' knowledge construction.

1.2.4 Instructional Scaffolding in SCLE

Teachers' explicit teaching helps students in learning and construction of knowledge (O'Neill, Geoghegan and Petersen, 2013). The researcher intends in this section to discuss the issue of instructional scaffolding (IS) in an online SCL environment.

Instructors have the potential to influence students' knowledge construction and competencies through learning environment (Entmalonwistle and Tait, 1995). They need to consider the metacognitive activities and IS applied in the engineering classroom. The implication of instructional scaffolding is that the instructor encourages student interaction in peer-to-peer online learning to construct knowledge when they are not in the engineering classroom. In other words, IS can promote knowledge construction and increase learning through social interactions, including negotiation of contents, understanding, and students' needs. Typically, scaffolding is also defined as a "guided by others" process (Stone 1998). It is a temporary support system provided for engineering students' needs, particularly at technical and vocational education and training (TVET) for them to complete complex projects in the engineering field.

Stone (1998) revealed that IS can effectively construct knowledge during face-to-face (F2F) interaction between lecturers and students. In order to address the issues about implementing IS in a learning environment such as SCL environment, the instructor needs to design supports that can be faded as students' understanding and capabilities improve (Jackson, Krajcik and Soloway, 1998). The issue is about the transformative learning environment in higher education that impacts engineering students' learning, particularly at TVET. Recent studies have indicated that online learning can enhance students' learning achievement (Young, 2008). Unfortunately, lack of guidance and ambiguity of the implementation of IS in the online learning environment during engineering students' knowledge construction is a stumbling block towards better T&L processes. How should it be constructed in such an environment (Gadanidis, Hoogland and Hughes, 2008)?

Innovative and/or transformative learning environment may help accommodate IS in the engineering classroom. Thus, in order to meet students' individual needs, a lecturer needs to implement IS effectively in the online learning. Hence, the other key issue is how to provide effective IS for students (Puntambekar and Hubscher, 2005). This also includes the engineering students' knowledge construction in the classroom.

There are various forms of IS (Greening, 1998). Different forms of scaffolding will provide different learning outcomes (Molenaar, Boxtel and Sleegers, 2010). A variety of scaffolding can be utilized to teach students in metacognitive activities. Yet, the challenge is that engineering students have problems performing well in constructing knowledge in their learning process, particularly in an online SCL environment. However, most researches are confined to the use of IS in specific teaching or learning activities, with little attention given to the design of systematic learning strategies or learning environment (Pol, Volman and Beishuizen, 2010). Moreover, there is a lack of research on the design and utilization of IS in knowledge construction of T&L scenarios in SCL environment. The process of knowledge construction is based on the students' reflection. Thus, the online SCL environment can be improved with "reflection". It provides engagement for engineering students to learn, as well giving impact towards knowledge construction.

In other words, instructors should be capable of selecting the appropriate scaffolding to assist engineering students to engage in constructing knowledge. The issue here is about the impact that IS designs (Belland, Kim and Hannafin, 2013) have upon engineering students to acquire knowledge to higher levels, as well as meaningful cognitive outcomes to support student learning (Greening, 1998).

1.3 Statement of Problem

Exam-based study does not seem effective in the T&L procedure (Leinhardt, Mccarthy and Merriman, 1995), while the traditional face-to-face pedagogical approach (aka traditional teacher-centered instruction) does not cultivate students' potential in optimal knowledge construction (Felder, 2012). Besides, the LCP (akin learner-center teaching) approach gives students the autonomy to direct their own learning and allow them to become problem solvers (Tchoshanov, 2013). Nevertheless, the issue here is how effectively and efficiently LCP and constructivist classrooms are embedded in engineering students' knowledge construction during the process of learning.

Moreover, students have different backgrounds of prior knowledge and past learning experiences (Tchoshanov, 2013; Donovan and Bransford, 2005; Wu, 2003). On the one hand, engineering students have different interests. It may occur that they may have different conceptions of learning, and there is a lack of personalized processes (Mbendera, Kanjo and Sun, 2010), such as interest in their process of learning in the engineering field. Thus, instructional scaffolding is provided that caters for engineering students' learning needs and interests. The utilization of IS implemented for engineering students' knowledge construction would minimize the gap between students' levels of knowledge construction and students' low prior knowledge (Moreno and Valdez, 2005). There is evidence that suggests it can support the teaching and learning process, as well as LCP to improve students' learning processes (Tchoshanov, 2013; McComb, 1997). Thus, in order to achieve learning goals, IS needs to be embedded into the learning process, particularly in engineering field.

Another issue is the transformative learning environment in the education system (holistic blueprint education) (Ministry of Education, Malaysia, 2013). Nowadays, students represent the 'Net-generation'. Information technology and computerized social media have affected students' learning environment. The revolution of social media has brought changes that have rapidly enhanced the learning processes for students, including in TVETs.

Subsequently, engineering students' capabilities are increased to construct knowledge as instructional scaffolding is provided. Educators use IS in T&L for engineering students to become independent and self-regulated problem-solvers in their future professional careers, as well in life. Belland, Kim and Hannafin (2013) claimed that these scaffolding strategies could motivate students to be more proactive in the learning process.

Meanwhile, the innovation of SMT has drastically modified our society. There are increased challenges in engineering students' learning environment and these challenges will raise issues about teacher's difficulties when deciding on the knowledge itinerary and how and where they should move (Van Oorschot, 2013) to construct students' knowledge in proper ways.

Jamalludin Harun (2003) reveals that integrated coaching, modeling, and scaffolding in the process of constructing and enhancing the learning environment through hypermedia is a good approach in T&L. This helps to create learning opportunities to cultivate a crucial concept, motivate discovery, explore, attempt problem-solving tasks, and understand cause and effect. Our society is moving online, therefore no one is left behind when everyone learns through SLEs.

Dewey's (1916/1997) ideas that "…*we never educate directly, but indirectly by means of the environment. Whether we permit chance environments to do the work, or whether we design environments for the purpose makes a great difference*...". Apart from that, Enosh, Ben-Ari and Buchbinder (2008) claimed that explaining knowledge construction as "*...a difference that makes a difference*..." or "*...a sense of differentness*...''. When implementing metacognitive activities in the classroom, instructors must make pedagogies more joyful and meaningful for students' knowledge construction. However, it is hard to define joy (Vujicic, 2014) and the meaning of learning.

Dewey (1913) revealed that learning based on experience is more fruitful and satisfactory. In other words, researcher produces SCL environment using SMT to support engineering students' learning engineering courses, and it is significant allow them to gain experience in the learning process towards knowledge construction.

This raised the question of whether providing IS in online SCL environment to support students of engineering courses towards acquiring higher knowledge could be more effective. Thereby, they ask how much IS should be given by the instructor through online SCL.

The question is just this: Why is it unclear whether integration and application of IS in online SCL environment have become a significant area in engineering education research. The study focuses on IS in a social, collaborative learning environment that cognitively steer engineering students at TVETs towards knowledge construction. Consequently, engineering students' knowledge construction levels have been investigated**.** The key issue here is whether IS can develop and enhance engineering students' knowledge construction level in an online learning. This study provides some useful insights from Salmon's (2004) model for knowledge construction processes in online SCL environment. Thus, the aim of this study is to investigate how IS in an online SCL environment can cognitively strengthen students' knowledge construction.

1.4 Research Objectives

This study aims to achieve the following objectives:

1. To provide an online social collaborative learning (SCL) environment using social media technologies to support collaborative learning for an engineering courses.

2. To design and develop instructional scaffolding strategies in an online SCL environment for an engineering course.

3. To evaluate the impact of instructional scaffolding in an online social collaborative learning (SCL) environment on:
    a. Engineering students' achievement in tests
    b. Engineering students' knowledge construction levels (KCLs)

4. To investigate on how instructional scaffolding in an online social collaborative learning environment that cognitively steer engineering students towards knowledge construction.

5. To investigate how online social collaborative learning (SCL) environment guided with instructional scaffolding support engineering students reach a higher level of knowledge construction.

6. To formulate knowledge construction model in online social collaborative learning environment, integrated with instructional scaffolding to enhance students' knowledge construction levels.

1.5 Research Questions

The research questions answered in this study area are:

1. What is the impact of instructional scaffolding in online social collaborative learning (SCL) environment on:
   a. Engineering students' achievement in tests?
   b. Engineering students' knowledge construction levels?

2. How does instructional scaffolding in an online social collaborative learning environment cognitively steer (strengthens) engineering students towards knowledge construction?

3. How does online social collaborative learning (SCL) environment guided with instructional scaffolding support engineering students reach a higher level of knowledge construction?

4. What is the knowledge construction model in online social collaborative learning environment integrated with instructional scaffolding that enhances engineering students' knowledge construction levels?

1.6 Theoretical Framework

This proposed theoretical framework (knowledge construction-scaffolding) is used in this study which consists of input, process and output (IPO) phases (Isard, 1972). The structural framework shows inputs of different learning approach environments in the online SCLE.

This theoretical framework comprises of a sequence of phases.

Phase 1: Access and Motivation

Briefly it will be explained in this phase why the researcher needs to invite engineering students to take part in an online learning environment beyond physical engineering classroom learning. In the initial phase, students will be encouraged to learn through online collaborative learning towards learner-centered practices (student-centered learning). Moreover, they will be invited to be involved in metacognitive activities to construct knowledge via online learning.

As claimed by Salmon (2004), students have to become online learners, which will lead them to post their first messages. Thus, the researcher plans to use online collaborative learning to motivate students towards knowledge construction.

Dillenbourg *et al.* (1996) mentioned that collaborative learning consists of two paradigms. These are conditions and interactions. Students are able to transit knowledge from online learning environment. They can access learning everywhere, and integrate it throughout their daily lives. They are committed to the use of mobile tools, which are transportable and interconnected across time, location, culture and experience in their learning itinerary, as well as the interaction with peers. This can motivate engineering students to go to the second phase.

The overview of major elements is presented in Figure 1.1 (Salmon, 2004).

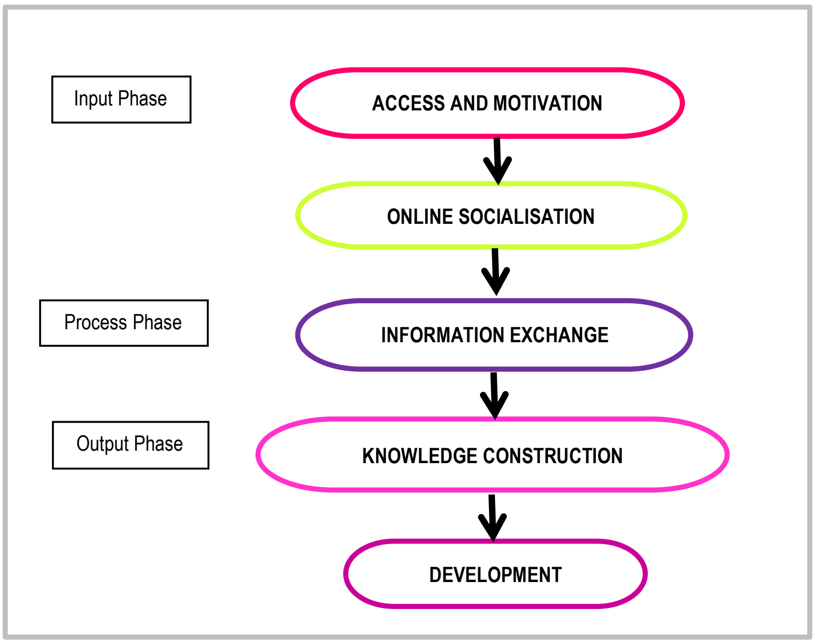

Figure 1.1 Overview of theoretical framework based on Salmon's Five Stages Model (Source: adapted from Salmon, 2004)

Phase 2: Online Socialization

In this phase, social interaction can encourage engineering students to feel free to work or learn together by utilizing the internet and technology facility via online learning environment. They can give “feedback” on current and future needs for learning materials by posting and receiving messages in their learning itinerary. According to Salmon (2004), students may establish peer-to-peer interaction in such an environment.

In the second phase, the researcher takes the view of Tu and Corry (2001) that there should be the emphasis on three dimensions of social presence. These are social context, online communication, and interactivity. Engineering students use networks related to technology and the internet to gain information and knowledge. Meanwhile, they can construct knowledge through online social learning environment. They have anxieties, hopes, and experiences while learning online. The instructor acts as a host through the web of e-activities. Students experience online socialization and create their own micro communities. Consequently, Reio and Crim, (2013) noted that there are two concepts of social presence: immediacy and intimacy. This leads to another phase, about how engineering students exchange information and how to cognitively scaffold them towards knowledge construction.

Phase 3: Exchange of Information by Scaffolding to Construct Knowledge

In the process phase, engineering students start exchanging information promptly through online learning, such as text chats, emails, or voice chats. They begin searching for knowledge and chatting with peers in relation to learning content. They face problems of information exchange and achieve collaborative learning tasks. Based on Salmon (2004), mutual engagement occurs in this phase when participants focus on exchanging information. Meanwhile, the instructor needs to use learning material to support participants in the learning process. Thus, the researcher utilizes IS to support and guide engineering students in their process of knowledge construction, based on Hogan and Pressley’s guidelines (1997). The researcher discusses how engineering students construct knowledge in the next topic.

Phase 4: Knowledge Construction

In the output phase, engineering students are able to take responsibility gradually for their learning itinerary. Moreover, they can construct knowledge when there is more interaction in online collaborative learning with their instructors or peers for e-activities. According to Gunawardena, Lowe and Anderson (1997), there are four levels of knowledge construction in interaction, such as sharing, comparing, discovering, exploring, negotiating, testing, and modification of synthesis, as well as application of newly constructed knowledge. Simultaneously, engineering students can increase their confidence and benefit from peers in the learning group. They become key learners in the knowledge construction community. Students have more interaction with knowledge construction to achieve their learning goals, as stated by Salmon (2004). Thus, the researcher as an instructor provides several guides in online learning, as well as integrating IS elements to assist engineering students towards the completion of their learning tasks. At this point, the researcher can start to build a knowledge construction model consisting of instructional scaffolding.

Phase 5: Development of Knowledge Construction Model

In the final phase, a knowledge construction model is developed in an online SCL environment and is integrated with IS to enhance engineering students' knowledge construction levels. Students have confidence as online learners. As a consequence, students are able to construct knowledge on new ideas acquired through e-activities and apply and integrate them into their existing knowledge and workplace, particularly in the engineering field. Hence, they enjoy learning afresh from the whole experience and are prepared to set out their own new learning itinerary. Salmon (2004) mentioned that developing participants to have independent critical thinking and reflection is of vital importance in this closure phase. Students deploy their new knowledge when assessed. Thus, the researcher uses this platform to develop a knowledge construction model in an online SCL environment.

However, it is vital to point out that there is a need to provide appropriate collaborative learning parameters for the online SCL environment in this study.

1.6.1 Collaborative Learning Parameters

The proposed hybrid characteristics of SCL environment produces collaborative learning supported by SMT, integrated with the process of learning.

The core characteristics of collaborative learning are adapted from Dillenbourg *et al.* (1996):

- **Conditions**
  - i. Group composition such as group size, gender distribution, and prior knowledge
  - ii. Task structure/feature: acquire new knowledge
  - iii. Collaboration context
  - iv. Communication medium

- **Interactions** (related to learning condition and learning outcomes)
  - i. Elaborate explanation
  - ii. Control
  - iii. Socio-cognitive conflict
  - iv. Negotiation
  - v. Argumentation

(Dillenbourg *et al.*,1996)

These characteristics are briefly expanded upon. Several characteristic are deployed in this study. In the condition paradigm, the researcher is concerned about the composition of the group. This is determined by group size, gender, and engineering students' prior knowledge. The function of the size of the group would be affected in online collaborative learning. Furthermore, students have different levels of prior knowledge, based on their maturity, age, and gender.

On the other hand, task structure (or features) is one of the characteristics that need to be considered. Typically, more complex tasks are related to problem-solving, using existing or prior knowledge to acquire new knowledge. The task structure comprises of a variety of problem-solving tasks, such as creative problem-solving

(Zheng and Yin, 2012), ill-structured problem-solving (Yampinij and Chaijaroen, 2010) and information problem-solving (Wolf, Brush and Saye, 2003). Thus, problem-solving tasks can enhance engineering students' knowledge construction.

The third characteristic is that the context of collaboration involves the roles of members. Each member plays his own role as a starter, moderator, theorist, resource searcher, or summarizer. They have sufficient opportunities to optimize the interaction. The medium of communication between instructors and engineering students, as well as in peer-to-peer communication, needs to be taken into account. They have sufficient opportunities to communicate with each other towards knowledge construction. This would benefit engineering students in constructing their knowledge from online collaboration learning.

The other paradigm is interactions. This is related to learning conditions and outcomes. One of the characteristics under interaction is "elaborate explanation." This means that engineering students describe the learning content. This would help others by providing a detailed explanation through online learning. For instance, information or knowledge received from other peers would help to solve the problem. This may "force" other peers to give another explanation for the problem. Explanation-based learning is more frequent when students effectively interact with each other in a learning group.

Another characteristic is control. This means that the starter's role is to "control" the other members' roles. This would help solve problems in their learning content. Moreover, it can stimulate AOD in the learning group. This may affect engineering students' achievement in tests, as well as their knowledge construction levels.

Subsequently, "socio-cognitive conflict" is one of characteristics of interactions. Thereby, moderator and theorist act as resolve the cognitive conflict situations while peers face contradictions in AOD. It may help engineering students reconstruct their knowledge when arguing learning content.

The other two characteristics of interaction in collaborative learning are negotiation and argumentation. Negotiation is a means to obtain "agreement" in aspects of who will do what, how they will do it, and what they will say. It "convinces" the other peers to take their respective roles. Negotiation of meaning is a type of verbal interaction (discourse, conversation, or dialog), a continuous process of adjustment of meaning. Nonetheless, social negotiation can be related to the social learning environment, which be discussed in the next section.

1.6.2 Social Learning Environment

The principle of SMT is based on user-centered, active participation, openness, interaction, social networks, and collaboration (Popescu, 2014). This is in line with the constructivist view of Dewey (1902). SMT supports learning by providing engaging environment and tools for understanding learning content.

In addition, this proposed framework also takes into account SLE that consist of social presence in an online learning community of inquiry (Tu and Corry, 2001). Figure 1.2 shows the characteristics of three dimensions of social presence (Tu and Corry, 2001):

- Social context (formal/informal)
- Online communication (real time discussion/discussion boards)
- Interactivity (type of tasks and size of groups)

Meanwhile, the two concepts of social presence is defined as an individual perception of communication in an online environment (Reio and Crim, 2013):

- Immediacy (distance between two-way communication, ability to exchange information rapidly)
- Intimacy (a sense of close feeling (salience), using emoticons to express social-emotional experiences)

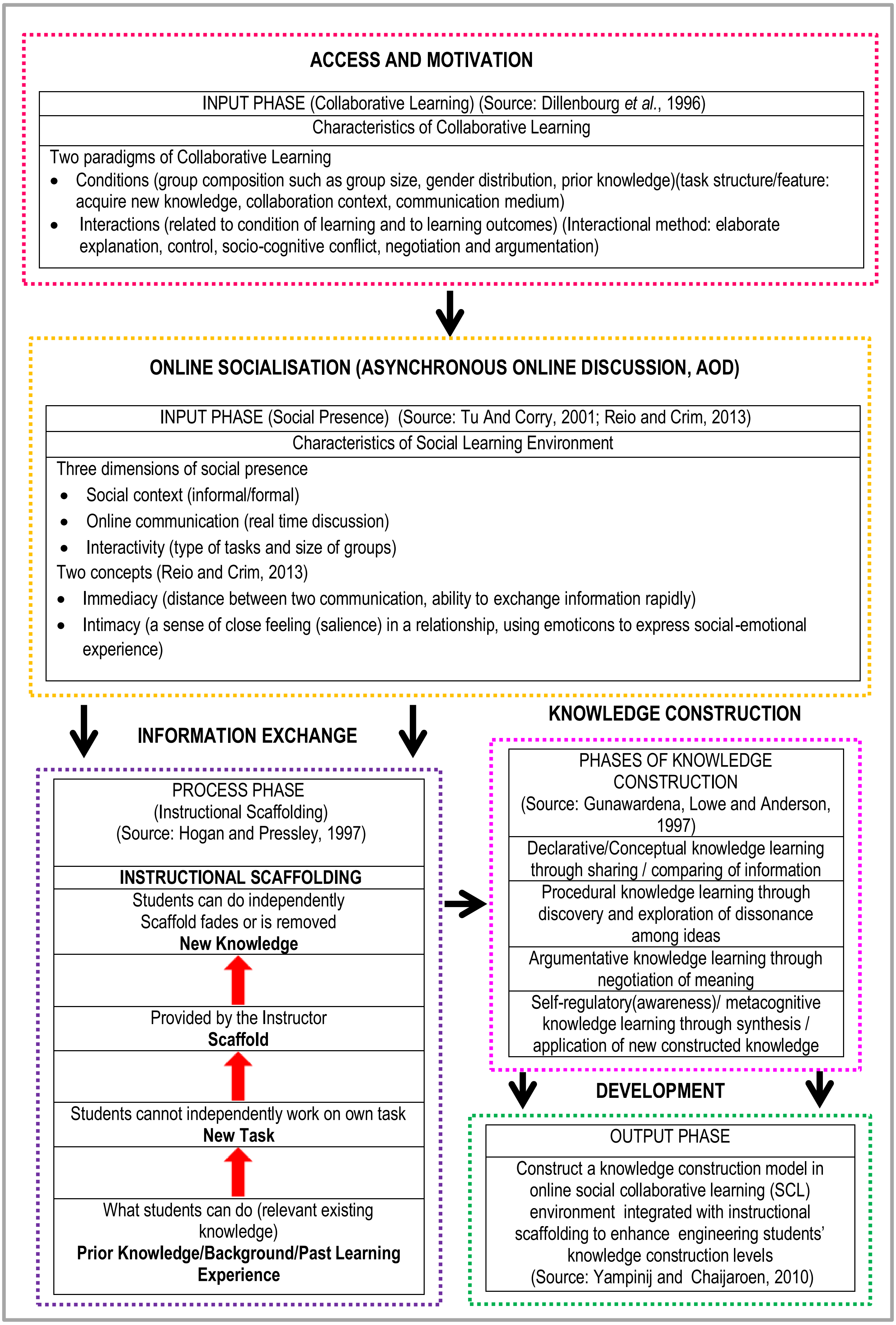

Figure 1.2 Theoretical framework based on Salmon's five stages model (Source: Salmon, 2004)

On the one hand, Garrison, Anderson and Archer (1999) claimed that social presence is the ability to participate in a community as ‘real’ person through the medium of communication. Similarly, Aragon (2003) has pointed out social presence is the quantity and quality of interpersonal communication and satisfaction with the online learning experience. Online social presence brings about a sense of community, student satisfaction, and, ultimately, positive learning outcomes. Students are able to achieve more when they feel satisfied with their online learning experience (Picciano, 2002).

Social presence is one of the important factors in the online learning environment. High social presence has a positive impact on students’ learning processes because more interactive online activities occur (Tu and Mc Isaac, 2002). This may stimulate student potential to achieve a higher level of knowledge construction.

Online communication is related to synchronous as real-time discussion or asynchronous as time-delayed discussion. In the synchronous discussion, participants communicate at the same time via video conference. Asynchronous participants communicate at different times and from different locations via email or an e-bulletin board. The researcher uses AOD to enhance engineering students’ knowledge construction.

Interactivity is one of the factors that affect online learning. It comprises of group size, and task type. It also benefits to engineering students such as easy to gather, share and compare information through social negotiation.

Immediacy and intimacy are two factors that affect peer interaction in online learning. Immediacy involves (i) distance between two participants while they communicate and (ii) promptness of exchanging information and ideas, as different students have different explorations and discoveries. It would bring impacts on both engineering students’ knowledge construction and achievement in tests. On the other hand, intimacy refers to a sense of close feeling (salience) in the relationship, using emoticons to express the social-emotional experience. Thus, engineering students would be engaged in their learning tasks and get satisfaction in their learning itinerary. This satisfaction can improve LCP (aka student-centered learning or learner-centered teaching). SLE are flexible, and allow knowledge to be accessed easily through the internet. IS needs to be integrated into online learning, as it can nurture social interaction. Hence, IS needs to be discussed to better understand how to cognitively steer engineering students' knowledge construction.

1.6.3 Instructional Scaffolding

In order to achieve effective knowledge construction, there are eight essential elements of IS as guidelines for implementation (adapted from Hogon and Pressley, 1997). Figure 1.2 shows the flow of instructional scaffolding.

- Pre-engagement between student and curriculum, which consists of curriculum goals, course learning outcomes, and students' needs.
- Provide a shared goal. This may motivate and commit students to learning in collaboration.
- Understanding of students' prior knowledge, background, and past learning experience. These may affect students' interest in learning.
- Provide a variety of support and guidance, such as examples, concept and mind maps, diagrams, questions, and prompts to meet the students' needs.
- Provide courage and praise. This may assist students in maintaining and focusing on their learning goals.
- Give feedback and monitor students' work. This may assist students in understanding their progress.
- Provide supportive and positive responses in the learning environment. Students may be free of frustration and risk of learning.
- Provide instructional support (such as encouragement, models, hints, or help) and guides that may let students be more independent and adaptable to other contexts. This means giving the opportunity for students to practice the task in a variety of contexts.

Meanwhile, there are several classifications of scaffolding according to Hannafin, Land and Oliver (1999), namely conceptual scaffolding, procedural scaffolding, strategic scaffolding, and metacognitive scaffolding. The researcher needs to choose the most appropriate IS available to be employed for metacognitive activities in the engineering classroom, particularly in the TVET.

The Knowledge Construction Model, built upon Yampinij and Chaijaroen's (2010) addresses issues of knowledge construction related to IS to promote and enhance students' knowledge construction levels. Hence, the researcher has also carried out a knowledge construction model in the next section.

1.6.4 Knowledge Construction Model

Students' learning environment is drastically changing, and under such a scenario, engineering students have to improve their competence and meta-competence in the engineering field. These skills would help students to become more self-regulatory knowledge discovering and self-reflecting. Thus, a high-quality knowledge construction model is needed in engineering education. One not only needs to understand the value of knowledge but know how to use it wisely and apply it to our daily lives and experiences.

Through meta-mapping, the researcher seeks to address knowledge construction issues, while remains aware of engineering students' knowledge construction. The idea of the constructed knowledge model is taken from Yampinij and Chaijaroen (2010) as the output of the framework. Their knowledge construction model makes T&L more effective in supporting problem-solving.

Yampinij and Chaijoroen's model was chosen for this study for two reasons. Firstly, to carry out research on scaffolding that can lead engineering students to reflect independently on what they already know. The scaffolding can support and guide students to create and construct knowledge through collaborative active online learning.

Secondly, problem-solving encourages the creation and construction of knowledge through AOD in their learning course. Hence, the key question is how does scaffolding support high-level knowledge construction in online learning? The researcher intends to use Yampinij and Chaijaroens' knowledge construction model as a guide and platform to develop a knowledge construction model in online learning for engineering students. All of these characteristics affect students' knowledge construction.

Briefly, a knowledge construction model is used for providing sufficient IS to assist engineering students' knowledge construction in online learning. Meanwhile, students are able to engage themselves in learning or learner-generated content (LGC) via social negotiation with peer-to-peer interaction. There are several elements need to consider when constructing knowledge construction model:

1) Instructional scaffolding

   The use of scaffolding to help, support, motivate, encourage, and guide by the instructor would enable engineering students to acquire new knowledge via problem-solving.

2) LGC

   Technical knowledge, consisting of competencies such as team work and good communication skills, would be of concern for engineering students in their future workplace (Goodyear and Zenios, 2007). Based on LCG activities, engineering students can negotiate learning content and be actively engaged in the process of knowledge construction. They can also self-reflect on their learning, which is related to the contents of the engineering course.

3) Online SCL environment

   The "Net generation" or "digital natives" need social and collaborative learning to support their learning process towards knowledge construction. AOD is a kind of interaction in the process of knowledge construction. They can communicate in a web-based collaborative learning environment.

The two challenging issues of this framework are the construction of knowledge model and the generation of high-quality knowledge construction. This knowledge model emphasizes the patterns in the problem related to real problems at the workplace (Yampinij and Chaijaroen, 2010). They can be used to solve problems in the engineering field related to social issues such as biodiversity, climate change, global warming, and land degradation. Consequently, they are vital for a strong knowledge construction model, particularly in engineering education.

1.7 Conceptual Framework

This is the researcher's conceptual framework, based on a concept map (Learner-centered framework) from Svinicki (2010), and illustrated in Figure 1.3.

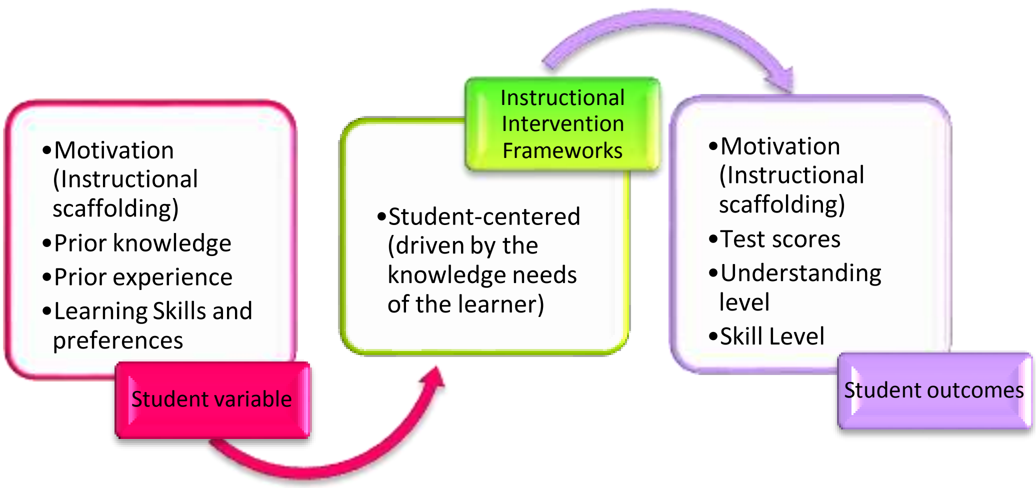

Figure 1.3 Concept Map (Structure of Assumption, Principle, and Rules Held Together with Ideas) (Philosophy Assumption): Learner-Centered Framework (Svinicki, 2010)

Thus, the conceptual framework is interrelated to input-process-output phases. The input phase consists of the online SCL environment and the process phase involves IS while the output phase comprises of knowledge construction. Typically, it is a cause and effect scenario. Simultaneously, the researcher integrated the theoretical framework in this conceptual framework. Eventually, there is a pattern of the process of knowledge construction influenced by IS in the online SCL environment. This is illustrated in Figure 1.4. The students' learning process affected them to construct knowledge. Thus, the researcher has design and develop an online SCL with IS for upgrading engineering students' knowledge construction level in order to gain high quality of academic achievement.

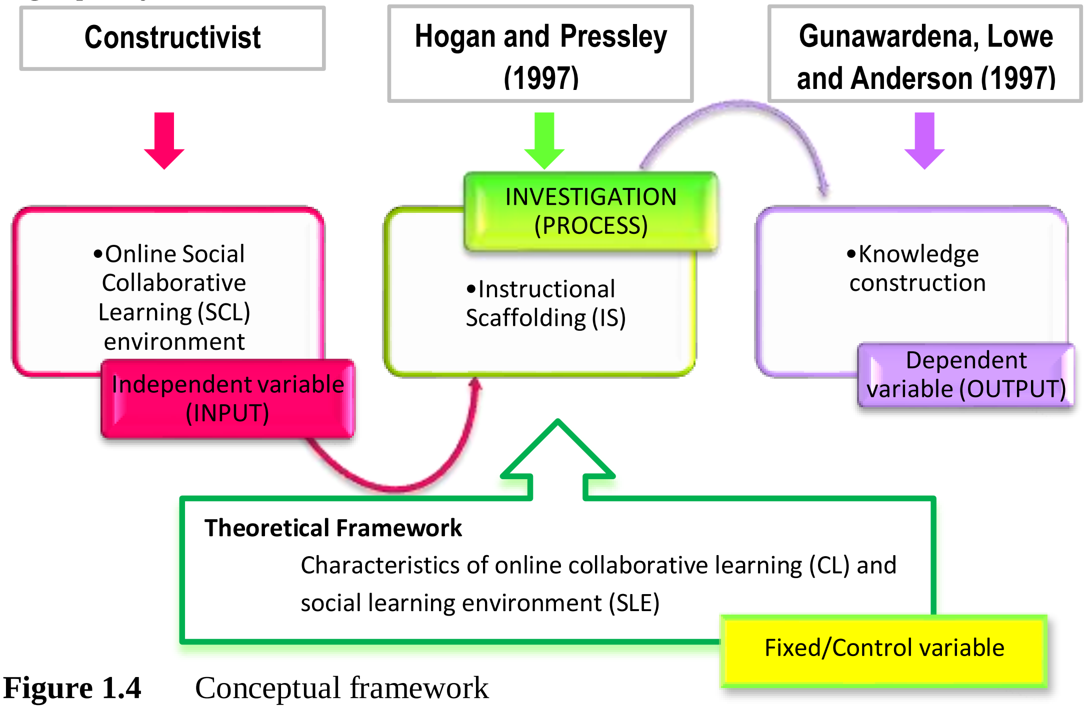

Figure 1.4 Conceptual framework

Review of literature, Dillenbourg *et al.* (1996) collaborative learning approach was chosen in this study because it looks like one of the most practice, widespread and fruitful in T&L. For instance, it utilizes in computer-supported collaborative learning (Notari and Schneider, 2003), creative and collaborative learning (Thousand, Villa, and Nevin, 2002), collaborative learning hybrid in virtual learning (Roussos et al., 1997) and collaborative learning enhances critical thinking (Gokhale, 1995). Moreover, Dillenbourg *et al.*'s theory and research of collaborative learning more comprehensive on how students work in a team. It is also appropriate to employ in this study for the researcher learning setting with AOD (Brewer and Klein, 2006). This supported by Suthers *et al.* (2008) and Hiltz, (1998) in the scope of learning environments among engineering students.

1.8 Significance of Study

In order to bring improvement for engineering LCP and transformative learning environment particularly at TVET, it is vital to know how instructors understand and conduct IS in an online SCL environment. This study is important to minimize the gap between IS and students' knowledge construction due to their prior knowledge, background, and past learning experience. Furthermore, it can also enhance students' knowledge construction. Simultaneously, the study also provides some useful insights for IS and measurement of knowledge construction.

The findings of the present study help to understand how to use appropriate IS to cognitively steer engineering students' knowledge construction in online SCL environment. The knowledge construction processes, as defined by the IS factors, would help instructors to redefine the roles and metacognitive activities in the engineering classroom. Additionally, engineering students become more actively engaged in the process of knowledge construction. The study can also be used as a basis for further research into online SCL environment. Obviously, a very limited number of knowledge construction models in online SCL environment have been integrated with instructional scaffolding. This research places the model in a new learning environment, particularly in online SCL alone. It indicates that instructors can use the indicators of the IS factors to plan an engineering course.

1.9 Scope and Limitation

The purpose of this study is to provide a SCL environment by using characteristics of CL and SLE. The researcher develops a learning environment based on constructivist theories to support problem-solving processes. This study focuses on SMT integrated with IS to support collaborative learning for engineering students' knowledge construction. Meanwhile, the researcher needs to know the impact of IS in an online SCL environment that cognitively steer (strengthens) engineering students' knowledge construction.

The researcher does not take into account age differences, gender, different background of prior knowledge, past learning experience, interests, or the learning styles of engineering students that could affect their achievement and learning. Races and socio-cultural background are also excluded from the present study.

Although there might be limitations to the types and amount of IS that a single individual can provide to a whole class of engineering students, recent approaches have been instrumental in broadening the scope by designing multiple modes by which support can be provided. There are many ways to build engineering students' knowledge construction into higher levels. However, the researcher only uses Gilly Salmon's five-stage model instruction strategy (Salmon, 2004). Meanwhile, this instruction is appropriate for students at different levels in various educational institutions, including engineering students on or off campus, and universities worldwide.

1.10 Operational Definition

There are six main definitions in this study area are:

1.10.1 Knowledge Construction

Knowledge construction is a social discourse process that consists of different views (Pea, 1993). There are exchanges of new ideas and the creation of new knowledge through meaningful negotiation, which affects individual or group cognition (Solomon, 1993). Young (1997) views knowledge construction as a narrative of human beings who need to communicate in a multiverse rather than a universe. Meanwhile, Aalst (2009) revealed that knowledge construction is a cognitive process in which students can solve problems and construct concepts. It also builds up students' knowledge to a higher level and expands their existing knowledge.

Within the context of knowledge construction research, the researcher holds that knowledge can be constructed (in breadth and depth) and further developed in many ways through an appropriate methodology. In order to make sense of meaning, reconcile a discrepancy, or satisfy their curiosity, engineering students may integrate new ideas and concepts with prior knowledge.

1.10.2 Scaffolding

Scaffolding is the support provided in tools to help students in their academic performance (Puntambekar and Hübscher, 2005). As Palincsar (1998) pointed out, scaffolding is flexible and it may consist of multiple dimensions in T&L. It means that support is provided to students to cope with the task until they can work independently (Hogan and Pressley, 1997). The types of scaffolding to be provided directly or indirectly are dependent on the task to be solved (Lenski and Nierstheimer, 2002). Dinsmore, Alexander and Louglin (2008) noted that scaffolds can be given by humans, by computers, or both. Scaffolding is support from peers and educators to provide careful and specific guided learning (Campbell, Richardson and Swain, 2005).

Within the context of IS research, the researcher can adopt IS as dynamic support to provide assistance or guidance for engineering students as needed. Meanwhile, the researcher can apply it in metacognitive activities in the processes of learning or knowledge construction.

1.10.3 Constructivist Learning

Constructivist learning is a process of constructing knowledge by an individual (Alavi, Wheeler and Valacich,1995). Meanwhile, Koohang, Georgia and College (2014) point out that it is active learning for knowledge construction in an online environment, based on interaction with others. Learning is an active process of constructing new ideas or concepts based on learners' past or current experiences (Wagner, 2003). Winter (1995) claimed that students construct their own knowledge through experience learning and engagement in social discourse.

Within the context of the constructivist learning study, the researcher focuses on aspects of innovative LCP (learner autonomy). Engineering students are responsible for the learning, and they construct knowledge via social negotiation based on their participation in learning activities with peers (collaborative learning). Besides, engineering students are engaged in an active learning process in metacognitive activities and are self-aware and self-reflective of their learning towards knowledge construction (reflective about learning and active engagement). In addition, the researcher should encourage meaningful group discussions to express new ideas through engineering classroom discourse.

1.10.4 Collaborative Learning

Collaborative learning is a social interaction that involves of a community of students and teachers, where students acquire and share the experience or knowledge (Zhu, 2012). It involves the joint construction of meaning through interaction with others (Law and Wong, 2003). It is a shared activity of students and interaction between students in learning society. It is also a construction of shared understanding through interaction with others (Dillenbourg *et al.*, 1996; Roschelle and Teasley, 1995.) In Baker's (2002) definition, students are able to work together until they negotiate to achieve a shared understanding. Mercer (1996) sees shared knowledge construction as a concept of collaborative learning. Meanwhile, Panitz (1996) stress that collaborative learning is a philosophy of interaction, personal lifestyle, and cooperation. It is a structure of interaction designed to facilitate accomplishment of an end product or goal through people working together in groups. Notari and Schneider (2003) define that collaborative learning as involving two or more persons engaged in an activity.

The term "collaborative learning" refers to students working together at various performance levels in small groups towards a common goal. Proponents of collaborative learning claim that the active exchange of ideas within small groups not only increases interest among the participants, but also gives students an opportunity to engage in discussion and take responsibility for their own learning (Totten *et al.*, 1991). Thus, they become active learners. Meanwhile, the lecturer is an instructor in the engineering classroom.

However, in this study, the researcher may adopt collaborative learning where there is an environment that allows knowledge construction to take place naturally between two or more people in different forms of interaction, such as social negotiation (for instance: AOD), face-to-face or computer-mediated, synchronous or asynchronous, in real time or otherwise. Nevertheless, collaborative learning can also be adopted for students' learning generated content (LGC) interaction with online SCL environment in this research.

1.10.5 Social Learning Environment

The learning environment can be described as a learning opportunity that comprises of lectures, facilitators, instructors, small group discussions, and a variety of learning resources through technology-based learning (Butler and Cartier, 2004). In order to offer a fruitful learning environment, learning should be social and involve instructional tools such as discussions, negotiations with each other, meaningful arguments, as well as experiential and natural situations (Tynjala *et al.*, 1997, 2006).

Furthermore, the social learning environment is due to overt learning activities through the use of multimedia or SMT to facilitate student interaction and increase active engagement in the engineering classroom (Menekse *et al.*, 2013). Students gain learning experience by using Web 2.0 applications and social networking applications like Facebook postings (Yeo, 2013). Additionally, it is also related to the social presence, in which individuals can communicate online (Reio and Crim, 2013).

In this study, the researcher holds that engineering students should be allowed to have online learning experience through synchronous and asynchronous online discussion such as Facebook discussion groups. Apart from this, it is related to real-life situations in such epistemological worlds to allow engineering students to construct their personalization value and meaning through learning or learner-generated content (LGC). The researcher uses social presence to interact, as an instructor has the potential to influence engineering students' knowledge construction. It also takes into account the aspects of CL and SLE.

1.10.6 Knowledge Construction Model (KCM)

A model that promotes students' construction of knowledge, and aims to accommodate such knowledge in lesson sequences, is referred to as a Common Knowledge Construction Model (CKCM) (Ebenezer, Chacko and Immanuel, 2003). Furthermore, it uses students' conceptions to develop a series of lessons and lead them to generate new concepts. KCM is based on constructivist theories to support the ill-structured problem-solving process of industrial education and technology students (Yampinij and Chaijaroen, 2010). Eventually, KCM is geared towards the development of personalized knowledge construction in an online learning environment (Mbendera, Kanjo and Sun, 2010).

Within the context of KCM study, this model provides various functions related to the process of knowledge construction. It guides instructor settings in the

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