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

TAN MAY LING

A thesis submitted in fulfilment of the
requirements for the award of the degree of
Doctor of Philosophy (Engineering Education)

School of Graduate Studies
Universiti Teknologi Malaysia

MAY 2017

To my beloved students in Ungku Omar Polytechnic

ACKNOWLEDGEMENT

A special thanks to God for giving me a variety of opportunities and the Holy Spirit.

I am grateful to my supervisor, Associate Professor Dr. Jamalludin Harun, who has always been there for me. During my research for my doctorate, he has continually provided a wide range of support and prompt feedback even though for three years, I was only a part-time student.

Sincere thanks to Mr. Foo Peng Tien and Aunty Ivy Olivier Abram who kept on encouraging me whatever it was when I encountered difficulties in my studies. We always discussed and checked my work together sentence by sentence in order to make sure that they could understand what I was doing in my research. They showed great patience and paid attention while I gave explanations of the thesis content although they were 72 and 65 years old.

I owe a huge debt of gratitude to Dr. Mok Chung, the orthopedic doctor who attended me after a serious accident when I was on the way home after finishing work at the office. Huge thanks are also due to Mr. Ahmad Hakiem Yahya, the physiotherapist who gave me effective treatment on my right ankle and hand to release the pain that I suffered following the road accident. He always said that "pain is better than no pain" meaning my muscles had feeling and were functional.

My deep appreciation goes to Miss Cheang Siew Kim, Mr. Hadwin Liang Han Wen and Mr. Hanschen Liang Han Zhi for their love and support. And also goes to Miss Ong Quee Eng, Madam Sharifah Osman, Mr. Mohd. Fahmi Adnan, Miss Umi Soleha Radzali, Miss Nur Ayuni Shamsul Radzi and Madam Faizah Jaffri for offering me peer support. Many thanks to Madam Norizan Yunus and Mr. Ramli Haron as UTM librarian who always provide guide for me to get the latest journals of engineering education.

Very special thanks to Miss Nor Azlinda Azmi, who noticed that I was almost becoming an isolated learner due to certain circumstances. She became aware of it and woke me up. We always discussed our studies with a cheerful mind.

Simultaneously, I would like to express my great thanks to Professor Dr. Richard M. Felder for his comments on Chapter 3 Methodology for our mentor and coach sessions. He asked me to visualize the instructional scaffolding part when conducting the online social collaborative learning environment research.

Finally, I would like to extend a special thanks to all of my lovely Ungku Omar Polytechnic engineering students, especially Miss Yap Li Min. She gave me a motto -"I will study, I will win"- and she has always been there. We kept on motivating each other and promised to each other to remain passionate in our studies.

Special appreciation and warmest thanks for all who have contributed to my PhD journey. Life is meaningful, wonderful and beautiful. Success breeds success. Go beyond. Think beyond. Thanks for everything!

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).

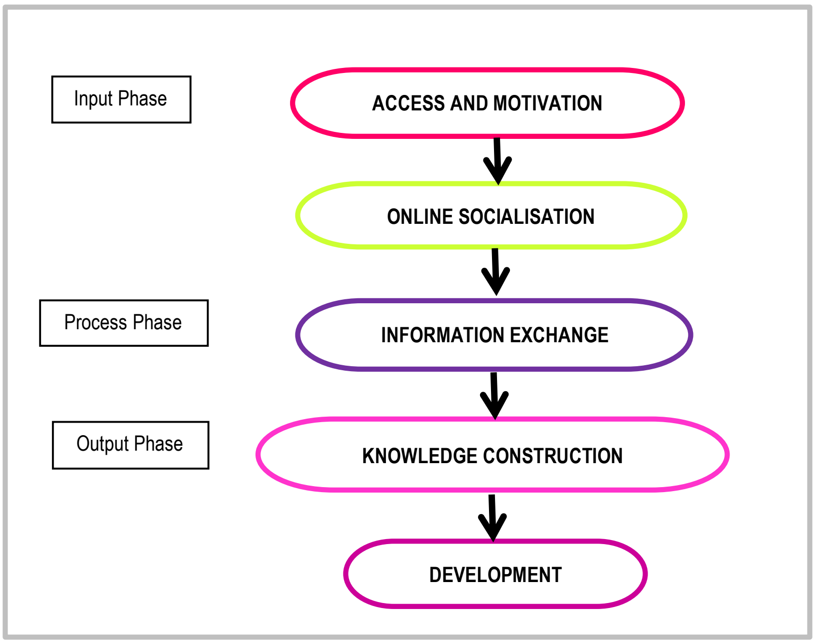


Figure 1.1 Overview of theoretical framework based on Salmon's Five Stages Model (Source: adapted from Salmon, 2004)

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)

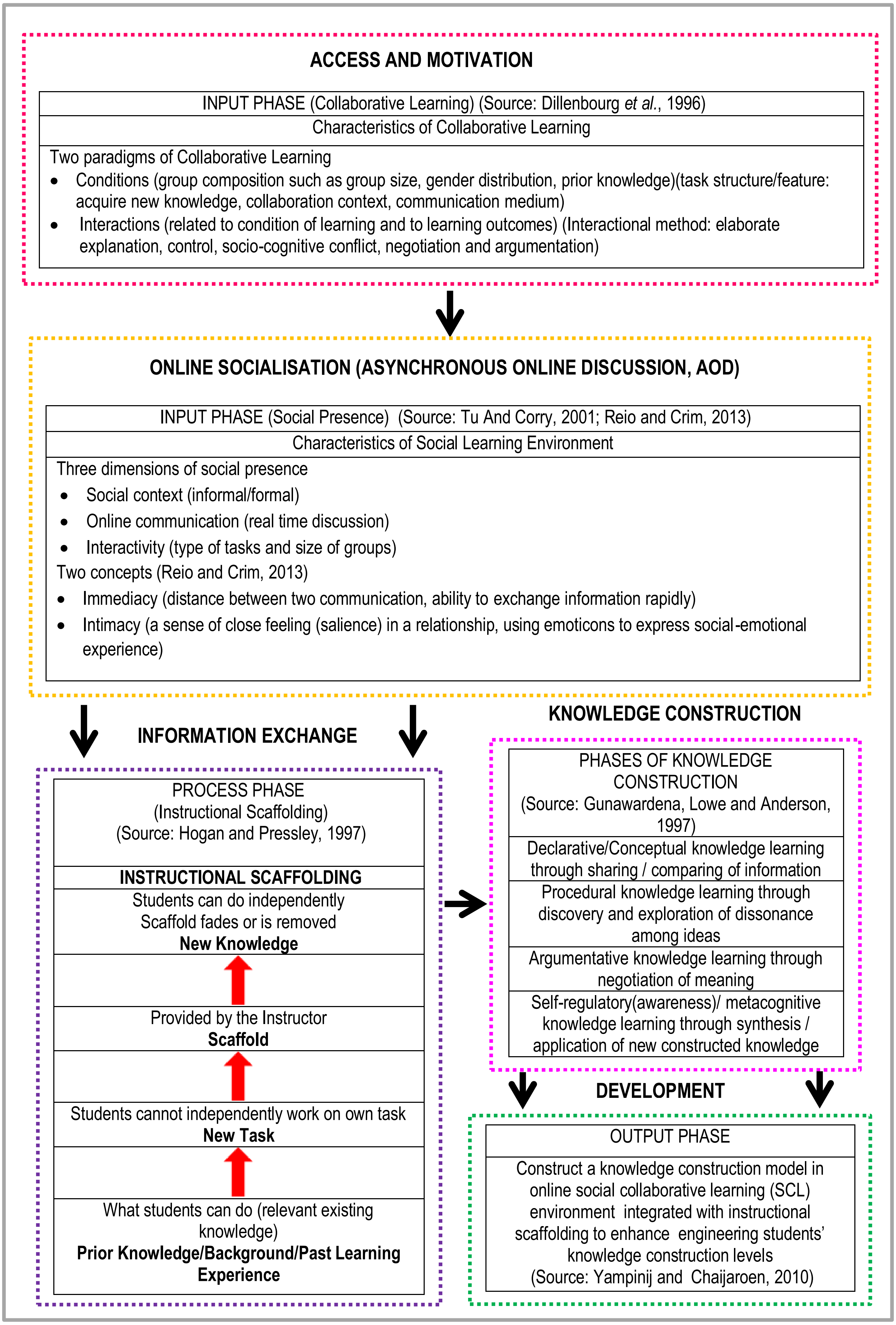


Figure 1.2 Theoretical framework based on Salmon's five stages model (Source: Salmon, 2004)

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.

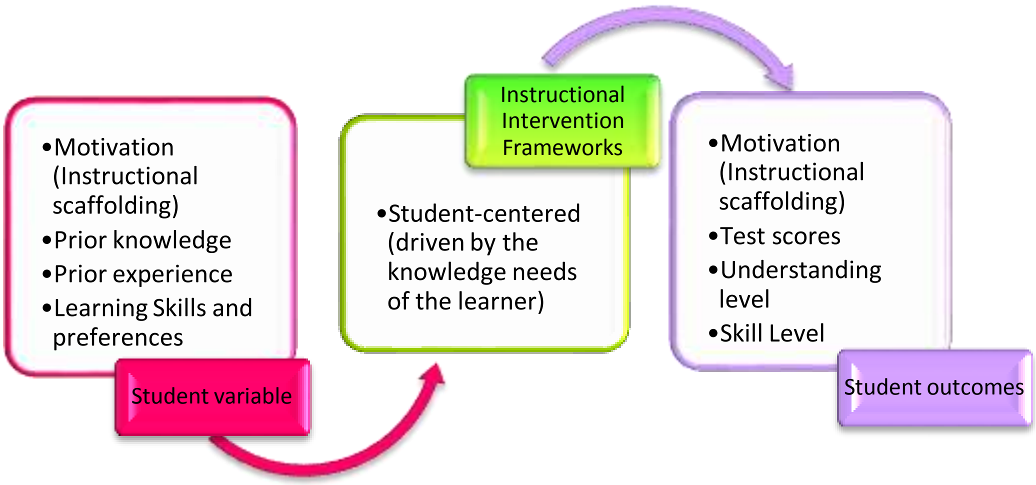


Figure 1.3 Concept Map (Structure of Assumption, Principle, and Rules Held Together with Ideas) (Philosophy Assumption): Learner-Centered Framework (Svinicki, 2010)

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.

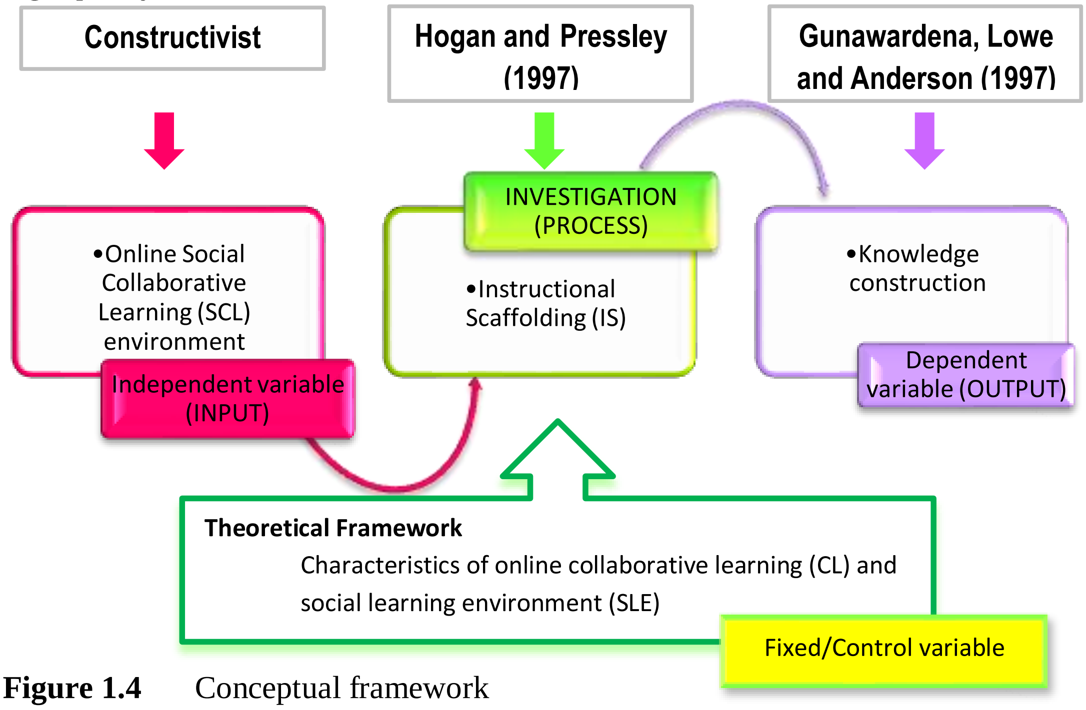


Figure 1.4 Conceptual framework

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 classroom. This may allow engineering students to construct or discover knowledge through exploration and questioning from SMT and CSLEs. It is also integrated with IS upon implementation of an online SCL environment. In comparison, directed knowledge is 'ready-made' (structured and systematic) and is imparted by a teacher to a student through lectures and textbooks.

1.11 Summary and Overview of the Study

This present study is focused on the impact of instructional scaffolding and online SCL environment towards engineering students' knowledge construction levels. In addition, it will build a hierarchy of knowledge construction by providing some useful insights to enrich students’ learning processes. It examines the use of appropriate instructional scaffolding for engineering students’ knowledge construction level in online learning environment.

The online learning environment comprises of AOD, which is related to engineering students’ interactions with SMT and embedded in metacognitive activities in the engineering classroom. In this study, the effect of IS on engineering students’ knowledge construction at higher levels is also investigated. In the next chapter, the researcher put forward the necessities of the present study based on the previous literature review. In Chapter 2, the researcher emphasizes the issues of students’ knowledge construction. Instructional scaffolding should be injected in the online SCL environment among engineering students.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter states the issues and challenges in knowledge construction notably in the engineering field, and explain the benefits of using hybrid learning such as online social collaborative learning (SCL) environment in order to engage and enhance engineering students' knowledge construction. Collaborative learning can considered as pedagogies of engagement (Barkley, 2010; Nilson, 2010; Prince, 2004) that can enhance students' knowledge construction with proper setting on learning environment.

The literature review of the study investigates how instructional scaffolding in online SCL environment affects engineering students' knowledge construction. There is also a need to investigate how students achieve the higher levels of knowledge construction based on the instructional scaffolding used. The results are interrelated with hybrid characteristics of learning approaches in SCL environment. For instance, computer-supported collaborative learning, online learning, and learning approaches using social media technologies as well as social learning environment (social presence) towards knowledge construction be discussed in detail in this chapter.

In addition, the literature on the classification of scaffolding and knowledge construction model in this study needs to be reviewed. The findings of this study impact on engineering students' knowledge construction level that is relevant to the research questions proposed.

2.2 Issues and Challenges in Knowledge Construction

Davenport and Prusak (2000) emphasized that "…*knowledge is broader, deeper and richer. It is also a fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information. It originates and is applied in the minds of knowers*…" From this statement, we can surmise that knowledge is a complexity that consists of a mixture of components and structures, although it is conventionally defined as an asset or possession. However, scientists typically look on it as a process and stock. It means that knowledge is intangible and evolves. It also comprises of judgments associated with our lives, and can grow and change when interacting with our environment. Thus, knowledge can be constructed through trial and error, experience, and observation.

Davenport and Prusak (2000) also claimed that the transfer of knowledge consists of transmission and absorption. It is a process of knowledge construction. When the absorption of knowledge begins, the knowledge construction process begins. However, the receiver of knowledge does not know how to use the new knowledge to solve the issues in real-world problems.

Furthermore, Sfard (1998) cited two metaphors of learning: acquisition and participation. Learning is involved of active participant to solve the problem together and acquire newly knowledge. The question concerns students' learning outcomes needing to be resolved, rather than asking how much or how structured individual student knowledge was acquired. Lehtinen *et al.* (1999) also asked how to facilitate learning and how to cultivate each student's own expertise. Students need to be self-regulated and collaborative in metacognitive activities, as well as being responsible for the task given as a group.

Lucas and Moreira (2010) emphasized that students should be given responsibility to create complex thinking in their learning process. It is also combined with autonomous learning and problem-based learning. Students work intra- and inter-group collaboratively. In knowledge construction, critical thinking and logical thinking are important goals for students' learning processes. Students need to learn to explain their opinion, and also elaborate the way in which they carry out tasks as well as solve problems in the tasks given (Ravenscroft and McAlister, 2008; Ravenscroft, Wegerif and Hartley, 2007). Nevertheless, they lack the self-confidence to form and construct their knowledge. Furthermore, they cannot appropriately construct knowledge since there are different types of knowledge in the learning process.

Mbendera, Kanjo and Sun (2010) claimed that the facilitator always presents a 'one content fits all' approach in the conventional classroom. This means that students will learn through the facilitator's presentation, which is the same content in the same format. However, learning is subjective and different for each person. Therefore, how can knowledge construction be adapted for online social learning environment to cater for individual students?

2.3 Knowledge Construction Issues and Challenges in Engineering

Engineering comprises of technical expertise and several elements of creativity, together with other design and applied scientific and technical professions (UNESCO Report, 2010; Chi, 2006; Nelson and Stolterman, 2003). Company and employer reports show a shortage of critical professional skills such as critical thinking, problem-solving, communication, and teamwork among engineering graduates (Allan and Chisholm, 2008; Bradford School, 1984; Earnest and Hills, 2005; Evers, 2005; McLaughlin, 1992; Sparkes, 1990).

This gap has led to the US Accreditation Board for Engineering and Technology (ABET) to change the accreditation criteria from content-based to outcome-based (ABET, 2012, 2013, 2014; Hardré and Siddique, 2013). ABET now intends to hold engineering schools accountable for the knowledge, skills, and professional values that engineering students will obtain throughout the course of their learning itinerary (Hardré and Siddique, 2013).

In 1999, the Malaysian Council of Engineering Deans (MCED) and Institution of Engineers Malaysia (IEM) authorized research to develop a Malaysian Engineering Education Model (MEEM). This model, adopted in 2000, shows that Malaysian engineers are technically competent, respected professionals who have leading technology at their disposal as well as wealth creation capabilities.

The skills of next-generation engineers need to be modified to suit changing demand, which means innovating to handle unexpected challenges (Blue *et al.*, 2005). Each professional has two levels of competence: task-specific competence (or competence) and generalized-skills competence (or meta-competence) (Bereiter and Scardamalia, 1993; Brown and Green, 2006). Task-specific competencies are the benchmark for graduates in certain fields. They also define how student achievement is ready to meet the demands of work and excel in the future (Allan and Chisholm, 2008; Earnest and Hills, 2005). General (meta) competencies are skill sets that allow students to work within a group, and include effective communication, working in teams, function in the organization, meeting quality standards, as well as transfer of skills to new specific tasks (Radcliffe, 2005; Wulf and Fisher, 2002).

Engineering innovations of the future will increasingly come from team collaborators who can bring together a variety of skills and views (Downey *et al.*, 2006; Warnick, 2011). To revolutionize learning, current and future engineers need to develop strength in meta-cognition and self-regulation (Hardré and Siddique, 2013). Hence, the competencies and meta-competencies required for success in next-generation engineering are different from those required in previous eras, due to the demand for innovation (ABET, 2012).

Ideas and technical skills are not sufficient to achieve innovation (Business Roundtable, 2005). The problems faced by society today have become increasingly global and complex in nature, so engineers need to be well equipped to handle social issues (Christensen and Raynor, 2013). This involves having overall competencies such as knowledge, skills, and the tendency to work effectively with various groups of people who may define issues differently (Downey *et al*., 2006). Additionally, innovators need the ability to facilitate communication and understanding across countries and cultures, bearing in mind teams' varying backgrounds and differences in technology (Warnick, 2011). Nonetheless, how can competencies be developed to support engineering innovation through knowledge construction in engineering curriculums? Thus, researchers in engineering education should focus on active learning and the development of knowledge construction integrated with meta-competencies to support innovations for problem-solving in engineering field.

In general, according to the National Science Board (NSB, 2007), students in colleges and universities view engineering as unfriendly and difficult to cope with, as well as requiring additional preparation. They do not see the benefits of engineering or its contributions to society. The other reason for student drop out is poor academic achievements in the field of engineering (Blue *et al.*, 2005).

In addition, students with lower achievement usually fail to establish prior knowledge and get to the solution to the problem (Hardré and Siddique, 2013). They may also lack cognitive and metacognitive strategies to guide their thinking and find solutions in the processes of learning towards knowledge construction.

Barak and Goffer (2002) found that most engineering students have not received clear instruction on metacognitive activities. Consequently, students do not reflect and proceed well in their learning process towards knowledge construction. There are clear requirements for engineering faculties to adopt effective teaching strategies to motivate students in learning and thinking upon constructing knowledge. Moreover, teachers have been unable to integrate cognitive theory framework in their teaching, particularly in engineering. Subsequently, they may not be effective at assisting engineering students to develop higher-order skills, or higher levels of thinking in knowledge construction (Zheng and Yin, 2012). In order to enhance students' knowledge construction, effectiveness in active learning should be implemented in their learning process.

Do 21st century engineering learning environments, then, support knowledge construction among engineering students? Based on Tryggvason and Apelian's (2006) point of view, engineering education needs to be re-engineered for the challenges ahead. The engineering education and profession face a challenging intersection (which can be looked on as a crisis or an opportunity) in 21st century society. As a result, engineering education continuously changes and evolves to fulfill the needs of 21st century society, and to address real-world issues, such as those connected with MH370, MH17 and QZ8501 Malaysia Airline incidents in 2014. Another critical incident in Malaysia, such as Bukit Gasing (KL-side) serious landslides in 2012 and Medan Damansara wall structure collapses due to soil erosion after heavy rain in 2008.

Moreover, Highland Towers collapses due to steep hill slopes, such as those at Bukit Setiawangsa and Ulu Klang are related to the engineering field. Engineering education has a large role to play in educating future engineers on how to address such challenging social problems. Simultaneously, educators should change their traditional teaching methods due to stimulate engineering students' learning. It means that the students have enthusiastic to construct engineering knowledge in the learning.

In order to address engineering issues, pragmatic (practical or hands-on) knowledge gained in workshops and at construction sites has proven effective. Apprenticeship can encourage young people to go into the engineering field. As Florman (1996) revealed, engineering from French has shown professional leadership in higher positions. Meanwhile, hands-on engineering is also included in navy work in Britain (Apelian, 1993).

Nowadays, engineers should be able to collect information and make decisions at any time, and about anything. Tryggvason and Apelian (2006) summarized that future entrepreneurial engineers will require the technical skills, people skills (communication), and innovation in fieldwork as described below:

- Know everything: be able to search information rapidly and know how to evaluate and utilize the information. Entrepreneurial engineers have the capability to transform information into knowledge.

- Can do anything: engineers need to understand the fundamentals of engineering in order to ensure that students can easily solve critical social problems, acquire the necessary tools, and use them proficiently.
- Work with anyone anywhere: engineers have communication skills, teamwork skills and understand global and current affairs. They are able to work effectively with other people.
- The imagination to make it a reality: have an entrepreneurial spirit, imagination, and the management skills to identify needs and come up with new solutions.

The issue concerned is how engineering education can educate current and future engineers to achieve this requirement, and face the various critical social problems that need to be resolved in engineering field.

2.4 Issues and Challenges in Malaysian Engineering Education

Worldwide engineering philosophy and model reviews have shown that the Malaysian model is dynamic and has foresight. While adoptions of the model have proven to be unprofitable, it can sustain the progress of the country. In Malaysia, there are many trained, technically proficient graduate engineers. However, they lack non-technical abilities such as management or transferable skills, which are needed for top leadership positions (Aziz *et al.*, 2005).

In order to prepare millennium students for the needs of the 21st industries area such as knowledgeable and skillful workmanships, Malaysia higher education take a further step to develop and enhance the National Education System (Grapragasem, Krishnan and Mansor, 2014). Ismail and Abiddin (2014) reported that the industries complain Malaysia students are inadequate skills to produce quality of works. The issue and challenge are how to ensure Malaysia higher educator achieve world-class status of employability particularly engineering students. This shift in pedagogical innovation by using advance technologies and/or hybrid learning to improve T&L

process as coined by Hamdan *et al.* (2015). Thereby, pedagogical comprises of curriculum design has been effected due to meet the market labor demands among engineering students in TVET sector (Ismail and Abiddin, 2014).

Most models of engineering education have been concerned with skills that can be transferred from an ongoing emphasis on technical efficiency or competency. Thus, engineering science knowledge is vital for engineers (Aziz *et al.*, 2005). It enables engineers to be flexible, moving to multiple engineering disciplines in a global context. Comprehensive training of students can result in engineers who can perform well in industry applications societies (IASs) (Aziz *et al.*, 2005). They are also able to communicate effectively, and may manage or lead organizations in appropriate ways, as well as having the skills to think innovatively (Goonatilake, 1982; Johari, 1999). Future engineers have to face worldwide challenges. Hence, knowledge construction in learning sciences needs to expand (O'Kane, 1999). This shift in pedagogical emphasis toward engineering students' knowledge construction in terms of improve their academic achievement, productivity and capability.

There are five important criteria or parameters in MEEM (MCED/IEM; 2000):

- Scientific strength in which innovative engineers can work in research and development activities as well as be adaptable to various engineering fields.
- Professional competencies in which engineers can identify, formulate and solve engineering problems. They are responsible professionals and can utilize techniques, skills, and modern engineering tools for engineering practice.
- Multi-skilled in which engineers are able to work in various fields of engineering and function in a multidisciplinary manner, whether working independently or in team.
- They are respected industrial leaders and potentials who can understand the impact of engineering solutions in a worldwide context. They understand current issues, can communicate effectively, and engage in community or social projects.
- In terms of morality and ethics, engineers can understand and react to ethical and moral responsibility.

In fact, there are six skills and competencies needed to be injected for engineering students to fulfill the criteria as mentioned: global and strategic, industrial, humanistic, practical, professional and scientific. Table 2.1 shows the recommended skills and competencies for civil engineering in MEEM (MCED/IEM, 2000).

Table 2.1 : Recommended skills and competencies in MEEM
(Source: MCED/IEM, 2000)

Skills and Competencies	Characteristics	Typical Courses in Civil Engineering
Global and Strategic	These skills enable students to adapt easily within a borderless world that is experiencing a drastic expansion in knowledge.	Languages, Strategic Planning, Information Technology, Multimedia, International Business.
Industrial	Skills that go beyond the scientific and professional and which are necessary in the advanced phases of a graduate's career.	Environment, Management Finance, Economics, Engineers in Society, Communication Skills, Law, Occupational Safety, Human Resource Management, Innovation.
Humanistic	These skills help create a balanced engineer with high ethical and moral standards	Islamic Civilization, Asian Civilization, Nationhood, Islamic Studies, Moral Education.
Practical	These enable students to be directly involved with hands-on activities or real-life situations, thus providing the basis for integrating the intra and inter engineering and non-engineering knowledge.	Final Year Project, Industrial Project, Practical Training, Engineering Design.
Professional	Such skills cover technical competency specific aspects required to perform engineering tasks.	Professional Subjects in Civil Engineering such as Foundation Engineering, Water and Waste Engineering, Highway Engineering, Concrete Structures, Public Health Engineering, Surveying.
Scientific	They enable students to have a firm foundation in science, thus engineering enable them to realign themselves with the changes in emphasis in the scientific field and to develop an interest in R&D and design.	Engineering Sciences, Engineering Mathematics, Engineering Materials, Fluid Mechanics, Engineering Statistics, Thermodynamics, Engineering Mechanics, Programming.

Table 2.1 shows that six skills and competencies are needed to prepare current and future engineering students to fulfill the five criteria of MEEM. The table also provides Civil Engineering courses associated with the six components. These models

have no limits, and do not impose a rigid barrier to the level and content of the civil engineering curriculum. Thus, there is no hurdle in scientific or professional skills and competencies to maintain equilibrium of both components. Aziz *et al.* (2005) noted that "…*reasonable significance on global and strategic skills and adequate exposure to industrial as well as practical skills and incorporating humanistic skills also allow completeness in the training. The model recommended that 30% of the curriculum be attributed to non-engineering subjects*…"

Hence, there is a need to provide active learning in an appropriate environment that can cultivate and foster self-regulation (self-awareness and self-reflection) as well as quality of knowledge construction for engineering students. In addition, the problems of retaining students in the engineering field need to be resolved (Zheng and Yin, 2012) due to the lack of engineers nationwide (National Science Board, 2007). Thus, engineering education plays an important role in addressing this issue.

However, Zheng and Yin (2012) revealed that current engineering education lacks the features required to develop creative problem-solving (CPS) skills, limiting the development of higher-order skills (such as high level of thinking) in knowledge construction. For instance, Magee *et al*. (2003) claimed that extreme emphasis on memorizing knowledge and procedure discourages self-reflection and self-assessment; overemphasis on structured learning lacks expression of ideas and adequate equilibrium between constructing a body of knowledge and creative use of that knowledge.

Meanwhile, engineering students possess metacognitive knowledge, which refers to acquiring knowledge about cognitive processes and strategies, as well as metacognitive experience (practice) which refers to activities that can control their own thinking and learning (Zheng and Yin, 2012). Furthermore, metacognitive activities need to be integrated in engineering students' learning tasks to construct their knowledge. As a result, they are be able to improve the metacognition and academic achievement in engineering courses.

2.5 Meta-analysis: Knowledge Construction Model (KCM) / Construction of Knowledge Model

The knowledge construction model is one that can promote and improve students' knowledge construction. In order to know the outcomes of KCM produced by the researcher in this study, it is helpful to consider some knowledge construction models previously discussed by other researchers.

In general, most of the development of knowledge construction models is based on constructivist learning theories, such as (a) Dewey in late 19^{th}. century who emphasis on constructivist approach means that learning by doing and through experience but not comprises of computers, (b) Piaget (1972) who emphasis cognitive constructivism means that learning is developmental that construct knowledge is a continuity (persistency) process, (c) Vygotsky (1978) who emphasis social constructivism means that learning through social interaction via collaborative discourse between learner and instructor, and Bruner (1990) who emphasis knowledge is constructed through discovery learning means that learning consists of explore the real problem which is interaction with the environment. The constructivist approach views that the learner needs to have active engagement in the process of knowledge construction. They construct knowledge through their experience, via prior knowledge they already have. Moreover, they also can construct knowledge through social negotiation (Adams, 2007).

Reviewing Table 2.2, the researcher insights two types of scaffolding in web-based and non-web based tools to develop a knowledge construction model throughout learning activities. It can be used as platform to develop a knowledge construction model for engineering students' knowledge construction engagement.

Based on Table 2.2, there are various types of knowledge construction models which comprise of ill structured problem (Yampinij and Chaijaroen, 2010), meaning making (Yampinij, 2010), sharing knowledge online (Zeng and Xu, 2013; Wang, 2011; Leiba and Nachmias, 2006), active online learning (Koohang, Georgia and College, 2014), personalized via learning object (Mbendera, Kanjo and Sun, 2010), instructional strategies: drill and practice as well as programmed instruction (Adam, 2007), graphical knowledge modelling via online learning design for engineering (Paquette *et al.*, 2006), and students' conceptions (ideas) (Ebenezer, Chacko and Immanuel, 2004). In this scenario of multiple knowledge construction, each has its own function for constructing a variety of knowledge models. There are two outcomes based on table 2.2. It consists web based and non-web based tools in knowledge construction model.

Table 2.2 : Review on Knowledge Construction Model which comprises web-based and non-web based tools

Author (Year)	Aim of Research	Scaffolding Form (Web based and Non-Web based tools)	Findings
Zeng and Xu (2013)	To design the construction of knowledge sharing platform in Universities	Ubiquitous Network (architecture techniques)	The knowledge sharing network can be efficient in ubiquitous learning.
Wang (2011)	To solve the problem of teacher implicit knowledge sharing	Web-based tool (Blog)	Blog - effective to enhance and solve the problems of teacher implicit knowledge sharing and improve the teacher professional development level
Koohang, Georgia and College (2014)	To advance a theoretical model (three stages: underpinning, ownership, and engaging) for knowledge construction To examine whether there is a positive and significant relationship between the independent variables of the underpinning and ownership and independent variables in which the construction of knowledge occurs.	Active online learning model	Positive and significant relationship between underpinning elements and ownership elements clearly linked to engaging elements which lead into knowledge construction
Leiba and Nachmias (2006)	To examine a knowledge building community involved in constructing a knowledge model	Web-based tool (online concept maps)	Using concept maps as a shared knowledge model. Three limitations need to consider: 1)the subjective nature of the concept maps

	through the process of concept mapping To explore students' usage, attitudes and limitations in constructing a knowledge model.		2)technological aspects 3)the scalability of the model
Paquette *et al.* (2006)	To explain the Learning Design based on Graphical knowledge-modelling	Graphical knowledge-modelling (based on Taxonomy of Knowledge Model categories)	As a result, knowledge engineering process where knowledge and competencies, learning design and delivery models are constructed in an integrated framework.
Mbendera, Kanjo and Sun (2010)	To develop Personalized Knowledge Construction Model	Learning objects	Enable personalization for the learning content
Adam (2007)	To determine how to move students from knowledge acquisition to knowledge application and to knowledge generation in a virtual environments	Instructional strategies: • drill and practice • programmed instruction	Producing model for knowledge development is presented that combines the dimensions of knowledge approach, the teacher-student relationship with regards to knowledge authority and teaching approach to demonstrate the recursive and scaffold design for creation of virtual learning environments.
Yampinij and Chaijaroen (2010)	To design and develop the knowledge construction model based on the constructivist theories to support ill-structured problem solving	Ill-structured problem solving based on constructivist theory	The knowledge construction model consists of essentials elements: 1)ill-structured problems, 2)data bank for problem solving, 3)the support centre of excellence 4)cognitive tools 5)transfer centre by related cases, 6)sharing and social collaboration 7)consulting and knowledge centre by experts 8)scaffolding 9)coaching Students can learn and solve problems by using the ill-structured problem solving. Students learning achievement up to 70% scores.
Ebenezer, Chacko and Immanuel (2004)	To provide insights on Common Knowledge Construction Model (CKCM) for teaching and learning Science:	Based on students' conceptions (ideas), develop sequence of lessons and teach the concept.	To implement the Common Knowledge Construction Model: (a)class preparation and assignment corrections will require more time

	Application in the Indian context		(b)heavy class load (45 and above students) not suitable (c)satisfaction because of students learning through peer interaction To explore and categorize students conceptions (ideas). It would engage student those activities using their mind and make them think. Then, they can understand the course.
Yampinij (2010)	To develop rich learning environment on Web to support Knowledge Construction based on meaning making	Web-based tool (not mentioned)	Rich Learning Environment on Web consists of seven important elements: 1)problem based 2)development centre meaning making 3)resources 4)related Cases 5)sharing Knowledge 6)scaffolding 7)coaching Rich learning environment on Web can support and promote learners to construct knowledge

2.5.1 Scaffolding Form: Web-Based and Non-Web-Based Tools

In this study, there are two types of scaffolding namely web based and non-web based tools.

Figure 2.1 summarizes the classification elements of scaffolding in knowledge construction model which is summarized from Table 2.2. Classification of web and non-web based scaffolding are displayed in pie chart. The analysis identified the ubiquitous network, blog, active online learning, online concept map and graphical knowledge modelling as web based scaffolding. Meanwhile, learning objects, instructional (drill and practice), ill-structured problem solving and students' conceptions (ideas) to develop sequence of lessons are non-web based scaffolding. Although theoreticians and researchers use different frameworks to describe the knowledge construction model and how it is obtained, most of the frameworks are successful (effective) to engage and enhance students learning and satisfaction.

In conclusion, different knowledge construction model would bring different impacts on learning process for students' knowledge construction. Hence, an engineering education researcher has to construct quality knowledge model appropriates for engineering field.

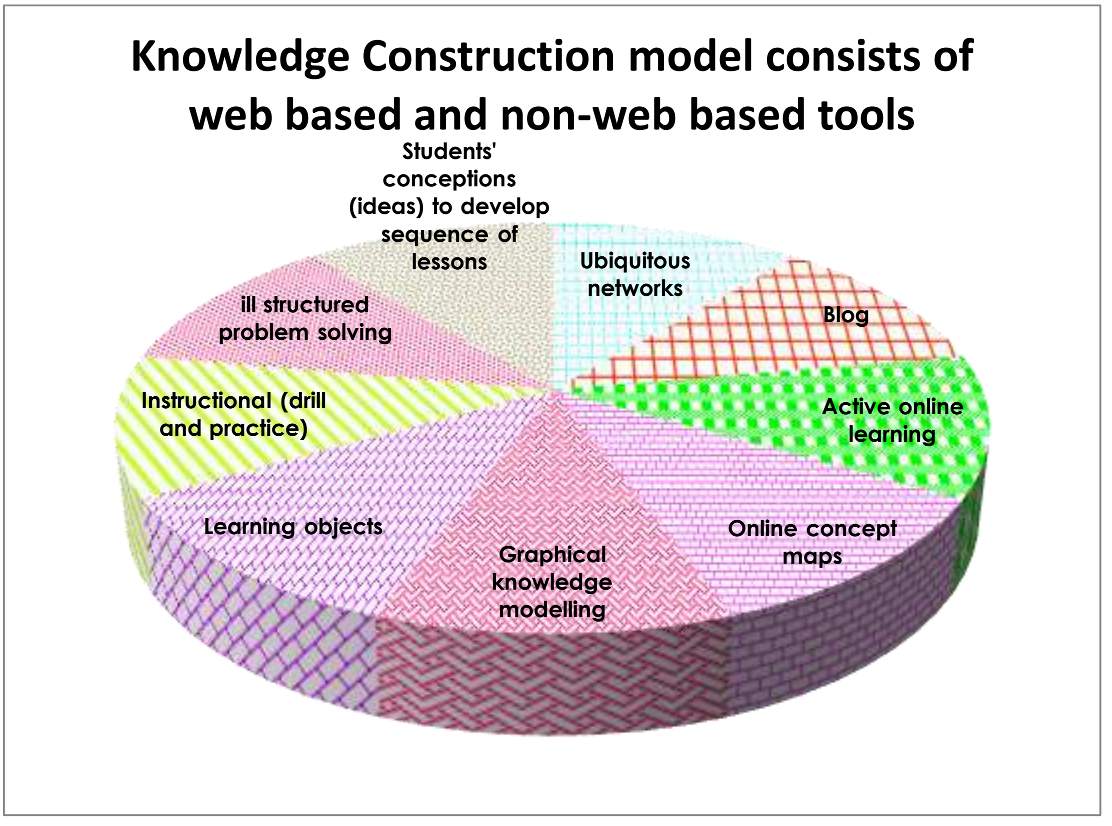


Figure 2.1 The findings of knowledge construction model

2.5.2 Findings of Knowledge Construction Model to Scaffold the Learning Outcomes

Study focusses on findings of knowledge construction model that can scaffolds students learning in the process of knowledge construction. Table 2.2 shows the list of studies from the year 2004 to 2014.

Knowledge construction model assumes that online learning environment like AOD enhance student learning achievement (Young, 2008). It also provides interaction of opportunities for engineering students who may employ more than one model that to scaffold student learning process towards knowledge construction. The development or progression for engineering students' knowledge construction is a vital topic to understand in the process of learning.

Leiba and Nachmias (2006) define knowledge construction model is as model that consists of symbols to construct knowledge through concept mapping which is associate with information or knowledge sharing of individual. They use the concept maps as online collaboration knowledge model to explore students’ learning content activities in a Web-based learning environment. But, there are three constraints when implementing it: the subjective nature of concept maps, technological aspects and scalability of the model. The meaning is students reveal difficult to construct the idea map based on their existing knowledge, access the server when utilize the software and construct a huge number of concept into a map due to disorientation.

On the other hand, sharing knowledge is a knowledge construction process via ubiquitous network and blog (Zeng and Xu, 2013; Wang, 2011). The ubiquitous network environment can effectively construct knowledge at anytime, anywhere and with anyone (Zeng and Xu, 2013). Wang (2011) claimed that in a blog there is freedom, sharing and openness for every one who can give relevant comments on the topic. Thus, it can improve sharing knowledge throughout network sites towards engineering students’ knowledge construction.

There are two aspects of scaffolding to be considered: (i) multiple types of scaffolding (Yampinij and Chaijaroen, 2010) and (ii) role and responsibilities of students (Koohang, 2012). In the classification of scaffolding, procedural scaffolding and conceptual scaffolding are used to generate students’ knowledge construction. In order to upgrade students’ knowledge construction, metacognitive scaffolding is used in their learning process. Such scaffoldings can be obtained from active learning.

In view of multiple role and responsibilities of students, ownership elements and engaging elements are used to activate students’ level of knowledge from active online learning model suggested by Koohang, Georgia and College (2014). Students setting their (1) goals and objectives, (2) self-mediating and control of learning, (3) self-reflection and self-awareness, (4) students' experience and self-assessment as well as (5) representing their ideas and/or concepts are considered as ownership elements. These elements generate students' role and responsibilities to construct the knowledge. Moreover, active learning created by an instructor is considered as an engaging element. This element leads students to be more active in collaborative metacognitive activities whether in the engineering classroom or online learning.

Table 2.3 shows characteristics of underpinning elements, ownership elements and engaging elements in the active learning model with the role and responsibilities of both the learners and the instructor for each level.

Table 2.3 : Active online learning model (Source: Koohang, 2012)

Active Learning: Underpinning Elements	Learner (Role and Responsibilities)	Instructor (Role and Responsibilities)
• Real world and relevant examples • Exploration • Higher-order thinking skills (analysis, evaluation and synthesis) • Scaffolding that can be used to make learners think above and beyond what they normally know	n.a.	Designing all course activities to immediately guide learners to become active learners and initiate deep learning

Active Learning: Ownership Elements	Learner (Role and Responsibilities)	Instructor (Role and Responsibilities)
• Learner's driven goals and objectives • Learner's self-mediating and control of learning • Learner's self-reflection and self-awareness • Learner's own experience • Learner's self-assessment • Learner's own representation of ideas and/or concepts	Setting own goals and objectives Taking control of learning Reflecting Being aware of learning Including own experiences Self-assessing Presenting ideas and/or concepts	Designing all course activities immediately to guide learners to become active by participating in the ownership of learning Actively communicating

Active Learning: Engaging Elements	Learner (Role and Responsibilities)	Instructor (Role and Responsibilities)
• Learner's active engagement in analysis	Actively creating knowledge	Actively coaching, guiding, mentoring, tutoring and facilitating

evaluation & synthesis of multiple perspectives • Learner's collaborative assessment		Actively providing feedback Actively assessing Actively communicating

As shown in Table 2.3, Koohang (2012) has developed an active online learning model for knowledge construction through three vital levels such as underpinning, ownership and engaging elements. This model asserts that all levels with their elements need to be shown in the active learning design. These elements synergize in the construction of knowledge.

In the first phase, the instructor designs the underpinning elements in the knowledge construction process. Then, activities and assignments of ownership elements are designed to encourage learners to act actively in the ownership learning. At the final engaging level, learners act actively and collaboratively to construct new knowledge based on the underpinning and ownership levels (Koohang, 2012).

The effectiveness of online learning is due to learner-centered practices. Meanwhile, knowledge construction relies on how well course activities such as assignments and/or projects are designed for active learning. Koohang, Georgia and College (2014) found that elements of underpinning and ownership are associated to the engaging elements. They also stated that underpinning and ownership levels have positive impacts and significantly contribute to the engaging level. This implies that the underpinning and ownership levels prepare students to move on to engaging level to achieve construction of new knowledge.

On the one hand, in this diversity of development knowledge model, Adam (2007) pointed out that student engagement is a center of learning. All levels of knowledge engagement (knowledge acquisition, knowledge application and knowledge generation) should be taken into account when creating knowledge and fostering students ownership elements. Students have the authority in the online learning environment. This provides a chance for students to explore and construct knowledge. They also can continually view the entire knowledge construction process through discovery learning. Different levels of discovery learning can be used to foster knowledge. Thus, this process is critical for student ownership elements.

Brainstorming can resolve these problems such as ill-structure question. It can help students come up more ideas. They can obtain the best solution when they have constructed knowledge.

In addition, Adam (2007) also revealed that conventional knowledge application tasks such as laboratory work, writing, presentations and other metacognitive activities require students to construct the knowledge to solve existing problems. Hence, collaboration among students can strengthen this process. Collaborative environment such as chat, discussion boards and instant messaging are useful for students to construct their knowledge. These can also lead teachers to avoid common misconceptions in basic knowledge. However, collaboration is often lacking among students in their process of knowledge construction.

Constructing high quality knowledge is vital. This is a demanding task. It is also a difficult task to address and needs to be solved gradually (Paquette, Crevier and Aubin, 1994; Paquette *et al.*, 2005; Paquette, 2003). Paquette *et al.* (2006) revealed that designers have raised several questions when constructing a Learning Design in engineering, such as "… *Which knowledge must be acquired and what are the target competencies or educational objectives for that knowledge?" and "How should the activities and the environment be organized to best achieve knowledge and competency acquisition?...*" Therefore, it is necessary to develop a knowledge construction model for engineering students to solve these questions.

Paquette (2003), showed that the five types of models can be modeled more accurately (refer Figure 2.2). Various fields of knowledge, sketches, diagrams and graphs can be utilized because a picture is worth a thousand words. For instance, conceptual map can be used to represent and explain the complex relationships between concepts to facilitate the construction of knowledge by students. Flowchart is a graphical procedural knowledge representation, consisting of actions and decisions that trigger a series of actions in a dynamic environment. Decision trees are another way of representation used in various fields, especially in decision-making.

Several advantages of graphical knowledge or cognitive modelling (Paquette *et al.*, 2005) are given:

- To describe the relationship between elements of complex phenomena
- To clarify the complexity of the interaction
- To facilitate communication of the actual study
- To enable completeness of the phenomenon
- To assist in obtaining idea as less text is used

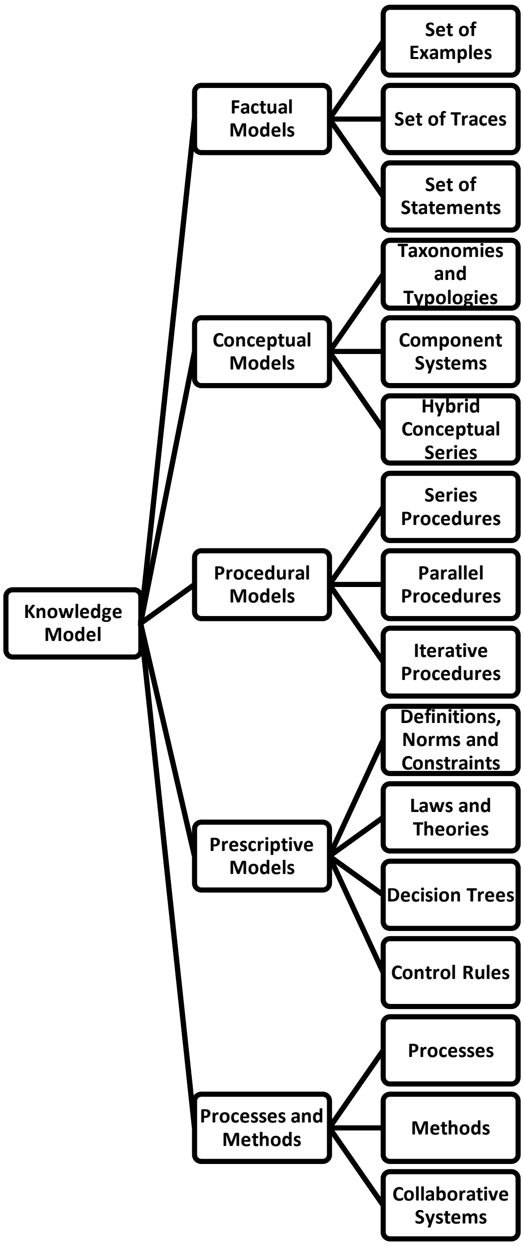


Figure 2.2 Taxonomy of knowledge model categories (Source: Paquette *et al.*, 2006)

Paqutte *et.al.* (2006) noted that there are five categories of model in structuring knowledge models: factual models, conceptual models, procedural models, prescriptive models, and processes and methods. Each type of models consists of sub-types (Figure 2.2). This knowledge model comprises workflow information on who does what, when and with what type of resources. The concepts, procedures and principles are connecting each other to describe a phenomena. The processes and methods fall under learning design, and law and theory consists of learning concepts. Particular cases are used to describe knowledge domains and competence. Thus, it is possible to represent concept maps, flow charts (iterative procedure) and decision trees, and also other types of models that are useful for modeling education.

Conceptual maps represent and clarify complex relationships between concepts to facilitate knowledge construction by the learners. Flowcharts are graphical representations of procedural knowledge or algorithms, composed of actions and decisions that trigger series of actions in a dynamic rather than static way. Decision trees constitutes the decision-making that cause and or effect (influence) the relations between various factors.

2.6 Online Learning Scenario for Malaysian Students

The Malaysia online learning (OL) scenario consists of several phases reported by Al-rahmi, Othman and Yusuf (2015) . The first phase of OL via web based browser such as internet, intranet, and extranet (Chiu, Chiu, and Chang, 2007) set up by the university itself where exclude the learning management system **(**LMS). Then, go to second phase's OL of Malaya University first establish the online learning course through LMS in 1998 (Asirvatham, Kaur and Abas's Report, 2005). From this incidence, it might seem that the important of on and/or off campus teaching particular distance learning education (Isa and Hashim, 2015). Hence, the university form up house development such as WebCT, Blackboard in order to assist the instructors upload the learning material for distance learning students. The students may download files that request by the instructors before conducting a lesson in the classroom.

The third phase of OL moved towards an open educational resources (OERs) which is refers to open course content, open source software and tools (Isa and Hashim, 2015). Atkins, Brown and Hammond (2007) revealed that the principle of OER is sharing the academic research. So that active discussion emerged between instructor and students as well as peer to peer via social interaction.

To be sure, gradually establishment the OL in the fourth phase that integrate the social media for students' learning process. Nowadays, utilize social media has become part of our daily lives. The Malaysian students access the files downloaded from social learning environments such as Schoology, Edmodo, Ning and Facebook. Nevertheless, Zhao (2003) revealed that technological aspects may impact the learning process. Isa and Hashim (2015) pointed that how to enhance students' learning in the shortestest time of such learning environment.

So that the OL further development into fifth phase in order to continuous quality improvement of its best of learning process for Malaysian students. Open course ware (OCW), Massive open online course (MOOC) and mobile learning are implemented in Malaysia universities for engage, enhance and effective learning via online. This is the ways of overcoming the students too rely on retrieve and download the lesson and/or course materials being uploaded online (Yee, 2013).

Nonetheless, the issue of conventional OL via web-based and LMS is that interaction deficiencies between instructor-students and peer to peer. Barab (2003) mentioned a little interaction through online groups such as forum where it is common for people to visit and lurking messages (read without posting). Moreover, the instructor has fully responsibilities and autonomies of the study and/or course material for students via traditional OL. The students unable to chose based on their interest and restraint on conventional modes of OL. In these cases, the researcher created a design of SCL in turn to engage, nurture and support of students learning with utilize of social media. A move from "teacher-centered" of instruction to the more on "learner-centered". Nevertheless, SCL emerged has the impact on raise students' passionate of learning due to knowledge construction.

Simultaneously, Facebook (FB) platform to be selected as social learning integration with collaborative learning for active engage the engineering students' knowledge construction. This is the main benefit of manipulate FB for design and develop SCL environment for the researcher. Hence, the constructivist approach as a potential learning environment that could engage and enhance engineering students acquire higher level of knowledge construction would be further discussed.

2.7 Constructivist Approach as an Active Engagement

Constructivists argue that knowledge is an ongoing learning process. It is constructed through past experience and social negotiation (Adams, 2007). Vygotsky (1978) and Bruner, J. (1990) carried out constructivist approaches, where Vygotsky (1978) focuses on social knowledge construction and Bruner J. (1990) on personal knowledge via discovery learning.

Constructivist approaches form a consensus on learning. Knowledge construction is a learning process of students. Koohang (2012) stated that constructivist theory was established by Dewey (1902), Piaget (1972), Vygotsky (1978), and Bruner J. (1990). Constructivism is related to active learning, where new knowledge can be constructed. Koohang and Paliszkiewicz (2013) also emphasizes that constructivism affects high-level thinking skills, exploration, and problems in real world. Hence, the issue is how students can actively participate in knowledge construction through active learning.

Similarly, Du and Wagner (2007) stressed that constructivism focuses on learning as a process of knowledge construction. They revealed that the cognitive perspective is based on constructivism. Students need to construct their own concepts by being active in experimental and personal observations. People learn by constructing new ideas or concepts based on past or current experience (Beetham and Sharpe, 2007). This assumes that students have different backgrounds and prior knowledge. Thus, how knowledge can be constructed has become a concern for lecturers and instructors. In addition, how to lead students to reach higher levels of knowledge, which can be utilized to solve on-campus or real workplace problems, is another aspect that should be looked into.

On the other hand, social constructivism is a variety of cognitive constructivism that emphasizes the collaborative learning. It developed by Vygotsky (1978). He emphasized that learning comes from social interactions. This means that learning is the process which is integrated into a knowledge community by the learner. Gunawardena and Zittle (1997) revealed that learning occurs socially within communities of practice (CoP).

Social learning environments (SLEs) can promote or encourage students to generate a sense of belonging to a particular community that has its own social and cultural identity, where students would actively participate and interact with the society (Mbendera, Kanjo and Sun, 2010). It is called "CoP (Community of Practice)" as it does not simply focus on the learning activity itself (Beetham and Sharpe, 2007). Through such group activities, students are able to share similar learning goals and interests and construct their knowledge in this CoP (Tu and Corry, 2001).

Knowledge is constructed within social contexts via collaborative learning. Engineering students would be engaged in social discourse such as Facebook group discussion. The issue looks into how to guide of or in collaboration with peers in effective ways towards knowledge construction?

Table 2.4 describes various learning insights. The potential of developing knowledge construction is still maturing. Overall, the table shows different definitions of learning as a process knowledge construction scenario. Based on the constructivist learning model, there are three definitions of learning. Wagner (2003) mentioned that learning is an active process that constructs or creates new ideas or concepts based on learners' prior experience or knowledge. Likewise, Alavi, Wheeler and Valacich (1995) claimed that learning is a process of constructing knowledge by an individual, and it can also be constructed upon interaction with others through sharing knowledge. Learning is a complex concept (Du and Wagner, 2007). Hence, collaborative learning is needed to integrate students' knowledge construction processes and this be further discussed in the next sub-topic.

Table 2.4 : Constructivist learning model (Source: Du and Wagner, 2007)

An overview of constructivist learning	Definition	Major Assumptions	Keys to Effective Learning
Constructivist	Learning is a process of constructing knowledge by an individual (Alavi, Wheeler and Valacich, 1995).	Shift from instruction-oriented learning to learner centered active learning. Individuals learn better when they discover concepts themselves, and when they have control over leaning space (Alavi, Wheeler and Valacich, 1995).	Promoting active learning and mental construction of knowledge is crucial. Learning curricula should be organized in a continuous process. To encourage self-directed learning, the teacher's scaffolding role is to support rather than to direct.
Cognitive Constructivist	Learning is an active process of constructing new ideas or concepts based on learners' experience (Wagner, 2003).	Prior knowledge and differences in learning or cognitive process require different levels of instructional support (Wagner, 2003).	To avoid free-riding and encourage non-anonymous learning effort, individual accountability is important and should be recognized. Provide personalized instructional support and encourage prompted feedback.
Collaborative Constructivist	Learning emerges through shared understandings of more than one learner and the construction of understanding built upon interaction with others which related to social interaction (Alavi, Wheeler and Valacich, 1995).	Emphasis on group oriented and collaborative learning. Learning is better achieved through interaction with others than by oneself (Felder and Brent, 1996).	Promote knowledge sharing and collective learning. Encourage participation in collaborative activities, and provide opportunities for diverse perspectives. Provide convenient access to information and knowledge of particular interest.

2.8 Computer-Supported Collaborative Learning

Collaborative learning (CL) has been proven to be effective for knowledge construction. Informal learning, such as group work and collaborative activities, enable increased interaction in a collaborative learning environment. Moreover, peer group interaction may scaffold students in knowledge construction (DeWitt, Siraj and Alias, 2014). Collaborative learning may also provide group interaction outside the classroom, and learning may take place anytime and in any place (Ally, 2004; Siraj, 2005; Siraj and Alias, 2005). As a result, collaborative learning is for acquisition of knowledge, skills, and attitudes (Johnson and Johnson, 2004). Nevertheless, how to make collaborative learning more effective in the students' knowledge construction process needs to be assessed.

The purpose of collaborative learning is to assist students in achieving successful academic goals (Gokhale, 1995). Likewise, such of learning is also suitable for engineering students. However, it is rarely implemented in TVET's classroom of pedagogical innovation in T&L (Hamdan *et al.*, 2015). Collaborative learning had taken practice in Malaysia notably in engineering education since 2005 when EAC Malaysia adopted ABET accreditation criteria for engineering programs and EAC quest to be member of Washington Accord.

On the one hand, collaborative learning can enhance and enrich learning experience for knowledge construction (Palloff and Pratt, 1999). The instructor needs teach students how to work in teams via small team sizes particularly in engineering (3 is considered optimal), and need give a clearly structured problem with some idea of what the task requires them to do (Prince, 2004).

DeWitt, Siraj and Alias (2014) coined that it is seldom implemented in Malaysia's pedagogical science classroom. Nevertheless, CL not fully manipulate in TVET Malaysia in terms of pedagogical innovation among engineering students (Hamdan *et al*., 2015).

Generally, teachers feel that there is insufficient time to implement collaborative learning in the engineering classroom, typically in the TVET sector. Thus, it results in providing little time for social interaction in formal learning. The effectiveness of collaborative learning has generally been less explored in relation to engineering students' knowledge construction level in TVETs. How to enhance and enrich the effectiveness of collaborative learning is a major concern, since it can help students' knowledge construction and is associated with students' learning performance and academic achievement; new knowledge is thereby constructed. Hence, as an engineering educator should employ CL in T&L in order to produce future technical engineers who can think creatively, innovatively, solve problems and make a decision logically. not been adequately instilled among engineering students in engineering educational.

On the other hand, collaborative learning relies on social interaction. It has been shown that teamwork can increase memory, reduces mistakes, and motivates students (Bligh, 2000). There are several elements affecting group interaction, for instance background components such as age, activeness, and value, as well as internal influences such as leadership and communication (Tubbs, 1995). This is the reason that collaborative learning needs to be injected for engineering students' knowledge construction.

The collaborative learning environment plays a key role in learning, in line with the viewpoints of contemporary academics. It is also important for engineering students' cognitive learning processes. In order to achieve Vision 2020, National Education Strategic Plan/Pelan Strategik Pengajian Tinggi Negara (PSPTN) has formulated a strategy with the intention of producing human capital to support the national mission to improve capacity for knowledge and innovation, as well as nurture first class mentality to transform Malaysia’s development (National Higher Education Action Plan 2007-2010).

Furthermore, the backbone of the development of Malaysia is our education system, which emphasizes economic competitiveness (goals of Asia-Pacific Economic Cooperation/APEC). This system provides the knowledge and skills for the younger generation to drive the economic growth and prosperity of the country. In order to achieve high aspirations in an environment of global competition, the Ministry of Education Malaysia plays a vital role in adapting the education system.

Thereby, the MoE restructured the higher education system to enable the process of education requires transformative approaches and strategies, so that prepare the younger generation to have the skills for the needed in the 21st century. Consequently, efforts are made to understand the transformation of the educational environment and to reach a dynamic T&L process. In pursuit of these desires, the Malaysian government unveiled the National Education Blueprint. This provides a comprehensive development framework for the transformation of education systems to be rebooted and be well established by 2025 (Ministry of Education, 2013). The demand for online learning is growing rapidly. These phenomena have revolutionized the construction of knowledge.

On the one hand, collaborative learning creates an environment that provides an opportunity to collect others' views. It is a social interaction that involves a community of students and teachers, where members acquire and share experience or knowledge. Furthermore, it can also enhance students' understanding (Teo and Chai, 2009). The collaborative learning environment enables students to achieve basic skills. Students learn and construct knowledge through group interaction (Puntambekar, 2006). Dillenbourg *et al.* (1996) emphasized two paradigms of collaborative learning:

- Conditions (group composition such as group size, gender distribution, prior knowledge; task structure, context, communication medium)
- Interactions (related to the conditions of learning and learning outcomes) (method: elaboration, explanation, control, socio-cognitive conflict, negotiation and argumentation)

Bromme, Hesse and Spada (2005) argued that there are three important 'barriers' or 'discontinuities' (see Table 2.5), which groups have to address in order to succeed in such collaborative learning interaction:

1) Meaning and meaning-making barriers, consisting of three classifications of gaps:
    - 'common ground gap' – the ways each participant understands the idea or interaction
    - 'epistemic ' gap - the gap between the knowledge or competencies of each participant
    - 'sharing knowledge' gap – arising from 'shared' and 'unshared' knowledge
2) Motivational barriers

- Gaps between the levels of motivation of different participants in a group or between the different levels of motivation of the same group at different times

3) Social structure barriers

- Gaps between different formations of participation and interaction of the group

Table 2.5 : Three basic discontinuities in knowledge communication (Source: Bromme, Hesse and Spada 2005)

Meaning of discontinuities	Social structure of discontinuities	Motivational of discontinuities
The individual and mutual construction of meaning and the exchange of information in groups: • Common ground barrier • The epistemic barrier • Unshared knowledge barrier	The establishment and maintenance of structure (social order) in social interaction.	The establishment and maintenance of motivation to cooperate and communicate.

Thus, an overview of the challenges of this study in knowledge communication is how interaction paradigms can reboot knowledge construction for engineering students in the TVET or engineering field.

Communication has also been associated with interaction that enables meaning-making to take place in learning courses (Sharma and Anderson, 2009; Tubbs, 1995). Students after the interaction would give feedback to reflect on their learning discussion, and the learning sharing experience is constructed through face-to-face (F2F) and online learning environment (So and Bonk, 2010, Palloff and Pratt, 1999). The challenge is how to address problems for students to have effective peer-to-peer interaction to achieve a high quality of knowledge construction.

The collaborative learning environment involves the joint construction of meaning through interaction with others (Law and Wong, 2003). Students can create and share information, practice critical reflection, negotiate meaning, and build a consensus in online learning communities. Zhu (2012) claimed that collaborative written assignments, group discussions, debates, and arguments can enhance students' knowledge construction through online collaboration. Nonetheless, this study views collaborative learning as an environment that allow students to have two-way interaction to achieve learning goals. Hence, the importance of the evolution of collaborative learning in 21st century educational environments, particularly in TVETs, cannot be understated.

In order to sustain collaborative knowledge construction, it is stressed that online learning should be accompanied with critical thinking to aid students' readiness for working life. It also saves students' time, while enabling them to acquire knowledge in breadth and depth in their social collaborative online learning environment. Thus, CSCL environment come into being to address engineering students' problems of not knowing how to work together in knowledge construction. In addition, the CSCL approach would replace the collaborative learning approach if it is effective for engineering students. However, interactions in CSCL take place mostly outside of the formal classroom environment.

Students attend a F2F classroom with internet-enabled digital devices, including in TVETs. This may bring distraction and isolation for student learning, although it provides F2F engagement opportunities (Matthew, 2012). These tools should be fully taken advantage of to maximize F2F engagement in active learning towards knowledge construction, helping students interact with other students and teachers in their rich technology learning environment. This is not a new issue, and the challenge remains of maintaining attention and managing distractions in such a learning environment.

In the 21st century, there are different types of learning environment, subject to technological distractions beyond the teacher's or instructor's control. They can bring about distraction impacts, such as failures in pedagogy. Matthew (2012) emphasizes that students' main learning experiences are listening, observing, and taking notes. The challenge from distractions is to find the best way to engage students in effectively constructing knowledge in modern learning environments, since they use technology extensively (JISC, 2009). Thus, we need to seek the most appropriate pedagogy for the student's role of being responsible for their own active learning, thereby sharpening their learning experience and supporting knowledge construction

CSCL may be a new approach in T&L for maximizing student engagement in active learning towards knowledge construction and effective practice in a digital or widget world. It is also technology that can enhance learning and teaching.

Computers and networks have the potential to create knowledge exchange. Meanwhile, they have become knowledge enablers through communication. People communicate via email, groupware, and the internet, using computers and networks to show that they can share knowledge from a certain distance. Desktop video conferencing and multimedia computing deliver sound and video, as well as text, making it easy to communicate knowledge from one person to another. Davenport and Prusak (2000) argue that technology is only for the exchange of knowledge. It cannot construct knowledge, even though it expands or shares knowledge, if there are no activities to enable construction.

Cobos and Pifarre (2008) suggested that self-regulated strategic activities are formed when students interact with CSCL, bringing about metacognitive learning. These activities help students to promote deeper learning, such as increasing their desire to understand the learning materials, interacting critically within a learning context, logical thinking, creating new ideas, debating and arguing on certain subjects, sharing knowledge, and discussing ideas with peers.

Students collaborate with anyone at any time and place. Gadget or widget technology provides the flexibility of time and space, although students miss out on F2F interaction in online learning (Lemke, Coughlin and Reifsneider, 2009). In addition, there is emerging evidence that CSCL benefits students in the development of higher-order thinking skills and student satisfaction (Resta and Laferriere, 2007).

Due to time and resource constraints in T&L for lecturers, online learning environment should be promoted. Nowadays, the gadget or widget world accommodates learning environments for the new generation of engineering students. The learning patterns in such situations contradict conventional collaborative learning. There is very little evidence yet to prove its effectiveness at construct engineering knowledge into higher levels. Furthermore, the way an instructor guides and supports the engineering students in an online environment is significant. Students engage themselves in the learning course and make their own meaning through the learning environment. Cobos and Pifarre (2008) revealed that collaborative knowledge construction can be achieved online. It can enrich the effectiveness of students' knowledge construction via online learning approaches. Thus, the importance of online CSCL learning environment should not be neglected in the construction of knowledge. This element would be discussed in the next section.

2.9 Computer-Supported Collaborative Learning (CSCL) in Online Learning

In e-learning, different approaches are utilized to deliver lessons to students. This enables students to leave the F2F and 'one content fits all' approaches in T&L. However, due to the lack of integrated applications of e-learning in practice and skills with social cultural issues, it has become blended learning. Blended learning uses both F2F and e-learning in classroom activities (Kahiigi *et al.*, 2008). Mbendera, Kanjo and Sun (2010) asserted that learning is a behavior and a social practice, as well as meaningful for knowledge construction.

E-learning is also known as online learning. It has become famous in the United States in higher education contexts (Allen and Seaman, 2014; Cobb, 2009). This has given rise to a high demand for online courses at an unpredictable rate (Koohang *et al.*, 2014). Allen and Seaman's (2014) report on online learning has shown that:

- 7.1 million students in higher education have taken more than one online course
- A growth rate of 6.1 %, accounting for more than 400,000 students taking online courses
- Growth in online learning outcomes from 57 % in 2003 to 74 % in 2013, equivalent to F2F instruction

Tu and Corry (2001) stated that online learning has not yet been well defined or well examined, despite becoming a vital learning environment. There are four elements to online learning: (1) CoP, (2) collaborative learning, (3) social presence, and (4) knowledge construction in an online learning community.

Balakrishnan (2014) mentioned that the benefit of online CSCL is build the teamwork characteristic, indeed, it is needed in the engineering profession field. Furthermore, it can provide students engagement and enrich the learning process. It is vital that knowledge construction can be achieved through online learning. Mbendera, Kanjo and Sun (2010) reported that most online learning platforms are not student-driven, because the conventional ‘one content fits all’ approach is adopted.

Online learning may present information and support active learning with feedback and discourse, with the support of new applications of learning (Mayes and Fowler, 1999). Nevertheless, it does not fulfill its potential for personalized knowledge construction. Kahiigi *et al*. (2008) claimed that personal learning is a learning approach to facilitate and support individual learning, where each student has a learning path that can meet their needs and interests in a productive and meaningful manner.

In this online learning environment, personalized knowledge construction has become a vital issue. Learning is subjective because each student has different learning goals. Thus, the content of a course needs to be modified according to students’ needs and their expectations for effective learning. The instructor designs content to be in line with the pedagogy of the course, and arranges access online, according to the sequence of the content (Mbendera, Kanjo and Sun, 2010).

Macdonald (2003) coined that the pedagogical advantages of online CSCL are (a) support students flexibility in learning at any time and any place towards knowledge construction, (b) influence students be active learner and (c) attract and motivate students have confidence to do the task in order to achieve competence.

Crucially, students do not have the ability to select course content in the online learning approach. They may not have a strong background on the subject matter. Hence, they need guidance and assistance to learn online. On the one hand, those who have a good background related to the online course content have more flexibility to pull the exact content that they need. The related issue is how to clearly display the sequence of the course content for students, who may then determine the use of personalized knowledge construction (Mbendera, Kanjo and Sun, 2010).

Online T&L have recently been developing gradually in higher education. These circumstances have brought challenges to educators related to technology and pedagogy. Online learning is reflective of the processes that students take part in during the practice. In this epistemic-engagement view, online environment can encourage knowledge construction through social interaction and discussion through asynchronous communication (Shea and Bidjerano, 2009).

Online learning is a form of transforming education in higher education (Gao, Wang and Sun 2009). It can support student learning in SLEs and is also different from conventional classroom discussion (Joeng, 2003). It uses internet and technology tools in a new educational concept. It transfers digital content and provides a learner-oriented environment for teachers and students. It gives an opportunity for students who want to continue their education, and benefits them in the same way as F2F communication with teachers. The online learning environment involves formal and informal information for different needs (Haghparast, Hanum and Noorhidawati Abdullah, 2013).

There are two main educational online learning approaches, such as synchronous and asynchronous learning. Synchronous learning refers to the form of learning in which students attend classes where they can interact with each other in real-time. Asynchronous learning, on the other hand, permits students to interact at different times. Both are supported by online tools such as email, Skype, You Tube, blogs, discussion forums, and web-based courses which can include i-books, e-books, and e-assignments.

Web-based asynchronous learning environments (WALE) have become vastly popular for instructional purposes (Holmes, 2005). A constructivist instructional approach is the main stream in WALE (Jonassen, 2000; Tam, 2000). It can transform learning into an active learning environment. It constructs knowledge by posing certain forms of questions and examples of real cases, such as videos or episode dialogues for metacognitive activities. Mayes (2001) points out that students are more interested in an environment of constructivist learning. Educational research has shown that more effective learning takes place if students are actively involved, rather than being passive listeners (Nurmela *et al.*, 2003).

Gunawardena, Lowe and Anderson (1997) (Figure 2.3) proposed an interaction analysis model for examining the social construction of knowledge in online discussions. They identified classification of knowledge through student feedback such as sharing or comparing information at “reflection” stage; discovery and exploration of dissonance or inconsistency among ideas, concepts or statements at “private world” stage; meaning negotiation or co-construction of knowledge at “discourse” stage; testing and modification of proposed synthesis or co-construction and agreement statement(s), or application of newly constructed meaning at “shared world” stage.

Akin, Pena-Shaff and Nicholls (2004) developed instruments for question, reply, clarification, and reflection to capture the knowledge construction processes. Researchers have developed some ways to promote the level of social knowledge construction in online discussions. Lebaron and Miller (2005) reported that each participant has a different role, which can affect online discussion activities and help to encourage the construction of knowledge in online learning environments.

Gilbert and Dabbagh (2005) discovered that explicit instructor guidelines and evaluation rubrics have had a positive impact on the online construction of knowledge. Rourke and Anderson (2002) studied the effects of asking students to lead discussions. Students perceived these discussions led by their peers as more structured, more fluid, more responsive, and more interesting than those led by the instructor, even though there was little difference in the quality of discussion.

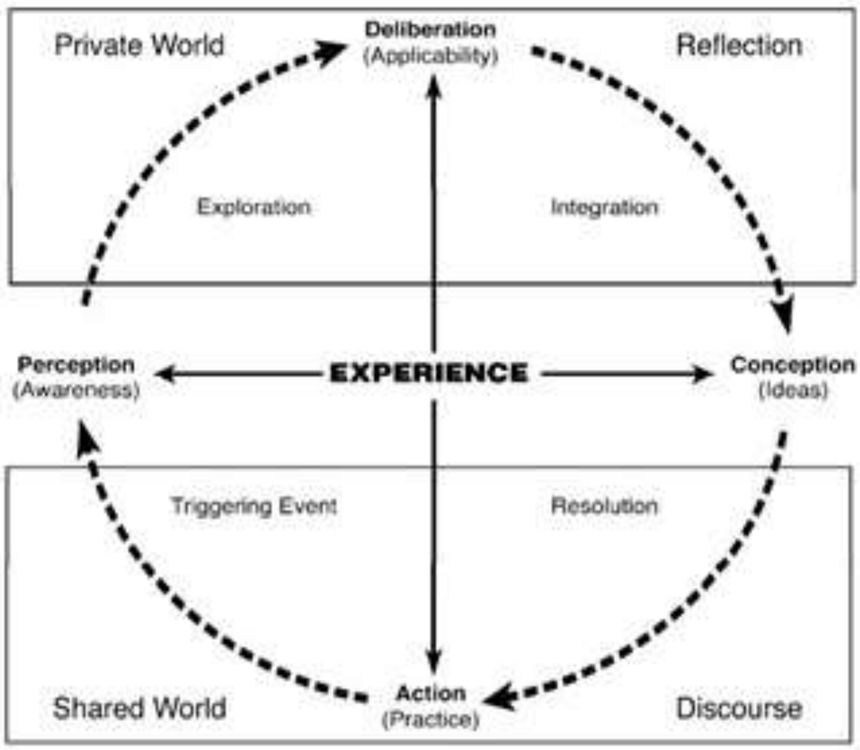


Figure 2.3 Practical Inquiry Model
(Source: Gunawardena, Lowe and Anderson, 1997)

Student discussion is the main feature of interactive online learning environment. Discourse among peers is an important interaction to promote the learning (Cunningham, 1992). Instructors stress interaction within the course, ease of interaction, and classroom dynamics. These are the factors that may affect online learning environments (Campbell, Richardson and Swain, 2005).

While online learning environments claim to enrich students' knowledge construction and collaborative learning (Mcloughlin and Luca, 2011), several researchers have asked whether peer-to-peer interaction leads to measurable learning outcomes (McConnell and Banck, 1998; Hammond, 1999; Hara, Bonk and Angeli, 2000; McKinnon and Aylward, 2000). It means that quality of discourse between peers carried out the productivity of learning outcomes in order to achieve knowledge construction. Online learning environments lead to sustainable collaborative learning by sharing views, resources and ideas through peer support. The features are supportive of collaborative discourse, and encourage students to participate in group learning (Mcloughlin and Luca, 2011).

Based on this, a learning society is the vehicle through which learning occurs online, being the interrelation and interaction of students through which knowledge is constructed (Palloff and Pratt,1999). Several researches have shown that instructor feedback and discussion of peer feedback allows students to foster friendship. They learn as well as scaffold their current knowledge and co-construct ideas from other peers (Roehler and Cantlon, 1997).

Discussion without guidance or feedback can be ineffective and inefficient, so significant time is needed to provide feedback on students' postings (Campbell, Richardson and Swain, 2005). Thus, it is timely for researchers to begin to explore how to apply online social collaborative learning (SCL) environment effectively. Meanwhile, it can also motivate engineering students to foster their potential through online learning environment such as those AOD.

According to a number of studies on online learning (Hill, Song, and West, 2009; Tallent-Runnels *et al*., 2006; De Wever *et al.*, 2006), there are three aspects of online discussion: cognitive processes, argumentation, and social knowledge construction to promote productive online discussions. The researcher designs specific discussion environments to enhance the level of knowledge construction in online discussions. The rationale is that a specific type of post will support engineering students' metacognitive thinking (Scardamalia and Bereiter, 1994). It assists them to engage in knowledge construction.

The important issues are how to engage engineering students in meaningful learning through productive online discussions, how to engage them with other peers in online environments, and how to structure the learning environment to promote high-quality discussion that engages students with higher levels of knowledge construction.

De Wever *et al.* (2009) found that giving a role to the students taking part in the asynchronous online discussions (AOD) led to more complex thinking. Furthermore, it produced more interactive learning activities for students' knowledge construction. Computer-supported collaborative learning can be used for deep learning (Van der Linden and Renshaw, 2001), which may occur in the process of knowledge construction. CSCL environment has traditionally lacked social interaction (Kreijns, Kirschner and Jochems, 2003). Particularly, students need more interaction and collaboration, which are the main challenges facing CSCL (Dillenbourg *et al*., 1996). Hence, social media technologies have emerged to address these issues, and be discussed next sub-topic.

2.10 Social Media Technologies Affecting Social Learning

The revolution of the World Wide Web, or Web 2.0 or social media technology), has opened up new social learning for the education environment (Dias and Diniz, 2014). This brought challenges and opportunities for teachers/lecturers/instructors and students in T&L scenarios, particularly in the TVET and engineering field. Nowadays, information and computerized social media affect engineering students' learning environment. They have brought changes rapidly in enhancing the knowledge construction processes for students. SMTs can help to bridge different knowledge construction levels. Pettenati (2007) claimed that innovation in SMT has brought about new social learning in the knowledge construction process.

Moreover, social media technologies (Web 2.0) such as Skype, Facebook, Twitter, YouTube, Instagram, Weblogs, WhatsApp, We Chat and Line produce collaborative knowledge construction (Ching and Hsu, 2011) and knowledge construction can be achieved with online learning (Zhu, 2012). Students interact and collaborate in knowledge construction through online (Lim, 2009) and LGC in engineering. This can facilitate the construction of knowledge and enhance the learning process (Torres and Guerrero, 2013). These are significantly vital in the teaching and learning scenario for students' knowledge construction. However, is the challenge providing a high quality of T&L in the classroom with engineering students? The effectiveness of students' learning and construction of knowledge need to be investigated (O'Neill, Geoghegan and Petersen, 2013).

Technology has encouraged students to be involved in active learning, providing interaction and discourse opportunities to students (Jonassen *et al.*, 1995). Knowledge construction is a social and discourse process (Pea, 1993). It also consists of the exchange of new ideas and constructing new knowledge through meaning negotiation (Solomon, 1993). It affects students' level of knowledge construction, including engineering students in TVETs or universities.

Prensky (2001) revealed, "*...Students are not anymore the people our educational system was designed to teach because of social media technology...*" SMT, therefore, helps to support engineering students in a more efficient way in their knowledge construction. They have also led facilitators towards more collaborative T&L in social learning (Ebner, 2009). The rationale of utilizing SMT in T&L is related to the conventional face-to-face instructional approach.

The increased use of SMT in today's society is integrated with online technology. It may bring many challenges to the educational systems. The availability of SMT has impacted the learning setting, as students have the opportunity to design their learning (Ebner, 2009). The important roles of SMTs are to support learning and enhance knowledge construction processes. However, research on the effect of SMTs on engineering students' level of knowledge construction has been limited in TVETs.

Ebner (2009) mentioned that T&L are related to social processes, and occur between people; facilitators interacting with students, and peers interacting with other peers. Since SMTs can significantly change engineering students' knowledge construction processes, a new way of interaction takes place between students and computers.

However, it has not been much used in TVETs or the engineering field. Scardamalia and Bereiter (1994) stressed that socially constructed knowledge requires intention. Scardamalia (2002) suggests that without an intentional goal or the creation of new learning, a collaborative environment fosters 'shallow constructivism', where the focus shifts to activity rather than knowledge construction.

Constructivism has begun to influence the design of technologically mediated learning environments. Jonassen (1994) pointed out that thinking involves perception and social experiences. Constructivists also believe that reality is shared through the process of social negotiation. He revealed that the implementation of constructivism in instructional design aiming for knowledge construction can be facilitated by learning environments which (a) provide multiple representations of reality phenomena in the real world, (b) focus on knowledge construction and not reproduction, (c) provide real world case-based learning environments, (d) cultivate reflective practice, (e) enable context and content dependent knowledge construction, and (f) support the collaborative construction of knowledge through social negotiation. Thus, SMT learning environments may promote collaborative learning, involving the active construction of knowledge through social negotiation. The development of social presence and a sense of an online community lead to the promotion of collaborative learning and knowledge construction. The issue here is SMTs are influence in T&L particularly TVET since Malaysia's National Education System has been tremendous changed and transformation (Hamdan *et al.*, 2015).

Students can reinforce their learning through social-cultural learning environments, as stated in Vygotsky's ZPD (Land and Hannafin, 2000). Raymond (2000) claims that the Les Vygotsky's sociocultural theory related to students' learning occurs when they participate in socially or culturally embedded experiences. From Vygotsky' perspective, students learn through social interaction. Engineering knowledge is constructed within social contexts, through interaction with a knowledgeable society to produce high-quality learning outcomes. Engineering students should learn about knowledge construction for the lessons to be more meaningful and instructive, and for them to be proficient in other skills such as competence, meta-competence and expertise in the engineering field to succeed in their professional vocation (Van Der Stuyf, 2002). Hence, the SCL environment is presented in online learning for engineering students.

Moreover, the impact of SMTs has led to the ability to obtain information easily through the internet, as well as connect with other people to find out what they have to say on an issue. There are various common forms through which we interact, such as social media sites like blogs for posting comments, social networks like Skype, Facebook or Instagram for making friends, social news Digg, Propeller for voting on articles and wikis, You Tube, Wikipedia, and Wikia for sharing information, all of which can be used for constructing engineering knowledge among engineering students.

Levy (1997) even revealed technology itself as an actor in the collaborative process. He sees technology as an instrument and integral component of the cognitive process when people collaborate in a technological environment. As noted by Leonardi (2007) the informational capabilities of information technology in organizations, SMT have application potential as tools for users in constructing knowledge. The underlying concepts of SMT involve the architecture of participation, collaborative knowledge construction, and networks as a platform. SMT tools can lead to learning improvement, students' knowledge sharing, and knowledge construction (Walker, 2005).

Meanwhile, SMT permits engineering students' discourse and interaction, either synchronously or asynchronously in SLE. Asynchronous interaction permits students and instructors to interact with each other, allowing them to exchange ideas. Students can review posted information and consider their own ideas before responding, because they are not required to respond promptly. Furthermore, online discourse is text-based. It has the potential to strengthen writing skills and encourage acquisition of new knowledge (Pena-Shaff and Nicholls, 2004).

Nevertheless, the researcher has to focus on analyzing the content of messages and the patterns of interaction. The researchers studies whether SMT encourages the process of knowledge construction. As an educator, he or she needs to be able to evaluate the quality of interaction and learning in SLE. Thus, it is timely for researchers to explore how to conduct online learning environments.

Additionally, with the steady growth of bandwidth, the mode of SMT interaction and LGC in engineering are increasingly multimodal, evidence by platforms such as YouTube. SMT is an online learning platform or a tool for collaborative knowledge construction and multimodal communication. Hence, to derive greater benefits in knowledge construction, issues related to course learning outcomes should be ironed out. How does SMT facilitate knowledge construction and more interactive constructivist learning environments in terms of engage and enhance engineering students’ academic achievement?

Moreover, the use of multiple teaching techniques, such as information communication technology (ICT) can support online learning environments. More powerful and effective active learning tools can be created for students to develop engineering knowledge construction. On the application of online T&L, the SMT is an important foundation for peer-to-peer learning. Instructors have also been changing the ways of interacting with engineering students in T&L. Thus, SMT plays a vital role for students' knowledge construction.

2.11 Social Learning Environment

Dias and Diniz (2014) revealed that educational paradigm shift from conventional to online environments in higher education. Learning activities can be done through ICT which is emphasized in the National Higher Education Strategic Plan (NHESP) of Malaysia 2007–2010 (Grapragasem, Krishnan, and Mansor, 2014). This includes delivery style of T&L that needs effective delivery system via ICT, whereby it becomes vital for students gather information and knowledge acquisition towards knowledge construction. It is seen as a challenge for students to engage in active learning and think in different ways. Furthermore, learner-centered web instruction for higher-order thinking, teamwork, and apprenticeships can appear in the engineering classroom of metacognitive activity among engineering students, particularly in the TVET.

Working together whilst accomplishing a task in SCLs can facilitate active construction of knowledge (Van Merrienboer and Paas, 2003). Studies have found that students in collaborative learning conditions had a more constructive learning process (Eichler, 2003). Wenger (1998, 2000, 2007) coined the phrase CoP, which he defines as “*...groups of people who share a concern or a passion for something they do and learn to do it better as they interact regularly…*”

In today's SLE, people learn through group activities and interaction in online environments, and resolve their problems. This is known as an online learning community (Tu and Corry, 2001). It means that people learn to solve problems together through an online environment in which they share information. Nevertheless, how people apply the proper information for knowledge construction is more vital than simply obtaining information. In other words, knowledge construction in SCL needs to be emphasized, rather than just focusing on sharing information or knowledge via learning together (Tu and Corry, 2001).

However, the key issue is how people can interact effectively and have a social presence via online learning that foments knowledge construction. Tu and Corry (2001) mentioned online learning migration from social learning to social presence. This may affect students' level of knowledge construction. Thus, it is necessary to understand perceptions of communication and interaction in the learning (Rourke *et al.*, 2001).

Eventually, F2F communication may prove conducive to social interaction, particularly for knowledge sharing. However, intensive social interaction also provides changes for learning and social knowledge construction through discourse. There is important sharing of knowledge that comes from social interaction environment. Social interaction influences knowledge sharing within the social learning environment. Although the importance of social interaction for sharing knowledge is generally accepted, the main element that affects communication is that knowledge flows, and is not social interaction, as argued by Noorderhaven and Harzing (2008).

In order to successfully develop a SCL environment, there is a need for a constructivist classroom approach consisting of social processes and the use of tools for students' knowledge construction (Mcloughlin and Luca, 2011). Social constructivists such as Weinberger *et al.* (2005), Pena-Shaff and Nicholis (2004), Veldhuis-Diermanse (2002), Veerman and Veldhuis-diermanse (2001), Gunawardena, Lowe and Anderson (1997), Zhu (1996) and Newman, Webb and Cochrane (1995) emphasized the use of tools in which language and technologies can deepen insight of thought and metacognitive activities in T&L. There has been some research on SLE becoming a form of social metacognitive experience (Reio and Crim, 2013). However, there may be some views critical of this and the benefits of SLE.

Social interaction is a precondition for collaboration and collaborative learning to construct knowledge. CSCL environment can be identified by their paradigms, such as social construction of knowledge. Learning is a social process which proceeds through conversation (Holzinger, 2002). Ebner (2009) stated that learning occurs when students give prompt or immediate feedback. This study views CSCL as consisting of social interaction, which needs efficiency and effectiveness in communication in collaborative learning. Gadanidis, Hoogland and Hughes (2008) stated that teaching and learning occurs in SLE, such as websites with dynamic reading and writing environments, where students interact and co-generate content and experiences. In the next section, the researcher emphasizes social collaborative learning (SCL) taking place in the social learning environment.

2.12 Social Collaborative Learning (SCL) Environment

According to Popescu (2014), the SCL environment means collaborative learning supported by social media technologies. Social collaborative learning (SCL) environments, such as collaborative mobile learning (CmL) (DeWitt, Siraj and Alias, 2014), game-based learning (Bellotti *et al.*, 2014), and blended learning (b-learning) (Jormanainen and Sutinen, 2014), form the 21st century learning environment for students. Likewise, TVET in Malaysia also involves such of pedagogical innovation (Hamdan *et al.*, 2015). Jormanainen and Sutinen (2014) mentioned that effective learning environments provide open and flexible support for students' learning itineraries.

On the other hand, openness and flexibility are vital elements in b-learning. There is imperative to create more comprehensive blended structure design (for instance based on techno-pedagogy skills) to support the environment, rather than maintaining the T&L process (Bates and Sangre, 2011; Sarirete, Chikh and Berkani, 2008). Nonetheless, how can teaching work in the domain of knowledge construction for engineering students and be efficiently produced? It must be aligned with learning outcomes and pedagogical challenges. Simultaneously, there is a burden on the teacher, who needs to organize the learning settings and continuously monitor students' activities in the SCL environment (Popescu, 2014).

Learning is a process consisting of collaborative learning, where teachers and students are partners in constructing knowledge (Conrad and Donaldson, 2010). According to Dillenbourg, Jarvela and Fischer (2009), collaborative learning comprises of interactions among peers, and is the most important factor in the learning process. Smith and MacGregor (1992) reveal that this means two or more students working in a group seeking to understand the task and finding a solution or creating a product, thereby making learning meaningful. Students can be actively involved in the learning process, through discussions with peers, exchange of points of view, raising doubts, and giving feedback. The social nature of learning is based on reflecting on the problem (Smith and MacGregor, 1992).

Learning mechanisms are based on interactions among peers. Thus, the collaborative learning environment should be conducive to student learning (Dillenbourg, 1996). There is imperative to provide a shared workplace for students for interaction and learning (Li *et al.*, 2008). Nevertheless, it is important for learning to utilize social media technologies, which should be integrated into an SCL environment in order to lead students more engagement in the active construction of knowledge through social negotiation. Knowledge and skills need to be injected in knowledge construction. Within the context of an SCL study, how does the SCL environment support and improve engineering students' knowledge construction in their learning process? In other words, the researcher has to consider how to implement the setting of online SCL environment in order to scaffold them gain a higher level of knowledge construction and perform quality results in their academic achievement.

The millennium generation in 21st era defines as modern students, who have different patterns of work and attention and learning preferences (Vassileva, 2008). They have grown up with different technologies (Tapscott, 2008; Prensky, 2001). The assumption is that students used to think, act and learn with different technologies in daily life (Valtonen, 2011). In other words, technology has become a part of their life. This causes the instructor needs to design T&L environments appropriate for constructing engineering students' level of knowledge.

There is an assumption that the next generation students are ready to work together, particularly in different online environments (Oblinger and Oblinger, 2005; Hartman, Dziuban and Brophy-Ellison, 2007). It is also known that in society, there are various SMTs that can support students' online collaborative learning and F2F teaching situations (Cress and Kimmerle, 2008; Dron, 2007; Ferdig, 2007; Alexander, 2006). It is assumed that students are able to learn well in collaborative learning with ICT (Stahl, 2003; Harasim, 2000). However, there are challenges to collaborative learning in real social online environments. Teachers in the classroom may face problems, such as how many groups of students can work in a team for projects.

In fact, the SMT phenomenon brings a new opportunity for the development of environmental education (Dias and Diniz, 2014). This has caused an education paradigm shift, from conventional environments to the online environment, particularly in Malaysian higher education. It is a challenge to create an active learning environment where students have the opportunity to be involved and think in different ways (Bonk and Reynolds, 1997). Likewise, the issue is also faced by those involved in engineering classes.

In b-learning, which consists of F2F and online learning, Learning Management Systems (LMSs) can be integrated with collaboration and interactive learning activities (Dias and Diniz, 2014). Kenny and Pahl (2009) claimed that in an active learning approach, learning is related to the acquisition of knowledge and skills training. Thus, students would achieve better learning achievement in test and higher levels of satisfaction if they are adequately trained for the effective use of LMS (Dias and Diniz, 2014). However, it requires teachers' and students' commitment in the engineering classroom in order to be optimized in T&L scenarios. Simultaneously, optimal feedback (reflection) from students can engage and enrich students' learning processes towards knowledge construction. There is therefore, an issue on how to use digital or SMT optimally integrated with a social learning environment in b-learning to enhance students' knowledge construction. Thus, there is imperative for scaffolding in such learning environments, which be discussed in the next topic.

2.13 Issues of Scaffolding in Online Learning

The developments in ICT of this century have brought about a close human-technology relationship that makes learning environments for students more effective (Zuniga and Shahin, 2015). Thus, much more needs to be known about the features of online learning before conducting instructional scaffolding on students' knowledge construction. Such research would allow for the promotion and improvement of students' engagement in construction of knowledge.

Using scaffolding is vital in teaching. Explicit instructional scaffolding needs to be implemented to help promote positive impacts on students' academic achievements, self-confidence, and self-regulation. Furthermore, it can upgrade engineering students' process of learning itinerary in order to achieve higher levels of knowledge construction. Nonetheless, the issue is how to use instructional scaffolding effectively in online learning environment?

There is variety of scaffolding. Scaffolding is undoubtedly a tool that can support teamwork, collaborative online learning, resource sharing, and knowledge construction (Lombardi, 2007). The question is how to select appropriate instructional scaffolding to benefit students when constructing their own knowledge. Meanwhile, students can be engaged in active learning in hybrid learning environments.

There is a wide range of classification for instructional scaffolding. Instructors are not properly trained to utilize scaffolding approaches in the engineering classroom. Thus, how can scaffolding in online learning environment towards knowledge construction be implemented? That such scaffolding is reportedly time-consuming is one factor that discourages instructors from using scaffolding when conducting a lesson (Van Der Stuyf, 2002).

In addition, several issues of instructional scaffolding in online learning need to be addressed. For instance, we must address how scaffolding can lead students to higher levels of knowledge construction (Rosenshine and Meister, 1992). How can instructional scaffolding be classified so as to provide quality support for engineering students in their process of knowledge construction?

Oshima *et al.* (2003) mentioned that computer-mediated scaffolding may improve learning. However, it may lack sufficient conditions to promote effective knowledge construction. In other words, each teammate has different perspectives and not working as team that cause failure in constructing knowledge as coined by Oshima *et al.* (2003). Moreover, it may limit the effectiveness of online communication when considering the use of appropriate scaffolding in online learning.

On the other hand, engineering students are encouraged to use online discussion to promote their learning process (Campbell, Richardson and Swain, 2005). However, students fail to use AOD to cognitively steer knowledge construction. The effective implementation of instructional scaffolding in online SCL environment is a crucial issue. Additionally, the researcher can see that there is a lack of instructional scaffolding in knowledge construction in engineering curricula. Certain aspects of scaffolding issues in SCL environment towards knowledge construction would be further discussed.

2.14 Issues of Scaffolding in Online Social Collaborative Learning Environment

Salmon (2004) mentioned that scaffolding for online learning comprises of five stages: (1) access and motivation, (2) online socialization, (3) exchange of information, (4) knowledge construction, and (5) development. There are immediacy, intimacy and responses in the scaffolding pathway. The online SCL environment is associated with collaborative learning and social learning environments. This would promote interaction between instructors and engineering students, as well as peer-to-peer interaction, to move forward and work with others in teaching and learning sessions, particularly in the engineering classroom. However, the issue is how can it cognitively steer engineering students in such online environment?

The online SCL environment, which consists of modern technology pedagogy in a scaffolding approach, includes four major cores: (1) the course content, (2) the coach (instructor or facilitator), (3) the students, and (4) the technology (Ibrahimi and Essaaidi, 2012; Sharma and Hannafin, 2007). Through online SCL, students may find inspiration, motivation, and improvement in the learning. Furthermore, it may bring about progress in engineering students' knowledge construction if the instructor uses such scaffolding in an online SCL environment. Can scaffolding be implemented to enhance engineering students' knowledge construction in a hybrid of collaborative learning and social learning?

Scaffolding in online SCL environment is a form of web-based learning that supports students' learning activities. In other words, it consists of collaboration with SMT, which is instructional scaffolding on internet-based applications (Popescu, 2014). Such learning environments provide students with some amount of information and engage them in learning activities, as well as guiding them in the learning process through scaffolding (Hannafin, Land and Oliver,1999; Jonassen *et al.*, 1999). It is a form of informal online learning. However, can it provide quality interaction between instructors and students, and between peers, in order to achieve higher levels of knowledge construction?

Zuniga and Shahin (2015) pointed out that digital technologies may transform and be integrated into our human society, possibly giving a positive impact to online social networks. They can be used more frequently to construct meaningful interactions in social life. For this reason, engineering students would be able to engage themselves in an online SCL environment. This may enable students to stay in touch with peers to construct their knowledge. They can gather, share, and update learning resources via the online SCL environment. Besides, this would bring positive influence to those participants in the online SCL. More ideas and opinions can be disseminated through SCL. Thus, the other issue is how engineering students can improve achievement when integrated with instructional scaffolding in online SCL environment.

Zuniga and Shahin (2015) mentioned of Katz and Gurevitch idea that four (4) main uses of media for motivation:

- Surveillance and information gathering
- Personal identity construction
- Social interaction
- Entertainment

The use of scaffolding in online SCL environment may help students to accomplish tasks normally beyond their ability. Instructional scaffolding can gradually be faded as students come to rely on it less. Thus, scaffolding is a temporary support that can be released when no longer needed, but reintroduced when necessary. There are different instructional scaffolding approaches and strategies, based on the needs of particular students. In order to obtain the benefits of knowledge construction, scaffolding can be carried out in a collaborative manner and in CSLE. However, there is insufficient knowledge on peer collaboration via computer.

There is a variety of instructional scaffolding approaches that may be employed in an online SCL environment. In modern pedagogy, the facilitator needs to understand the different classifications of scaffolding that can enhance the quality of instructor and engineering student interaction when used. This would be discussed in the next section. There are a variety of indirect instructional scaffolding techniques used to encourage engineering students' knowledge construction processes, such as questioning, hinting, and prompting. This may bring meaningful online learning engagement. Furthermore, it may improve engineering students' learning processes of knowledge construction.

2.15 Meta-Analysis: Classification of Scaffolding

Learning is based on prior acquisition of knowledge and skills. It is not a simple task process (Ilomaki *et al.*, 2003). Students have to actively construct their own knowledge with their different backgrounds, prior knowledge, and learning experiences in their learning itinerary (Gao, Baylor and Shen, 2005). Additionally, students frequently have various conflicting opinions before building on their existing knowledge. Students' existing knowledge plays an important role in understanding new knowledge (Chen and Bradshaw, 2007).

Some researchers view that students have low prior knowledge for higher knowledge construction in interactive scenarios, and they lack adequate knowledge to guide them through the process of knowledge construction (Moreno and Valdez, 2005). Hence, it is important to explore scaffolding approaches that can better facilitate or scaffold engineering students into higher knowledge construction.

Apparently, in order to make engineering courses more interesting and learning processes more engaging, instructional scaffolding needs to be implemented for engineering students' knowledge construction. Instructional scaffolding is not only used as a teaching strategy, but is also employed to support students towards higher levels of thinking (Rosenshine and Meister, 1992). Consequently, scaffolding knowledge plays an important role in cognitive apprenticeship (Collins, Brown and Newman, 1989). Likewise, Scardamalia and Bereiter (2003) claimed that there is a need of instructional scaffolding to prepare students for knowledge construction.

Nowadays, there is a transformative open learning environment to be employed for engineering students' knowledge construction and for higher student engagement in learning activities. Thus, instructional scaffolding should be integrated, particularly in online SCL environment. It can stimulate in students to more consistently reflect on their ideas and thoughts, and construct a coherent as well as robust conceptual understanding of the knowledge construction process. Moreover, this enables engineering students to experience metacognitive learning. It can also support students to tackle higher levels of thinking.

In this section, instructional scaffolding to build upon online SCL environment is analyzed. This provides some useful comparisons of different classification of scaffolding and scaffolding approaches in such a situation. Additionally, the researcher also analyzes the scaffolding approaches that support various learning outcomes in online learning. It can be used to support and improve engineering students' knowledge construction engagement. Fifteen (15) papers were selected, as shown in Table 2.6.

Table 2.6 : Classification of scaffolding and scaffolding approach which support learning outcomes

Author (Year)	Classification of Scaffolding	Scaffolding Approach	Support (Scaffold) a variety of Learning Outcomes
Hannafin, Land and Oliver (1999)	Conceptual Procedural Strategic Metacognitive	Open-ended learning	Not mentioned.
Hill and Hannafin (2001)	Conceptual Procedural Strategic Metacognitive	Resource-based learning	Not mentioned.
Way and Rowe (2008)	Conceptual Procedural Strategic Metacognitive	Digital resource-based learning environment	Learning object (such as number trains, finding the area of rectangles etc.)
Teo and Chai (2009)	Conceptual Procedural Strategic Metacognitive	Asynchronous Online discussion (AOD)	Collaborative critiquing
Tiantong and Teemungsai (2013)	Conceptual Procedural Strategic Metacognitive	Computer network (on Moodle LMS)	Collaborative problem-based learning
Belland, Kim and Hannafin (2013)	Not mentioned	Computer-based (Software programs)	Providing social interaction (promote belonging-encourage shared goal)
Dijk and Lazonder (2013)	Not mentioned	software-based tool (Online inquiry learning environment)	Improve students' interaction with learner-generated content (LGC) through searching information in peer-created concept maps
Sharma and Hannafin (2007)	Not mentioned	TELE (Technology enhanced learning environment	Provide interactions between expert (teacher) and novice (learner). Expert assists novice to perform well in a task. To support specific learning.
Li and Lim (2008)	Not mentioned	Instructional in online inquiry tasks: • Writing prompts • Argumentation template • Questioning • Modelling	Peer interacts to achieve a better performance
Hadwin and Winne (2001)	Tacit scaffolding Explicit scaffolding	CoNote2 software	Promoting self-regulation

Osman (2010)	Metacognitive scaffolds consists of: • Expert modelling on digital online video • Access to procedural • Self-assessment prompts • Collaborative interaction among teachers and students on a WebCT platform	Online learning	Students' understanding to solve physics problems
Wolf, Brush and Saye (2003)	Metacognitive	The Big Six information skills	To reinforce students information-seeking behaviour (ISB)
Chou and Hsiao (2010)	Visual Scaffolds: • Static scaffold • Interactive scaffold	Online reading	The two visual scaffolds effectively improve students' online reading for lower order cognitive process; the interactive scaffold can enhance students' lower and medium cognitive thinking.
Chen and Bradshaw (2007)	Scaffolding Strategies	Web-based learning environment: Question prompts • knowledge integration • problem solving	Students' conceptual knowledge
Saye and Brush (2002)	Hard scaffold Soft scaffold	Hypermedia/ multimedia learning environment	Supporting problem-based social Developing critical reasoning

2.15.1 Classification of Scaffolding versus Scaffolding Approach

There are two kinds of instructional scaffolding, namely online scaffolding and non-online scaffolding. There are two outcomes throughout this analysis retrieved from Table 2.6.

There is a wide range of classification of scaffolding. However, only four types of classification scaffolding (conceptual, procedural, strategic, and metacognitive) have been established since 1999 (founders Hannafin, Land and Oliver, 1999). Although similar instructional scaffolding is used, the scaffolding approaches in online learning environment are distinct. Moreover, technology can enhance the learning environment (Sharma and Hannafin, 2007). Teo and Chai (2011) share this opinion. Researchers have found that gathering, sharing and updating ideas and opinions are at the essence of student collaborative learning. Thus, the online SCL environment is a hybrid of collaborative learning and social learning environments.

In this study, "metacognitive" scaffolding is most preferred in online SCL environment to support a variety of learning in process of knowledge construction. Figure 2.4 summarizes the number and percentage of instructional scaffolding in online learning environment which is retrieved from Table 2.6. Any of classification is composed in the graph.

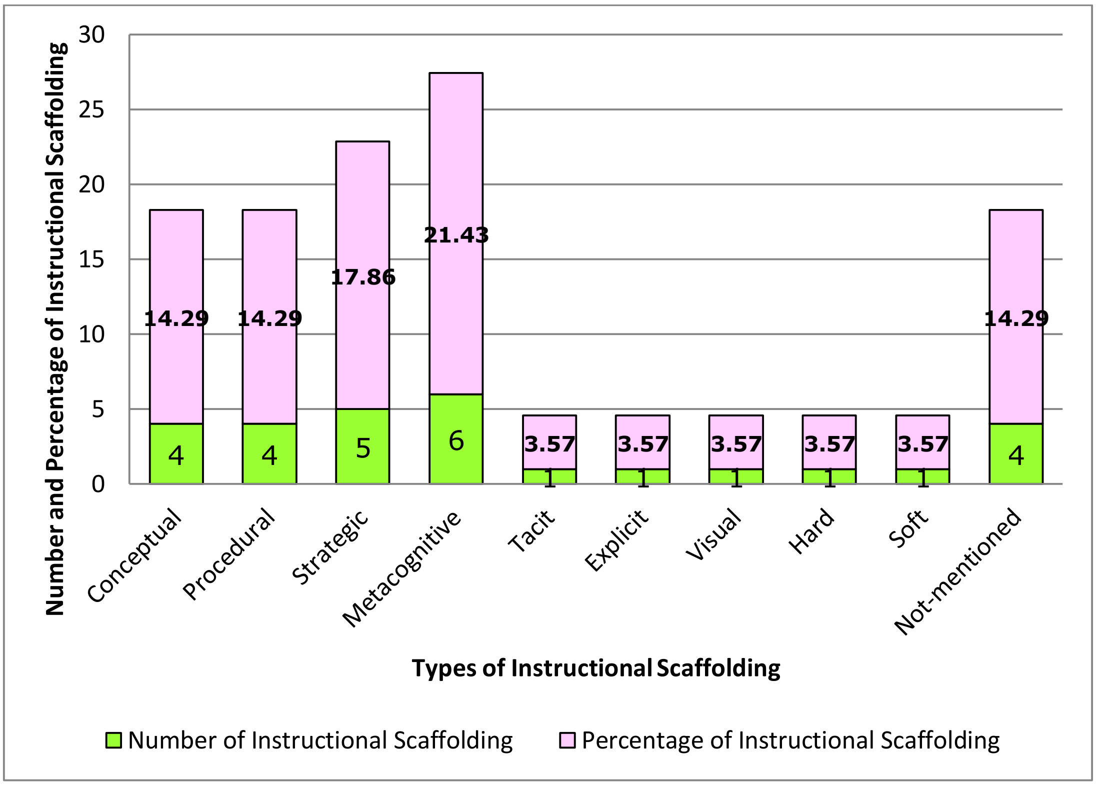


Figure 2.4 The findings of instructional scaffolding

On the other hand, non-online scaffolding has a variety of approaches towards cognitively steering engineering students' knowledge construction. There are software-based scaffoldings (Belland, Kim and Hannafin, 2013; Dijk and Lazonder, 2013; Sharma and Hannafin, 2007; Li and Lim, 2008 and Hadwin and Winne, 2001). These can affect the efficiency of students' knowledge construction.

Hill and Hannafin (2001) assert that the four classifications of scaffolding address the problems of "not knowing the issues to be discussed" and "not knowing how to discuss them". These four classifications of scaffolding can support student learning through resource-based learning.

These instructional scaffolding approaches are for constructing knowledge in the online learning environment (Teo and Chai, 2009). The next section explains the importance of scaffolding approaches for supporting students' variety of learning outcomes, particularly engineering knowledge construction engagement through online SCL environment.

In conclusion, different classifications of scaffolding may need different scaffolding approaches, such as software-based tools (standalone software), web-based tools (internet application for instance: Moodle LMS, CIDOS LMS, AOD, blogs, Wikis and social network sites (SNS) and virtual learning objects (3D animation cartoon and avatars).

2.15.2 Scaffolding Approach Support a Variety of Learning Outcomes

Subsequent study focusses on the variety of scaffolding approaches that can support a variety of learning outcomes. Studies from 2006 to 2013 reflect on the related scaffolding interaction:

- To provide social interaction (Belland, Kim and Hannafin, 2013).
- Learner-generated content (LGC) through searching for information with peer-to-peer created concept maps (Dijk and Lazonder, 2013)
- To provide interaction between expert (instructor) and novice (students) (Santoso, 2010; Sharma and Hannafin, 2007).
- To provide peer-to-peer interaction to achieve better achievement and learning outcomes (Santoso, 2010; Li and Lim, 2008).

To some people ideas, the use of scaffolding approaches in the online learning environment may be problematic, due to system breakdowns or power failure to optimum engineering students to construct their knowledge. The facilitator or instructor uses a different form of scaffolding approach, producing different learning outcomes for engineering students.

Regarding Table 2.6, hypermedia learning environment can support students in answering problem-solving questions by providing proper information through online learning (Osman, 2010; Saye and Brush, 2007; Wolf, Brush and Saye, 2002). This could encourage engineering students learn to complete the task given by the instructor. Saye and Brush (2002) revealed that hard and soft scaffolds would exist in a hypermedia/multimedia-supported learning environment.

Meanwhile, the use of an appropriate scaffolding approach can effectively improve and enhance students' cognitive thinking (Chou and Hsiao, 2010) and conceptual knowledge (Chen and Bradshaw, 2007). Some studies have shown that scaffolding facilities can encourage engineering students to be involved in peer interaction, either face-to-face, online; or both. They would be more motivated and stimulated in the learning process (Johnson, Johnson and Smith, 1998; Springer, Stanne and Donovan, 1999). Eventually, they also engage engineering students to accelerate their knowledge construction (Van Der Stuyf, 2002).

Overall, different classifications of scaffolding may be adapted to different needs of engineering students. Hence, instructors should supply different classifications of scaffolding for all engineering students at all levels. Thus, it is important to have a flexible and feasible design in online SCL learning environment to assist engineering students to continuously construct knowledge. Besides, it may also affect engineering students' active learning and construction of knowledge. They can construct knowledge by understanding, acquisition, generation, analysis and manipulation of information through SCL environment. Furthermore, due to teamwork in learning enable them to have multiple perspectives by social interactions with the instructor or other peers in SCL environment with instructional scaffolding support.

This study shows that, in meta-analysis of classification of scaffolding and scaffolding approach, instructors need to be able to use appropriate instructional scaffolding and tap their potential for engineering students' knowledge construction. This instructional scaffolding allows instructors to gradually withdraw their direct instruction.

2.16 Summary

Overall, in this chapter discussed the issues of knowledge construction occur in engineering field, variety of issues and challenges about CL, online CSCL and social learning comprises SMT as well as SCL.

Active learning emerges when the engineering students active participate in metacognitive learning activities, rather than passive learning (such as lectures or reading). The instructor needs to further enhance students' knowledge construction level by increase students engagement with a task or topic. Thereby, CL plays a vital role for nurturing the spirit of teamwork amongst engineering students' knowledge construction in TVET.

Apar from that, the two influencers on knowledge construction are (a) interactions between peer or instructor and students; (b) active learning through online SCL and learning or learner generated content (LGC), uses both influencers. Using a Web 2.0 applications for increasing and enhancing the interactions that the engineering students engage with in and/or out of the engineering classroom.

Now, a social problem that needs to be addressed has come to the fore. An issue in daily life needs to be solved. A question at engineering classroom needs to be answered. Thereby, the researcher needs to explain research design due to solve and answer the "what" and "how" questions in the next section. Hence, the researcher looks an appropriate tools to answer the research questions 1, 2 and 3.

CHAPTER 3

METHODOLOGY

3.1 Introduction

In this chapter, the researcher describes the methodology to be used in this study. This study seeks to address a social question in an engineering context. The research was designed specifically to answer the question, with this section dealing notably with the “what” and “how” questions in order to ask the research questions 1, 2, 3 and 4 for this study

There are consists of several subtopics, viz. (1) research design (see Figure 3.1), (2) research process and procedure (see Figure 3.4), (3) sampling, (4) research instrument, (5) validity and reliability of instruments and (6) data analysis procedures to be discussed in this chapter.

3.2 Research Design

This study comprises of two designs: Quasi-experimental for a quantitative approach, and a case study for qualitative approach. The quasi-experimental element involves the pre and post-test design approach (Creswell, 2014). Meanwhile, the case study involves a process to provide the detail and depth of exploration in a ‘real’ situation (Yin, 2008).

Before designing the quasi-experimental and case study approaches, the initial research design consisted of several phases. These were aligned with research questions, 1, 2, 3 and 4 mentioned in Chapter 1.

3.2.1 Rationale for the Design

The research design takes into account that the study describes an existing phenomenon (Zainudin Awang, 2012), which be described in this study based on research objectives and research questions. Thus, the research approach is an inductive procedure in which information and data be collected. Then, data are analyzed to note the patterns formed. Figure 3.1 presents an overview of this design.

The data collection method was longitudinal (Zainudin Awang, 2012), meaning that the researcher measured the same sample and same variables at two different times 2012). In this study, the researcher needed to study the process on engineering students’ knowledge construction through a social collaborative learning (SCL) environment, integrated with instructional scaffolding. In order to understand the process, research methodologies associated with descriptive survey and experimental methods were considered (Leedy, 1993). This aligned with the research phases by adapting a basic design cycle: input-process-outcome, as shows in Figure 3.2.

The Research Onion (Saunders, 2007)

Research Philosophy	**Pragmatism (Crotty, 1998; Gray, 2009)**
Research Approach	**Inductive (General to specific) (Siti Uzairiah, 2013)**
Research Strategy	**Quasi experiment (Creswell, 2014) and Case Study (Creswell, 2014)**
Research Method/Choice	**MIXED-METHOD (sequential transformative Design)-Theoretical perspective to guide, better to understand a phenomenon or process** (Creswell, 2009, Creswell, 2008, Creswell and Plano Clark, 2007, 2011)
Time horizons	**Longitudinal (Zainudin Awang, 2012)**
Research procedure	**Sampling, data collection and data analysis**

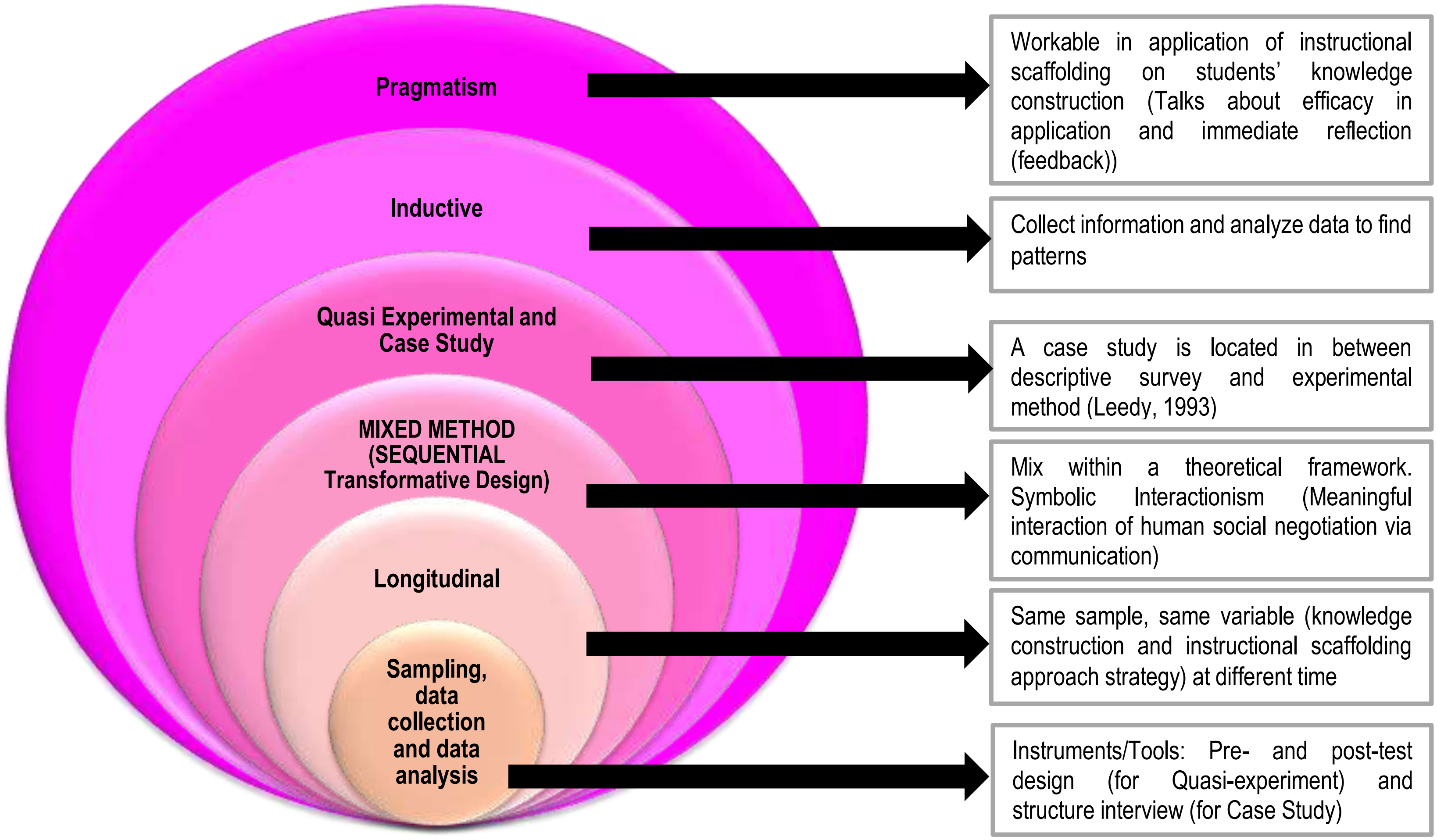
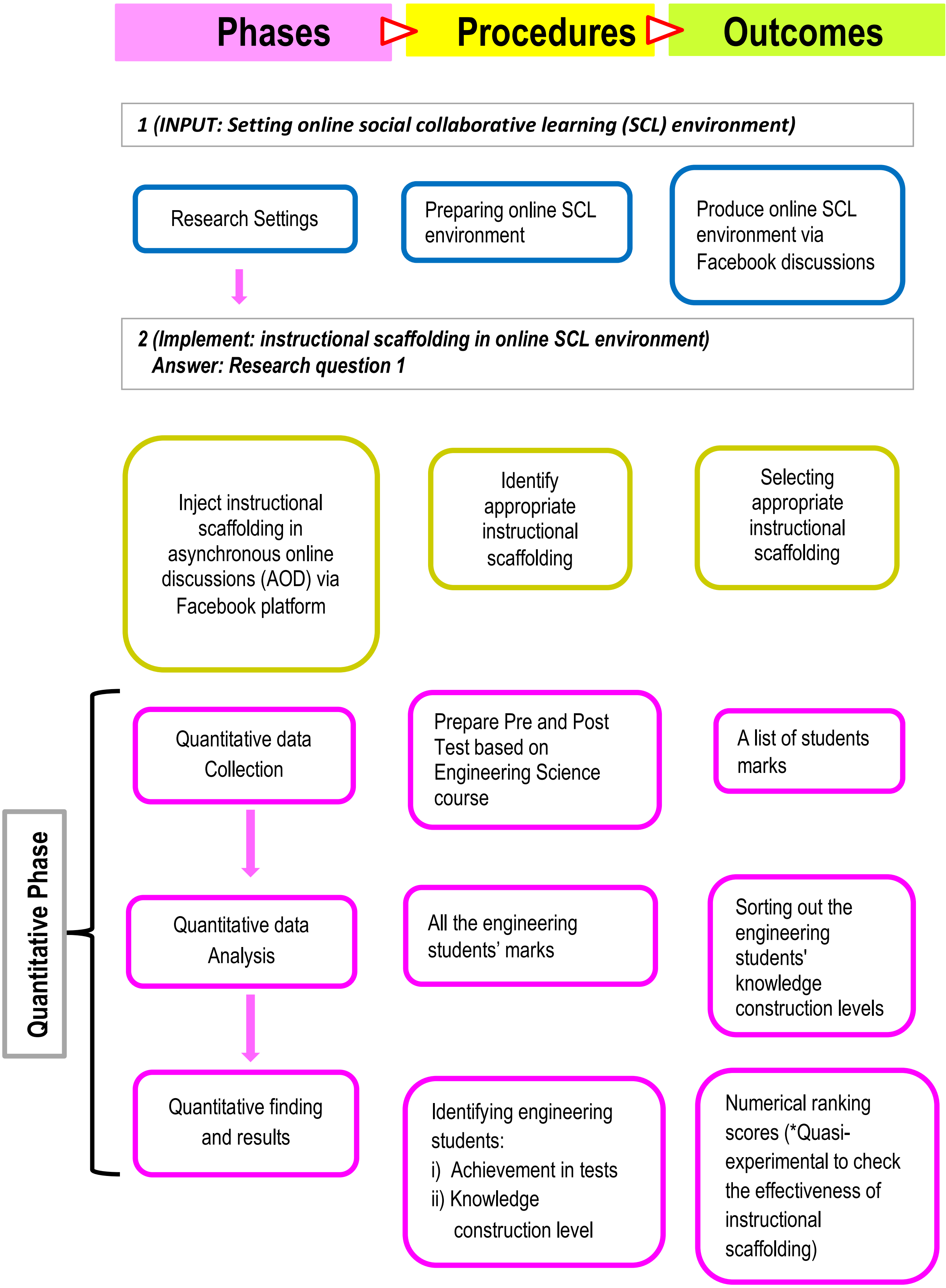


Figure 3.1 Overview of research design



Phases
Procedures
Outcomes
1 (INPUT: Setting online social collaborative learning (SCL) environment)
Research Settings
Preparing online SCL environment
Produce online SCL environment via Facebook discussions
2 (Implement: instructional scaffolding in online SCL environment) Answer: Research question 1
Inject instructional scaffolding in asynchronous online discussions (AOD) via Facebook platform
Identify appropriate instructional scaffolding
Selecting appropriate instructional scaffolding
Quantitative Phase
Quantitative data Collection
Prepare Pre and Post Test based on Engineering Science course
A list of students marks
Quantitative data Analysis
All the engineering students' marks
Sorting out the engineering students' knowledge construction levels
Quantitative finding and results
Identifying engineering students: i) Achievement in tests ii) Knowledge construction level
Numerical ranking scores (*Quasi-experimental to check the effectiveness of instructional scaffolding)

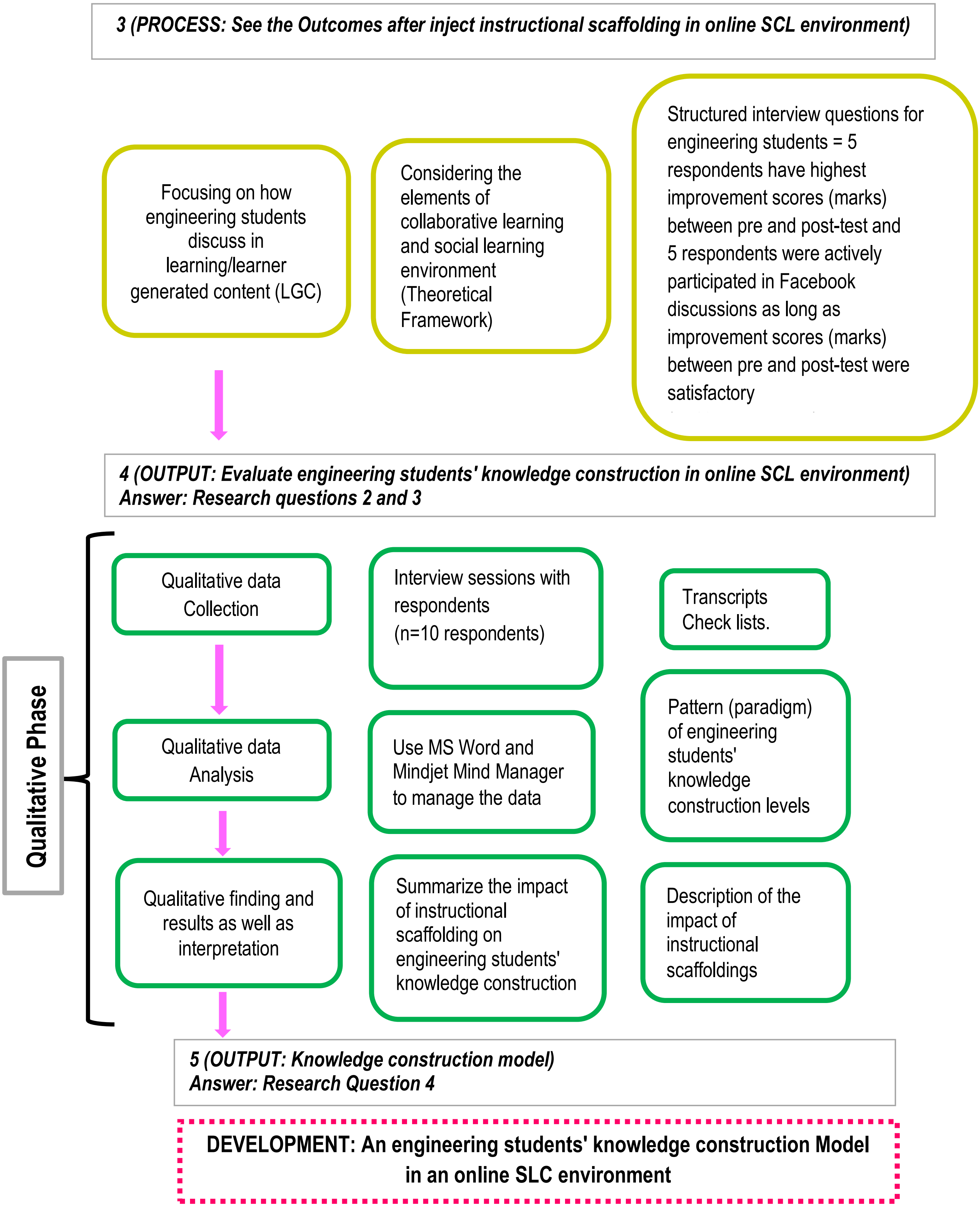


Figure 3.2 Overview of Application Research Design (Hybrid with Sequential Transformative Mixed Methods Design)

3.2.2 Application Phase in Quasi-experiment

Before designing the quasi-experiment, the researcher prepared the setting for an online SCL environment. The research setting involved an online SCL environment such as Facebook platform. It was related to the real-world practices which can be adjusted and justified through AOD.

There was four reasons for the researcher chosen quasi-experimental design such as (a) cannot simply assign a group of students to do the pre and post-tests (only select of homogeneous groups), (b) related to the "real" and "true" phenomena in order to describe what actually happens in depth, which means that specific to the context of the study (c) can minimize the internal and external threats (for instance: age, gender, history background), (d) can generalization as well (manipulate to other subjects or settings in different department).

Table 3.1 presents the application technique for data collection in the quasi-experiment design that was used to address the research problem (research question 1).

Table 3.1 : Application stage in the Quasi-experiment design

RESEARCH QUESTION	RESEARCH DESIGN	INSTRUMENT/ TOOL
What is the impact of instructional scaffolding (IS) in online social collaborative learning (SCL) environment on: a. Engineering students' achievement in tests b. Engineering students' knowledge construction levels	Quantitative	a. Pre and post-test based on an Engineering Science course i) Online collaborative assignment on learning / learner generated content (LGC) task or project through AOD on Facebook discussion groups (within groups) ii) Online problem-solving question assignments related to data analysis of experiment via AOD on Facebook discussions (between groups)

Creswell (2014) defined quasi-experimental design as an experimental condition in which the researcher assigns, but does not randomly chooses the respondents to groups. Groups cannot be naturally created for the experiment. Thus, for the purpose of this study, the researcher needs to designate two (2) groups: a control group and an experimental group for data collection.

Table 3.2 : Quasi-Experimental Designs: Pre and post-test design (Source: Creswell, 2014)

Control Group	Pre-test	No Treatment	Post-test
Experimental Group	Pre-test	Experimental Treatment	Post-test

Reviewing Table 3.2, the researcher applied the pre and post-test design approach to a quasi-experiment design. Meanwhile, the researcher conducted a pre-test in both groups. The experimental group underwent experimental treatment activities with instructional scaffolding. In other words, respondents received 'treatment' in the experimental group. Then, the researcher conducted post-tests to assess the differences between the two groups or classes. Thus, results between groups/classes could be compared, but not within group/class.

3.2.3 Application Phase in a Case Study

A case study is an in-depth exploration of the "actual" case (Yin, 2008). The activity can involve individuals or an event (Creswell, 2007), and can be located in-between a descriptive survey and an experimental method (Leedy, 1993). The application phase focusses on qualitative design. According to the research questions 2 and 3, the purpose of the study is to determine how instructional scaffolding cognitively steers engineering students towards knowledge construction. The study also seeks to determine how SCL environment guided with instructional scaffolding is an important factor that stimulates engineering students' knowledge construction through AOD. Thus, the researcher needed to consider what types of data to address research questions 2 and 3.

Table 3.3 shows the application techniques of data collection in the case study design. It was used to address research questions 2 and 3.

Table 3.3 : Application phase in case study

RESEARCH QUESTION	RESEARCH DESIGN	INSTRUMENT/ TOOL
How does instructional scaffolding in an online social collaborative learning environment cognitively steer engineering students towards knowledge construction?	Qualitative	Structured interview
How does online social collaborative learning environment guided with instructional scaffolding support engineering students reach a higher level of knowledge construction?	Qualitative	Structured interview

The case study design used to describe an experimental group in order to investigate how instructional scaffolding cognitively steers engineering students' knowledge construction in an online SCL environment. Moreover, the case study enables the researcher to observe processes and outcomes across two groups (control and experimental groups).

The use of the qualitative case study approach is justified by understanding the process on how instructional scaffolding is implemented towards engineering students' knowledge construction. Later, the use of purposeful sampling is discussed. The data collection involved face-to-face interviews. Moreover, the reason for researcher selecting the purposeful respondents is that a good rapport between instructor or facilitator and respondents had already been established. Therefore, the researcher needed to “bracket” personal bias when conducting the interview sessions (Creswell, 2014).

3.2.4 Application Phase to Develop a Knowledge Construction Model

This phase is the final application, as shows in Table 3.4. The researcher developed a knowledge construction model for engineering students in an online SCL environment. Data collection came from research questions 1, 2 and 3, enabling the researcher to generalize from samples to a similar population.

Table 3.4 : Application phase to develop a knowledge construction model

RESEARCH QUESTION	RESEARCH DESIGN	INSTRUMENT/ TOOL
What is the knowledge construction model in online social collaborative learning environment integrated with instructional scaffolding that enhances engineering students' knowledge construction levels?	Quantitative and Qualitative	No new instrument to be used. Triangulate the result of pre and post-test, online collaborative assignment on learning/learner generated content (LGC), online ill structured problem-solving question tasks, questionnaires and structure interview.

3.2.5 Sequential Transformative Mixed Designs

The sequential transformative mixed-design model is unlike the sequential explanatory and exploratory approaches, meaning that it is mixed within a theoretical framework. The rationale of the study is to better understand a phenomenon or process (Creswell, 2008; Creswell, 2009, Creswell and Plano Clark, 2011). Hence, the researcher focusses on the impact of instructional scaffolding on engineering students' knowledge construction. Consequently, the researcher intends to examine how instructional scaffolding cognitively steers engineering students' knowledge construction processes in AOD groups. In addition, the researcher wishes to find out whether SCL environment guided with instructional scaffolding is an important factor in stimulating engineering students' knowledge construction through AOD. In Figure 3.3, the sequential transformative model for data the collection process is presented (Creswell, 2014).

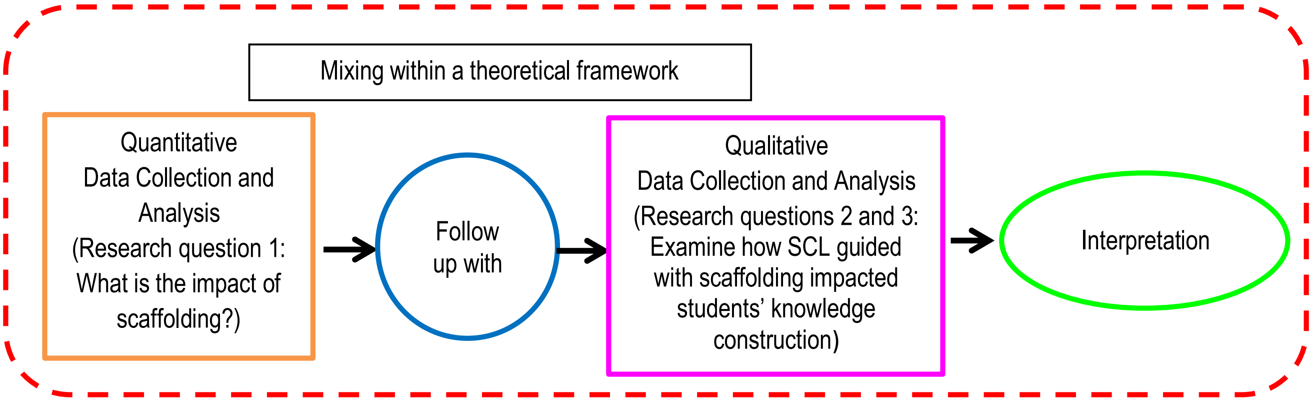


Figure 3.3 Sequential transformative mixed methods design (Source: Adapted from Creswell, 2014)

On reviewing Figure 3.3, it is noted that the sequential transformative model has two methodologies: quantitative for the first phase, and qualitative for the second. It uses different phases to facilitate its implementation, information and sharing of results. More importantly, the design of mixed-methods research takes place within a theoretical framework (Creswell, 2014; Creswell and Plano Clark, 2007, 2011). Moreover, that it is value-based is the strength of this design (Caracelli and Greene, 2010). Unfortunately, there is little guidance on how to use the transformative design. Hence, there is a need to decide which of the findings from the first phase forms the focus of the second phase (Creswell, 2009). An additional challenge is presented by integrating the theoretical framework into a mixed-method study (Creswell, 2014).

A sequential transformative mixed-method design (Cresswell, 2014, Cresswell and Plano Clark, 2007, 2011) was used as the main design to address the research questions. In the quantitative phase, the data collection method was pre and post-test (field site), under the quasi-experiment study methodology. On the other hand, in the qualitative phase the data collection methods used were structure interviews (field work), under the case study methodology. This can assist researchers in better understanding the context and phenomena of the study. Meanwhile, it enables researchers to collect both quantitative and qualitative data via tests, questionnaire and interviews.

3.3 Research Process and Procedure

The research process and procedure are dependent on the research design, which was planned to conduct quasi-experiment hybrid with a case study. Thus, the researcher divided the study into several processes.

3.3.1 Research Setting

The researcher needed to prepare the setting of the online learning environment for the study. This research was focused on knowledge construction via a SCL environment (collaborative learning with social media technologies or web 2.0 integrated with instructional scaffolding (IS) to support meaningful construction for engineering students. The research setting involved an online SCL environment design such as Facebook.

In this setting, the mixing with a theoretical framework is the main characteristic of sequential transformative mixed-methods design. On reviewing Table 3.5, there are five phases of knowledge construction, based on Gunawardena, Lowe and Anderson (1997). Engineering students can have such knowledge construction learning through sharing, comparing, discovering, exploring, and negotiating to promote and upgrade their knowledge construction levels (KCL). Hence, the students can have productive and meaningful interactions among their peers through an online learning environment, facilitating knowledge construction.

Table 3.5 : Phases of knowledge construction

(Source: Gunawardena, Lowe and Anderson, 1997)

Phase	Description
I	Sharing and comparing of information
II	Discovery and exploration of dissonance among ideas, or statements advanced by different participants
III	Negotiation of meaning
IV	Testing and modification of proposed synthesis or co-construction
V	Statement or application of new constructed knowledge

Additionally, the researcher divided the research process into the five (5) phases based on the instructional design model. ADDIE model which exemplifies Analysis, Design, Development, Implementation and Evaluation is used in the research setting:

1) Phase 1 (Analysis):

- This study began from related issues. Learning conceptual (declarative) knowledge in Engineering Science be the most challenging for engineering students to learn (Streveler *et. al.*, 2008). Thus, the researcher has chosen this engineering course for this study because it is a compulsory course for engineering students who study at polytechnic Malaysia.

  In addition, linear motion (as one of the topic in Engineering Science) was rated as the most misconceived topic in science, since it involved a lot of factual (true-to-life) knowledge (Duit, 2007). Meanwhile, it also consists of procedural knowledge, related to many applications of problem solving. This may cause engineering students to find it most difficult to learn when they are not directly observable (Streveler *et. al.*, 2008). There are benefits to investigate the interaction between conceptual (declarative) and procedural knowledge (Streveler *et. al.*, 2008). This might increase the researcher's need to study related topics.
- Engineering students in polytechnics as respondent or sample of participants were selected in this study due to they are slightly involve in CL and CSCL environments.
- The documents, theories, the principles of Constructivist Learning environment, collaborative learning, social learning environment (SLE), meaning construction, cognitive theory, and others related to research were studied.
- The environment consisting of collaborative (such as conditions and interactions) and social learning (such as social presence) elements were analysed.

2) Phase 2 (Design): Design learning environment

- Design a hybrid environment with collaborative and social learning environments for engineering students.

- Characterise collaborative learning (Dillenbourg *et al.*, 1996), social learning (Tu and Corry, 2001) and two concepts of social presence, namely immediacy and intimacy (Reio and Crim, 2013).
- The researcher designed an open and flexible learning environment, such as online learning for engineering students. Furthermore, design metacognitive activity such as reflection that can improve engineering students' knowledge construction.

3) Phase 3 (Develop): Provide an online SCL environment and use the environment
   - Developed the elements (collaborative and social) of the learning environment.
   - Provided the SCL environment for the study.
   - Integrated the instructional scaffolding in SCL environment.
   - AOD as the communication tool used in the SMT environment.
   - AOD through Facebook platform to be used in the study. It was important to ensure engineering students have quality of a discussion from short participatory times within the online SCL environment. Thus, they were able to produce quality knowledge construction in the learning process.

4) Phase 4 (Implementation): Determination of the instructional scaffolding effectiveness and content validity
   - Evaluated pre-test content validity by panel of expert in Engineering Science course such as head of the program.
   - The researcher conducted the pre-test on the engineering students.

     The researcher conducted a pre-test consisting of four levels of knowledge construction learning at the same time for respondents based on rubric (cognitive domain) in the Engineering Science course. The rationale of the study is to find out the level of engineering students' knowledge construction. Simultaneously, the researcher needed to observe the impacts of IS after implementing the "treatment" for respondents through AOD in the online SCL environment. The researcher gave an assessment namely post-test on the respondents again.

- Engineering students began to learn linear motion topic in an Engineering Science course.

  Then, they were divided into sub-groups of five (5) or six (6) students in a discussion group. Each group of students from the created learning environment had to solve problems from assigned learning tasks/activities. After that, they had to find information from sources that provide learning knowledge construction. When the students collaborated and found answers, they sent the answers as the learning tasks to the instructor. The instructor checked and analysed whether the engineering students gave correct answers. If the answers were incorrect, the instructor had to reply to the engineering students immediately to point out the mistakes they make, and motivate as well as scaffold them to get the correct answers together. They were then allowed to resubmit new answers.

5) Phase 5 (Evaluation): The processes of data collection

- Studied the effect of using instructional scaffolding and concluded the research result.

  This research collected data to study the knowledge construction levels. Moreover, this research studied engineering students' learning achievements: (1) data from surveying engineering students' achievement test (quantitative data) and (2) interviews on level of knowledge construction from 10 engineering students (qualitative data).

- After the engineering students have been exposed (meaning that knowledge has been constructed) to such a learning environment, the researcher collected the data to survey the achievement results and knowledge construction level of students.
- Engineering students did the test to measure their learning achievement and knowledge construction level.
- Ten engineering students were interviewed, and recorded their opinions about the level of knowledge constructed. They are 5 respondents have highest improvement scores (marks) between pre and post-test and 5

respondents were actively participated in Facebook discussions as long as improvement scores (marks) between pre and post-test were satisfactory) Then, the researcher analysed the information received by protocol analysis method.

3.3.2 Procedures on Conducting a Quasi-Experiment cum Case Study

This study focuses on two instructional approaches to stimulating knowledge construction through social negotiation in asynchronous e-discussions (De Wever *et al.*, 2008), namely collaborative assignment on learning or learner generated content (LGC) (for new knowledge), and assignments in online discussions on problem-solving questions (for metacognitive activities or self-regulatory knowledge).

The quasi-experimental control group design was employed. This study examined the achievement of engineering students who were taking Engineering Science course. Two groups or classes of students were formed: a control group and an experimental group. Each group/class was assigned randomly to either the traditional IS or web-based IS treatment.

The Engineering Science course that consisting of LGC assignment and guidelines were used over a period of 15 weeks (refer to Appendix A). The test was conducted to assess students' achievement in tests and level of knowledge construction in the Engineering Science course. A set of post-test was conducted would be carried out. Linear motion topic was employed to test the effects of both traditional and web-based IS approaches.

In this study, the researcher provided one group/class of engineering students with teaching and learning via the problem-based strategy with collaborative support. On the other hand, the web-based IS group/class underwent teaching and learning with initial presentation of web-based materials consisting of SMT such as YouTube. This was followed by instructor facilitation of learning, using a SNS. The researcher used

AOD on Facebook for collaborative learning (CL) environment. Engineering students used social media tools such as those YouTube and Facebook in order to do the LGC assignment. The experimental group (class) would create Facebook group for discussing their task. Guidelines for LGC assignment and problem-solving question assignment posed on Facebook. The final goal was to produce a presentation on LGC assignment and a problem-solution question.

The engineering students were given notes highlighting and focusing on the important new knowledge, as well as learning outcomes to be achieved. They were also encouraged to source information on the website and any textbooks suggested for the course. Meanwhile, students were motivated to answer the questions by using multiple resources prepared and suggested by the instructor or facilitator. They were also asked to complete the first assignment with the guidelines provided before proceeding to the second assignment. During this session, the instructor acted as a facilitator, providing guidance and monitoring the discussions. Simultaneously, the instructor also provide IS such as the provision of a variety of support mechanisms and providing the students with supportive and positive responses as necessary when the experimental group of students post the script on the Facebook platform.

Additionally, they were given assignment questions (a problem-solving question) and were told to work collaboratively in their own time. Next, each group of engineering students was presented with the solution to the assessment questions. Engineering students' understandings and misunderstandings were clarified and concluded during this session by the instructor. A test was conducted for both experimental and control groups in order to measure students' achievement in the tests and level of knowledge construction. These tests answered the research question 1. The test comprises of two parts: part 1 (Low KCL) and part 2 (High KCL). Both are structured questions. Engineering students' conceptual and procedural knowledge was measured by total scores of the first part of the tests, and engineering students' argumentative and metacognitive knowledge was measured by total scores of the second part of the tests. The process of implementing IS in efficiency and the process of engineering students' reaching a higher level of knowledge construction was also investigated during the learning phase in solving assignment problems via interview sessions. This section would be conducted for experimental group. These answer research questions 2 and 3.

The means and standard deviation of the performance in test (overall) for two groups and results of independent-sample t-Test are provided. The overall achievement in test scores ranged from 0 to 10. The t-Test analysis shows that the difference in means was significant, F, $p < .05$. The magnitude of the differences in the mean is based on Cohen kappa. The guidelines proposed by Cohen for interpreting this value are: .01= small, .06=moderate effect, .14=large effect.

There are five or six students in each asynchronous online discussions group for experimental group. Additionally, face-to-face working sessions are organized weekly. The discussion groups are organized to help engineering students process the learning contents and by confronting them with tasks, to promote discussion on the different concepts presented in the online SCL environment sessions. Collaborative assignment on LGC was used with engineering students when collaborating in the asynchronous online discussions so as promote the knowledge construction through AOD. Previous research has presented empirical evidence that students act in line with assigned roles (De Wever *et al.*, 2008). This specific structuring approach is combined with other assignments (problem-solving questions) in order to enhance engineering students' reflection.

Discussion group meetings were held in parallel with weekly online SCL environment sessions to encourage study of theoretical concepts and application through social negotiation. The duration of SCL process start from week 4 to week 7 (see Table 3.6). It was expected that engineering students would engage and construct four (4) levels of knowledge when using and learning through SMT hybrids with collaborative learning environment during AOD on Facebook discussions groups. Meanwhile, engineering students used YouTube and other social media technologies such as wiki or Yahoo to enhance their understanding of the Linear Motion topic. It means that engineering students would use social media tools as a social learning environment (SLE) and AOD on Facebook as a collaborative learning environment (CLE).

Based on the presented Modularized Engineering Science Pedagogic Curriculum (Appendix B), the research procedure schedule Table 3.6 was executed in the study.

Table 3.6 : The research procedure schedule

Week	Scheduled research procedures
Week 1	***Setting phase: Online SCL environment*** Introduction week to navigation computer network and technical skills ***Input phase: Access and Motivation*** The instructor posts the instructions such as Appendix A via Facebook platform. The researcher assigns roles through AOD on related to collaborative assignment on learning/learner generated content (LGC), creating online SCL environment setting to engineering students. The students surf the internet at any time and at any place. ***Input phase: Online socialisation – AOD*** The instructor (researcher) injects social presence and immediacy as well as intimacy through AOD on Facebook platform support with IS in SCL environment. Conducting Pre-test before giving any treatment for engineering students (respondents) to find out their knowledge construction level and achievement in tests.
Week 2	Conducting class as usual
Week 3	Conducting class as usual
*Week 4-5	***Process phase: Information exchange through AOD on Facebook while implementing Online instructional scaffolding (Implementation stage)*** Assign AOD Case 1 (collaborative assignment on learning/learner generated content) to the engineering students respondents Activity 1: Discussion of learning content topic within the group. Compulsory use of SMT to help students engage more in learning activities. Submission of AOD Case 1: Discussion within group.
Week 6-7	Assign AOD Case 2 (problem-solving assignment on linear motion experiment) to the engineering students respondents. Experiment 2 is conducted for the students. Activity 2: Reflection: Immediacy – Engineering students solve the problems in Experiment 2 (linear motion) that they needed to feed back their ideas resulting from the data experiment (analysis part). Submission of AOD Case 2: Final Writing through Facebook.
Week 8	***Output phase: Knowledge Construction (Evaluation stage)*** Conducting post-test for engineering students (respondents) to find out their knowledge construction level.
Week 9	Interview sessions
Week 10 -15	Conducting class as usual

Based on Table 3.6, this procedure schedule is for treatment groups. However, the differences between two groups (control and experiment) are:

The researcher used traditional instructional scaffolding (IS) with collaborative learning based on not using AOD in the control group. On the other hand, the treatment (experimental) group will be given web-based IS. This means that students learned through AOD in SCL environment guided with IS.

Reviewing Table 3.6, before the fourth week when linear motion on the topic of T&L is performed, a pre-test is conducted. The main aim is to determine engineering students' level of knowledge construction. Additionally, engineering students' achievement in the test was also identified. Thus, the researcher justified the classification of instructional scaffolding implemented for engineering students' knowledge construction. They needed scaffolding during their learning process, particularly in AOD for a first year polytechnic diploma course in Engineering Science. Students' postings in Facebook discussion groups were used as research data for this study. Each group consisted of 5 to 6 students. All messages were submitted within four weeks of discussion, from week 4 to week 7. There was a discussion theme for each week.

After a week of trials with AOD in SCL environment, a formal lesson plan required students to discuss the tasks. Each discussion lasted a week within the four-week period (see Figure 3.4 shows an overview of the Operational Framework). Students collaborated in online learning. The task discussion was the same for all groups, and was associated with the same chapters in Engineering Science course. The main goal was to stimulate negotiation on theoretical concepts presented in an online SCL environment session.

Participation in Facebook discussions group was a formal component of this course, and made up 20% of the course grade. Students were required to contribute at least once for every discussion theme. As always, facilitators gave tips or strategies on achieving CLO goals and ensured students were on track after the AOD on Facebook discussions group.

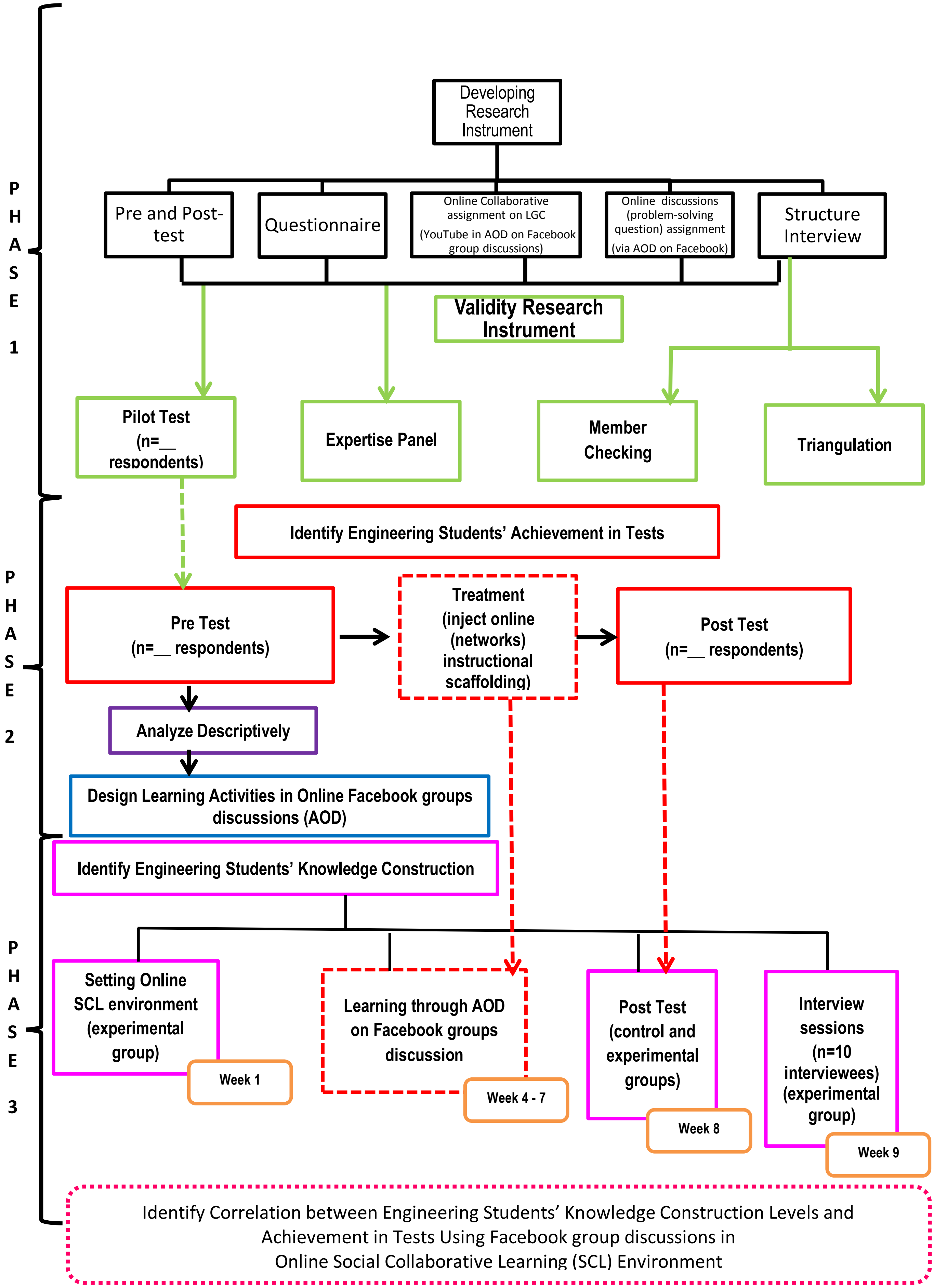


Figure 3.4 Overview of operational framework

3.3.3 Enhancing Online Collaborative Assignment on Learning/Learner Generated Content (LGC) in Asynchronous Online Discussions (AOD) on Facebook

In Table 3.6, activity 1 included elements of social learning and collaborative learning in an online collaborative assignment. Engineering students were obliged to use YouTube as an SMT tool to complete the LGC task. This may have helped the students to engage more in the learning activities. They received feedback via AOD (Asynchronous Online Discussions) on Facebook as a collaborative learning environment.

Scaffolds are a form of learning support provided to bridge the gap between prior knowledge and new knowledge. There are different classifications of scaffolding. Scaffolds can be implemented as stated in theoretical framework (refer Chapter 1) proposed by Hogan and Pressley (1997).

AOD on Facebook is an online learning for instructor or lecturer and engineering students to interact with each other. It is acquired through social negotiation. The students were given learning or learner generated content (LGC) as collaborative assignments via Facebook. Every engineering student was subscribed to this discussion grouping. Each student needed to make a post on AOD via Facebook, related to their learning course and activities. They addressed the task via collaborative discussion. The engineering students constructed their knowledge through negotiations in AOD. The main role as a facilitator or an instructor is to make sure that the students can actively engage themselves in their learning activities through AOD in social collaborative learning (SCL) environment. Moreover, students had never before been involved in collaborative LGC in their learning itinerary. Engineering **s**tudents had to rate their knowledge construction through social negotiation after each discussion assignment and discussion group.

In order that effectively use SMT for the students' active learning, they would download videos from YouTube. Then, each video should be made a discussion consists of sharing, comparing, discovering, exploring, negotiating and synthesizing via Facebook group. This would bring instructional scaffolding in such online SCL environment to assist them complete the LGC task given.

Fahy (2001) revealed that reflection and scaffolding were under the categories of online interactions. He clarified that scaffolding as encourages, models, provide clues, hints or assists, and also common supports others in difficulties, new or unfamiliar experiences or moments of doubt in their process of knowledge construction. Meanwhile, he also points out that reflection as revealing on both what is thought and why, which consists of feedback in reasoning processes and experience. Thus, the researcher would make use of instructional scaffolding to stimulate and steer the engineering students reach higher level of knowledge construction in online SCL environment.

3.3.4 Rationale for the Chosen Topic

Engineering Science consists of several topics (Refer Appendix B). There are (1) Physical quantities and measurement, (2) Linear motion, (3) Force, (4) Work, Energy and Power, (5) Solids and Fluids and (6) Temperature and Heat. As mentioned previously in phase 1 (Analysis), linear motion was selected as the learning domain of this study because of its complexity. Moreover, this topic fell within the "appropriate time frame", based on actual learning content. Thus, the researcher considered it appropriate for this study.

The choice of a topic (linear motion) to be employed in present study depended on several factors:

- Scope of the study

  Since the engineering students come from a variety of engineering backgrounds and experiences such as Marine, Civil, Mechanical and Electrical, the researcher needed to choose an appropriate course related to each engineering field. This can be reflected on the engineering discipline of the study. It is a compulsory course in Engineering Science course in semester 1 at a polytechnic. The students do not have any experience in this engineering field. Moreover, this subject lies at the foundation of the engineering field. Thus, it was rational to choose this single course for the present study.

- Advanced knowledge construction of the target population

  In this case study, all polytechnic engineering students studied a related topic. Hence, it was representative of the target population of engineering students' knowledge construction at polytechnics in Malaysia. Furthermore, the linear motion topic can lead engineering students to reflect their knowledge construction related to daily life.

- The prerequisite of linear motion topic is the most complicated when compared to other topics. This topic is related to the interactions between conceptual and procedural knowledge (Streveler *et.al*, 2008). It means that linear motion topic comprises of complex applications that need to really understand the concept embedded in the problem solving questions.
- There has been very little study on this topic of learning science on engineering learning (Johri and Olds, 2011) compared to other topics in this engineering course. Several researchers have focused their research on force and heat topics (Streveler *et.al,* 2008).
- The linear motion topic involves many concepts, and application of knowledge that can make engineering students more likely to misunderstand knowledge construction in their learning itinerary. It might cause engineering students to lack interest in studying this topic.

3.4 Sampling

The demographic features such as those gender, age, and level of existing/prior knowledge of the sample were reasonably consistent with the population. It means that the sample’s attributes (criteria) is similar with population. The population focused on first year engineering students studying Engineering Science as a compulsory module in polytechnics in Malaysia. The respondents selected were a purposive sample of the engineering program from Marine, Civil, Mechanical and Electrical Engineering. There are several samples, as described below:

3.4.1 Real Data Collection Sample

In order to draw a real data collection sample, purposive sampling non-probability (non-random) was considered. The researcher might have one or more specific groups to seek, and it can be very useful for such situations when a researcher needs to obtain a targeted sample quickly. The polytechnic was the institution selected and is purposely chosen for this sample. For the purpose of qualitative data, the same sample would be used. Purposive sampling seeks to identify information that can be studied in-depth (Patton, 2002).

The statistical population was the first year engineering students from Civil, Mechanical, Electrical and Marine Engineering who were taking Engineering Science as a compulsory foundation course in the engineering field in polytechnics in Malaysia. The purposive sample for the study comprised 74 engineering students from Ungku Omar Polytechnic who were in the first semester of the 2015-16 session. The sample for the study was selected using SPSS and divided into a control and an experimental group. The thirty-eight (38) Mechanical Engineering students in the control group completed the learning tasks in a conventional collaborative learning (CCL) environment, which was conducted in the engineering classroom. On the other hand, the thirty-six (36) Civil engineering students formed the experimental group and completed the learning activities in the SCL environment via AOD with instructional scaffolding (IS) support.

Table 3.2 shows that the researcher engaged two engineering classes: a control group and an experimental group. Both selective groups of the sample were polytechnic engineering students. Pre and post-tests were conducted for them. The control group would not be given any “treatment” for the sample. On the other hand, the experimental group would be engaged in instructional scaffolding as a treatment for the quasi-experiment study. These samples were required in order to fulfil research question 1 of the quantitative part of the study. Then, the researcher needed to analyse the impact of instructional scaffolding in online learning activities such as the SCL environment.

In fact, the rationale for choosing a polytechnic as the context for this study is as follows:

- Engineering students from the major departments, such as Marine, Civil, Mechanical and Electrical, have similar learning environments to construct their higher level of knowledge. Thus, the students' academic performance or achievements face similar issues, like a lack of self-regulatory learning. Such environments would not be able to construct higher level of knowledge for engineering students.
- Most engineering students are lack experience of constructing learning or learner generated content (LGC) based on the background learning itinerary. They come from a variety of backgrounds and experiences, from secondary schools and vocational colleges throughout Malaysia.
- The respondents in fact met the criteria chosen for the sample. They are studying in engineering field. Moreover, they are future engineers in national or international society. It means that they would work in the local or global society when they complete further study at university. This representative of the sample towards its population, which is the whole engineering discipline.
- The engineering students can conduct peer-to-peer discussions easily via AOD on Facebook. They can be active learners through meaningful online learning. This can lead to engineering students being active participants in the learning content through problem-solving activities.

The selection of groups (control and treatment) for data collection was a purposive sample based on discussion with the head of department. Thus, the researcher had to select different departments for each group.

3.4.2 Other Samples

- Pilot test Sample

Respondents from the Marine/Civil/Electrical/Mechanical Engineering Department were in the online discussion groups. One group or class of experimental design was used for the pilot test, which is a test conducted in the field study. Corrections can be made if any weaknesses are found during the pilot study. The pilot test sample is very important, as it can affect the outcome of the study. Before conducting the pilot test and actual case study, a "panel of expert" needs verify (externally) the validity and reliability of the instrument. The criteria and role of expert that should be considered are shown in Table 3.7. He or she experiences and expertise's in some area such as IT and course content.

Table 3.7 : Classification of criteria for expertise panel

Role Of Expert Panel	Classification Of Criteria (Elements)
Content expert	The head of the course has wide experience, at least five years in teaching the Engineering Science course. Thus, he or she has sufficient knowledge to validate the content of the pre and post-test.
Pedagogy with technology expert in IT (online AOD on Facebook support with instructional scaffolding in social collaborative learning environment)	The lecturer who has at least five years' experience in teaching multimedia courses at Department of Multimedia Information and Communication Technology (ICT) in polytechnic. Thus, he or she is eligible to validate the AOD learning activities via Facebook platform in online SCL environment.

There is one (1) content expert and one (1) online expert with technology in AOD on Facebook to be selected.

This sample is used to test sample learning activity, and answer exam questions. Feedback can be received on the social collaborative learning activity or environment and also on exam questions would be generated from the sample.

- Interview Sample

In order to accurately acquire data from the qualitative part, the researcher needs to conduct an interview session on the respondents at the present polytechnic. Respondents were chosen based on their achievements in the test. The researcher would select five (5) engineering students who have highest improvement scores (marks) between pre and post-test and another five (5) engineering students who actively participated in Facebook discussions as long as improvement scores (marks) between pre and post-test were satisfactory. In this way, research questions 2 and 3 would be answered. Meanwhile, before conducted the interview session, the researcher chose randomly two (2) engineering students from experimental group for pilot test in order to get reliability of interview questions.

3.5 Research Instrument

Instruments are tools used to collect and measure data and information in the study. On one hand, instrumentation is a potential threat to validity (proofing) in the experiment during pre and post-test conducted in a sampling (Creswell, 2014). Reviewing Tables 3.1 to 3.3, there are two types of instrument, namely pre and post-test for collecting data in the quasi-experiment, questionnaire and structured interview for collecting information in the case study. Figure 3.5 presents the variety of instruments to be used in the study.

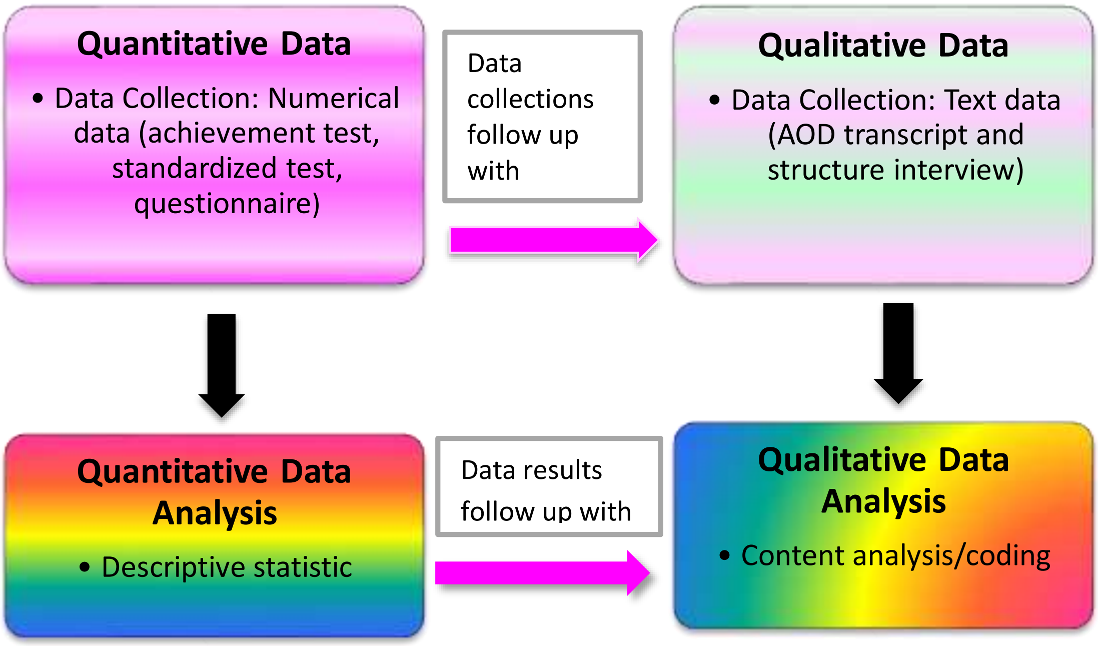


Figure 3.5 Types of instrument

3.5.1 Instrument: Pre and Post-test

As mentioned in sequential transformative mixed designs, there are two sets of data collection and data results to be conducted. The quantitative data followed up with qualitative data to identify actual and true data collection. Thus, pre and post-test be used for evaluating the level of engineering students' knowledge construction in the topic of linear motion in engineering classrooms (refer to appendices C and D). The achievement and standardized tests are carried out with 25 marks as the maximum scores for each assessment, and 45 minutes are given to complete each assessment. The assessments are based on Engineering Science syllabus (DBS1012), set by the higher educational department. The detailed question and answer scheme be consulted in appendices C, D, E, and F.

In Appendix G (a), it is shows that each test has eight (8) questions consisting of Part I and Part II. Each question identifies the degree of knowledge construction. There are several examples of questions to show the degree of knowledge construction (Appendix G (b) and (c)).

3.5.2 Online Collaborative Assignment on Learning/Learner Generated Content (LGC) and Problem-solving Assignment via AOD on Facebook

Research Question 1 seeks to answer:

- What is the impact of instructional scaffolding in an online social collaborative learning environment on both engineering students' achievement in tests and levels of knowledge construction?

The researcher created different kinds of assignments through AOD on Facebook in order to identify the impact level of instructional scaffolding, such as low, medium and high.

Table 3.8 and Table 3.9 show two (2) types of assignments to be given for engineering students. They consist of online collaborative assignment on LGC and a problem-solving assignment. After the respondents conducted the experiment on linear motion, they have to write the analysis in the problem-solving assignment. Then, they posted through the Facebook. Each respondent posts one discussion.

This encourages the engineering students to engage themselves actively in the online learning towards knowledge construction. They reflect and analyze the data from the experiment. Furthermore, they improve and enhance learner-centered practice (LCP) or learner-centered teaching (LCT).

In this study, online learning was introduced to improve students' reflection and stimulate self-regulatory learning (Larres, Ballantine and Whittington, 2003). Engineering students' problem-solving of experiment 2 was conducted on week six of the semester. This experiment 2 comprises of analysis and problem solving questions that the students should answer it. The guidance was based on Lab work Rubric: DBS1012 Engineering Science which is set by the higher educational department (see Appendix S). This would scaffold students' metacognitive activities via online SCL.

Table 3.8 : Form of tools related to online assignments

Instructional approach	Form of Content Activity	Forms of Discussion (Creswell, 2014)	Examples of the Task
Group Discussion (AOD on Facebook)	AOD and download at least one (1) video from YouTube (mp4) related to the topic	A discussion about the different.	A discussion about the differences of linear motion and non-linear motion.
Group Discussion (AOD on Facebook)	AOD and download at least one (1) video from YouTube (mp4) related to a problem-solving question	A discussion raising further question that needs to be addressed?	A discussion raising questions about the application of problem-solving which is related to the linear motion topic.

Table 3.9 : Learning course related to learning activities

Instructional approach	Type of Assignment	Learning Task Activity	Reflection Task (Characteristic)
Group Discussion (AOD on Facebook)	A Task: Collaborative learning/learner generated content (LGC) with SMT tool such as YouTube and Facebook (online discussions task)	*Group activity:* Group of 5 to 6 students. Task to generate learning content related to Linear Motion topic which includes mind map and download 3 videos from YouTube (mp4). Then, the engineering students discussion consist of sharing, comparing, discovering, exploring, negotiating and synthesizing via Facebook group. After that, post the finding on the AOD on Facebook. Each group has to present their presentation.	Collaborative learning: • conditions • interactions Social learning: • social context (informal) • online communication • interactivity (embedded within the conditions) Instructional scaffolding: • support and guide the new task
Group Discussion (AOD on Facebook)	A problem-solving question (online discussions question)	*Group activity:* Solve the problem and questions that generate students' immediate feedback	Social learning: • social context (formal/informal) • online communication • interactivity (embedded within the conditions) • immediacy • intimacy

3.5.3 Structure Interview

In the quantitative approach, the evaluation of engineering students' achievement in tests and students' knowledge construction levels are based on the pre-test (research question 1). This was followed up with the qualitative approach to investigate the process of instructional scaffolding implemented towards engineering students' knowledge construction (Research questions 2 and 3).

In this study, the process and procedure to conduct structure interview based on Appendix H. The interview approach allowed the researcher to focus on different types of activities related to IS that can describe different outcomes in those activities. Consequently, several elements need to feature in the interview, such as the physical environment (SCL environment), the respondents in detail, and learning activities that require web-based scaffolding to support the interactions.

A structured interview format, with open-ended questions aligned to research questions 2 and 3, was constructed in a way deemed relevant to the research objectives. Morgan, Krueger and King (1998) mentioned that there are five (5) criteria to consider when developing questions:

- Opening (respondents need a "warm up" before the interview session starts)
- Introduction (initial discussion on the topic)
- Transition (proceed to the main topic)
- Key (main area of concern of the study)
- Closure (ending for the interview session)

In Table 3.10, the relationship of the interview questions to research questions 2 and 3 is shown. The question flow (OITKC stages) from Morgan, Krueger and King (1998) was prepared for interviews.

Research question 2 seeks to answer:

- How does instructional scaffolding in an online social collaborative learning environment cognitively steer engineering students towards knowledge construction?

Research question 3 seeks to answer:

- How does online social collaborative learning environment guided with instructional scaffolding support engineering students reach a higher level of knowledge construction?

Table 3.10 : Relationship of interview questions to research questions

Research Questions	Types of Interview Question	Interview Questions
2 and 3	Introduction	Describe the benefits of guidelines (refer Appendices A and L) for all the learning tasks and collaborative learning activities via Facebook discussions
2	Transition	Think back how the guidelines affect your knowledge construction.
2	Key (conditions) *online group task	Let's think about the most challenging part when you had online collaborative assignment on learning/learner generated content (LGC) with your peer. You wanted them to discuss a related topic. Tell me about how instructional scaffolding can improve and enhance your knowledge through ADO on Facebook.
2	Key (interactions) *online group task	Tell me about how YouTube can engage and enhance your prior knowledge through AOD on Facebook discussions. *(peer-to-peer interaction)*
2	Key (immediacy)	Whether instructor's feedback lead you to the knowledge construction.
2	Key (intimacy)	Tell me about your felling that instructional scaffolding when I provide "assist" statement in your AOD via Facebook discussions.
3	Transition	Consider the challenges you face during online collaborative via AOD. How does online SCL environment guided with IS support you to reach a higher level of construct knowledge?
3	Key (support) *online discussion question	Let's think about the learning tasks and SCL activities such as working in groups, sharing and comparing linear motion and non-linear motion, discovering and exploring uniform motion and non-uniform motion, negotiation of meaning/argumentation of distance and displacement.
3	Key (guideline) *online discussions question	How do all these help you reach a higher level of knowledge construction?
3	Key (elaborate explanation) *online interactive	Let's think about ill-structured problem solving questions that you have to work and collaborate with your group members. Each member plays his/her own role as starter, moderator, theorists, resource searcher and summarizer. How does this setting help you have to work in online learning via Facebook discussions (SCL environment) in order to construct your knowledge?
3	Key (control) *online interactive	Tell me about how do all these (assigned role/group/task), help you to reach a higher level of knowledge construction?

2 and 3	Closing	Any general comments on how interaction with instructor and friends (scaffolding) and the use of online SCL via Facebook help you in constructing higher level of new knowledge.

In the quantitative approach, evaluate engineering students' achievement in tests and students' knowledge construction levels are based on their pretest (Research question 1). Follow up with the qualitative approach to investigate the process of instructional scaffolding implemented towards engineering students' knowledge construction (Research questions 2 and 3).

3.6 Validity and Reliability of Instruments

Research quality is measured through validity and reliability (Patton, 2002). Thus, the validity and reliability of the instruments used is discussed in this section.

3.6.1 Validity and Reliability of Pre and Post Test

The goal of pilot test was to establish the sampling instruments (pre and post-test). It is also necessary to make sure that the instruments work properly and effectively. The pilot test is conducted in the experimental group to ensure that the instruments can be more accurate and reliable. Each sampling instrument needs to be tested very carefully.

In order to validate the pre and post-tests, the researcher refers to content expert, as outlined by Creswell (2014). He or she identifies whether the questions are valid. The content expert checks that the test's content relates to the knowledge construction level that it intends to measure. The panel of experts provides a relevant, clear and meaningful reflection for both format and content. Therefore, the researcher needs to revise the questions based on feedback from the expert panel. The test revised based on experts' suggestions and comments in content validity form (see Appendix I).

3.6.2 Validity of the Online Collaborative Learning Assignment and Problem-solving Question Tasks

The panel consists of two experts, one in content and the other in pedagogy with technology (AOD on Facebook). The content expert is the head of the course. He or she has at least five years' teaching experience in the Engineering Science course. Thus, they have sufficient knowledge to validate the content of the collaborative learning assignment and problem-solving question tasks.

Furthermore, the pedagogy technology expert verifies the content of the online collaborative learning task and problem-solving question tasks. They are from the Department of Multimedia Information and Communication Technology (ICT) in the polytechnic. He or she works as a lecturer, and has experience in teaching multimedia for at least five years. They validate the AOD learning activities on Facebook in the online SCL environment. Finally, both panels of experts sign the content validity form (CVF) (see Appendix J) to verify the learning content activities.

There is a Lab work Rubric: DBS1012 Engineering Science which is developed by the higher educational department. In order to validity of the analysis and problem question task in experiment 2 Linear motion, the researcher follow the guideline.

3.6.3 Validity of Structure Interview Questions

The researcher uses structured interviews with open-ended questions to answer the research questions. This means that respondents answer the questions within the scope determined by the researcher. The questions are based on research questions 2 and 3, which are validated by the panel of expert in the area. The interview sessions are audiotaped and transcribed for content analysis and thematic analysis.

3.6.4 Validity of Interview Scripts: Member checking and Triangulation

There are two strategies for conducting validation: member checking and triangulation (Creswell, 2014). Member checking is used for the validity and reliability of the qualitative research. It is a procedure that can mitigate researcher bias.

In order to ensure that the findings and interpretations of the data are accurate and reliable, Creswell (2014) states that triangulation is used in a qualitative approach. It is a process of verifying evidence from different respondents, data collection methods such as interviews in descriptions and themes/coding. In this study, multiple data sources are used. The results of the interview are coded into thematic categories by the researcher.

Member checking from respondents is a counter-check of findings. The researcher needs to confirm with respondents whether the descriptions are real and complete, interpretations are fair, and representative of the findings. In other words, the researcher needs to ascertain whether the report findings are accurate, consistent, and systematic (see the pattern).

The data collection from two cohorts respondents, namely (a) 5 engineering students who have highest improvement scores (marks) between pre and post-test and (b) 5 engineering students who actively participated in Facebook discussions as long as improvement scores (marks) between pre and post-test were satisfactory. The input assists the researcher with an unbiased review of the accuracy of themes from the interviews. However, member checking is conducted to determine the accuracy of the data collection. In order to verify the accuracy of the thematic categories from the interviews session, the researcher can recall the respondent again for further reflection and clarification upon review of the interview scripts.

Moreover, the researcher uses the Statistical Package of Social Sciences (SPSS) to gain Cohen's kappa. In Table 3.11, the value of Cohen's kappa is higher than 0.8, showing that the test is reliable. The interpretation of kappa is given by Viera and Garret (2005).

Table 3.11 : Value of Cohen's kappa (Source: Viera and Garret, 2005)

Interpretation of Kappa					
Poor	Slight	Fair	Moderate	Substantial	Almost perfect
0.0	.20	.40	.60	.80	1.0

Value of Kappa	Indicator of Agreement
< 0	Very Poor
0.01–0.20	Poor
0.21– 0.40	Fair
0.41–0.60	Moderate
0.61–0.80	Good
0.81–0.99	Very Good

3.6.5 Reliability of Instruments

Gray (2009) cited reliability is consistency between two measures on the same thing. The measurement can rely on the same instrument (pre and post-test and interview scripts) with two different groups of respondents. Gray (2009) revealed in order to ascertain the reliability of instrument, the researcher has to ensure:

- Stability – measure the achievement scores on the same test at different times
- Equivalence – comparison of the different instruments (pre and post-test, interview) conducted on the same respondents

Interview (field work) is a qualitative stage to be used in the study. There are some advantages to face-to-face interviews:

- Can be used with respondents who would not be able to provide information in another format, such as those who are bedridden or illiterate
- Can elicit a more in-depth response or fill in information if respondents do not understand the question
- Can know for certain who the respondent answering the question is.

When conducting structured interviews with an interview guide, there are seven criteria for researchers to consider, such as:

1. Establishing a good rapport with cultural respondents. This means that respondents can feel comfortable with the interaction. Rapport is constructed over time, and consists of active listening, showing respect and empathy, as well as being truthful.
2. The setting processes include choosing a site that will facilitate easy access to the data. The data collection helps to answer research questions 1, 2 and 3.
3. Mapping out the setting that helps researcher understand the situation. This enables the researcher to know what other topics to cover and from whom to collect data information.
4. The human and social environment that leads to the understanding of the existing cultural scenario.
5. Decide what, when, and where to interview.
6. The language of program respondents that the researcher is more familiar with, or which would help gain access to more information. Meanwhile, this increases rapport with respondents.
7. Reporting field notes to see for pattern observation, followed by writing up the findings.

On the other hand, researcher also look at which interactions have occurred and which have not, who speaks to whom, who listens, who keeps silent, and how the researcher's role affects the engineering students' knowledge construction process.

The interview process comprises of both data collection and analysis. Then, an in-depth description is given. However, regardless of the coding in the interview sessions, the coding used must allow the researcher to obtain relevant information. Meanwhile, the researcher also focuses on the types of information needed for the study through interview. They describe the structure of the code representing the 'truth' in this study. The themes reflect the reliability of data. Then, narration can be written from the data collection. Thus, the conclusion is made up of what happened, followed by what was covered during interview, and what was recorded in the field.

3.6.6 Strategies to Minimize Threats

There are different types of threats in this study. The researcher employed Yin's (2003) strategies to minimize threats, as shows in Table 3.12 (Matusovich, Streveler and Miller, 2010).

Table 3.12 : Definitions for measures of quality and descriptions of implementation in this qualitative study (Source: Matusovich, Streveler and Miller, 2010)

Measure	Definition (Yin, 2003)	Application of this study
Construct validity	Research actually measures intended constructs (For instance: interest, utility, knowledge construction level)	Data and researcher triangulation (Creswell, 2014; Yin, 2003) through multiple data sources.
External validity	Research is generalizable.	Replication of findings (Yin, 2003)(also described as triangulation) across cases (Stake, 2006) by analyzing individual cases (Matusovich and Streveler, 2009)
Internal validity	Research verifies causal relationships	Not an appropriate measure (Yin, 2003).
Reliability	Research establishes a chain of evidence (Yin, 2003) such that another researcher could follow the same procedures (same code) and yield the same results	Incorporation of detailed descriptions of the data sources and collection methods, and analysis process including development and application of the codes.

To alleviate problems with bias, the researcher used a scoring rubric as a guideline for marking engineering students' examination papers. The scoring rubric of the course is used throughout all Malaysia polytechnics. This may mitigate the bias on choosing the polytechnic as the researcher's workplace. Besides, other lecturers (member checking) were invited to double-check the engineering students' achievement in tests. Furthermore, the researcher needed to gain a percentage of agreement from the committee of the course, including form the course coordinator. There is one (1) content expert and one (1) online expert with technology, employed to check the online discussions content.

In addition, interviews were designed to allow participants to reflect on their experience (Stevens, O'Connor and Garrison, 2005). The aspects of structured interviews dictate who is interviewed, when and where he or she is interviewed, what is covered in the interview, and how the interviews are recorded. The researcher has to choose an appropriate time and period to conduct the metacognitive activities, such as reflection in the engineering classroom. Thus, the researcher needs to be careful when designing and implementing learning activities for this study. This way, interaction among respondents between control groups and treatment (experimental) groups can minimize or avoid altogether.

In other words, more threats to internal validity and interaction of selection in the quasi-experiment emerge when exchanging tools during pre and post-tests. Threats need to be addressed when researchers conduct the quasi-experiment design.

There are practical limitations in the quasi-experiment, in which the researcher may not randomly assign respondents to groups, but they are still valuable (Creswell, 2014). However, there are four threats (Creswell, 2014), given below:

i. Interaction of selection - threats to external validity that include inability to generalize beyond the group, such as to other racial, social, age, gender and personality groups.
ii. Interaction of setting - threat to external validity that includes inability to generalize from one setting to another setting.
iii. Interaction of history - threat to external validity occurs when the researcher generalizes findings to past and future conditions.
iv. Interactions with selection – potential threat to internal validity consisting of:

a. Mature at different ages during the study. For instance, 18-year-old boys may have different maturity levels to girls of the same age.

b. Historical background of respondents, because each individual has come from a different setting (prior knowledge, educational background, and past learning experience).

c. Selection of respondents may also influence the tool scores, particularly when different groups score at different mean position on a test in which the intervals are not equal.

In order to minimize the threats that may occur in the present study, there are appropriate ways to overcome them, as shows in Tables 3.13 and 3.14 (Creswell, 2014).

Table 3.13 : Strategies to minimize threats to internal validity

Internal Validity	
Interaction With Selection (Related To Respondents)	**Application in this study**
Maturation – mature individuals in age with experience, and prior knowledge.	Most of the respondents are of the same age and have the same level of prior (existing) knowledge in the control and experimental groups
History – Conduct the test over time. This means that a grace period between pre-test and post-test would be applied on the respondents.	Conducting the pre-test on the first week and post-test on the eighth week. The range of time for pre and post-test are in an appropriate time frame. Based on Creswell (2014), who claimed that the tests are still valuable. There are no problems with history and others. Engineering students cannot remember the questions during post-test. However, they can still remember the learning activities.
Regression – Individual scores over time. In other words, the researcher selects the respondents who achieve the highest scores. It may affect the result of the post-test.	Select the respondents who have the average scores on the post-test.
Interaction among students (control group versus experimental group)	Conducting the quasi-experiment in different departments. For instance, Electrical engineering students for control group and Marine engineering students for

	experimental group. Moreover, the researcher can conduct the post-test for the control group and experimental group on the same time and same place. This means that they do the test together.

Table 3.14 : Strategies to minimize threats to external validity

External Validity	
Interaction Of Selection (Related To Generalizability Of The Results)	**Application of this study**
Other factors and assumption that treatment can affect the results - Unable to generalize to include outside groups because of racial, social, age, gender and personality differences.	Make all the samples of respondents who feel comfortable representing a population. In other words, the respondents would volunteer to do the tasks.

In order to analyze thematically and write up the findings of the study, mapping is an essential process for qualitative data. Kutsche (1998) suggested that the researcher need to map out a setting from the data collected without using the researcher's preconceptions or ideas. Consequently, the mapping process particularly uses five (5) senses. It consists of looking at the interaction of respondents with the environment. It should describe the correlation between engineering students' knowledge construction and instructional scaffolding. Besides, it aligns with the physical environment, such as SCL environment. This enables the researcher to know more and draw out as much detail as possible through the interview.

3.7 Data Analysis Procedures

In this quasi-experiment cum case study, the analysis process began with the data collection and identification of the knowledge construction levels (KCL). The researcher independently reviewed the data that could be used for the analysis.

3.7.1 Analysis on Quantitative Data Collection: Pre and Post-Test Based on Bloom's Revised Taxonomy of Cognitive Domain

In order to analyze research question 1, the researcher has to find out the engineering students' achievement in tests and knowledge construction levels (KCL). Thus, Bloom's Revised Taxonomy of Cognitive Domain is used. Quantitative content analysis was applied, focusing on the results of pre and post-test data collection.

At the initial stage, the researcher has a list of marks obtained from the test. Each question identifies the knowledge construction level. Hence, analysis can be carried out accordingly, in Table 3.15. The answer scheme referred to appendices E and F for the pre and post-test.

Table 3.15 : Marks obtained in each level of Bloom's Revised Taxonomy

Level of Knowledge Construction	Level of Bloom' s Revised Taxonomy	Question	Marks Obtained x	Question	Marks Obtained y	Sum marks x+ y =z	Ratio (r) = $\frac{\text{Sum marks}}{\text{Total marks}}$
Declarative	Remembering	1					$\frac{z}{2}$ =
Procedural	Understanding	2a		2b			$\frac{z}{5}$ =
	Applying	3					$\frac{z}{5}$ =
Argumentative	Analyzing	4					$\frac{z}{3}$ =
Metacognitive	Evaluating	5					$\frac{z}{4}$ =
	Creating	6a		6b			$\frac{z}{6}$ =
Achievement in Tests for each engineering student of each level of knowledge construction (overall)							$\frac{z}{25}$ =

After calculating the ratio, the results in Table 3.16 shows each respondent's knowledge construction levels. Then, the achievement in tests such as low, medium and high are identified, as presented in Table 3.17. The results of the engineering students' achievement in tests, and their knowledge construction levels, is based on the percentage of respondents who showed good achievement in tests, according to Bloom's Revised Taxonomy (presented in Table 3.18).

Table 3.16 : Achievement in tests for each respondent (students) of each level of knowledge construction based on Bloom's Revised Taxonomy

Respondent (Student, S)	Achievement in Tests						
	Remembering	Understanding	Applying	Analyzing	Evaluating	Creating	Overall
S1							
S2							
S_{n-1}							
S_n							

(n = total number of respondents)

Table 3.17 : Speculating engineering students' achievement in tests

Ratio (r)	Achievement in Tests
$0.8 < \mathbf{r} \leqslant 1.0$	High (H)
$0.40 < \mathbf{r} \leqslant 0.8$	Medium (M)
$\mathbf{r} < 0.40$	Low (L)

Table 3.18 : Number of respondents with good achievement in tests and percentage of respondents with good achievement in tests

Level of Bloom's Revised Taxonomy	Number of respondents with good Achievement in Tests			Percentage of respondents with performed well in Test
	High (H)	Medium (M)	Low (L)	
Remembering				
Understanding				
Applying				
Analyzing				
Evaluating				
Creating				
Overall				

3.7.2 Analysis of the Impact of Instructional Scaffolding in a Social Collaborative Learning (SCL) Environment

In order to find out the impact of instructional scaffolding in a social collaborative learning environment, the researcher needs to use different types of instrument to measure data collection.

3.7.2.1 Impact of Instructional Scaffolding in Social Collaborative Learning (SCL) Environment towards Achievement in Tests

Before the engineering students learn the different kinds of learning tasks through AOD on Facebook, the researcher needs to conduct a pre-test. In order to find out the impact of instructional scaffolding on engineering students' achievement in the test, the researcher has to carry out a post-test on the respondents after conducting the learning task in the SCL environment. Two sets of data to be collected on each engineering students' achievement in the tests. As shows in Table 3.19, the distribution of scores between pre- and post-test can be calculated using Excel software.

Table 3.19 : The distribution of scores between pre and post test

Respondent (Student, S)	**Pre Test score, *p***	**Post test score, *q***	**Score difference, r = *p* - *q***
S1			
S2			
S_{n-1}			
S_n			

(n = total number of respondents)

Moreover, Table 3.20 shows the engineering students' achievement in the pre and post-test, showing whether it had improved or regressed. If the mean score of the post-test is higher than the mean of the pre-test, it indicates that achievement is improved. On the other hand, if the mean score of the post-test is lower than pre-test, it indicates that achievement has regressed.

Table 3.20 : Tabulation of engineering students' achievement in tests

Achievement in Test	Number of respondents, n	Percentage (%)
Improve ▲		
Regress ▼		

3.7.2.2Impact of Instructional Scaffolding in Social Collaborative Learning (SCL) Environment towards Knowledge Construction Levels

After conducting instructional scaffolding in the learning tasks, the post-test was to the engineering students. The data was analyzed, as in 3.7.1. The questions of the test aimed to assess the students' KCL of their learning process during the learning tasks. These were related to the online interactions via AOD on Facebook.

Reviewing the theoretical framework as mentioned in Chapter 1, the researcher used the model developed by Gunawardena, Lowe and Anderson (1997) to promote and enhance students' knowledge construction level. The interaction analysis model of Gunawardena, Lowe and Anderson (1997) was applied to analyze the transcripts. There are five (5) levels of knowledge construction through learning activities: (1) sharing and comparing of information, (2) discovering and exploring of disagreement, (3) negotiating meaning, (4) evaluating and testing synthesis, and (5) agreement statements and application of new knowledge construction.

The AOD groups posting the scripts can be used to analyze the impact of instructional scaffolding towards KCL as shown in Table 3.21.

Table 3.21 : Knowledge construction level promoted and enhanced through the model given by Gunawardena, Lowe and Anderson (1997)

Level of Knowledge construction	**Level of knowledge construction in the interaction analysis scheme of Gunawardena, Lowe and Anderson (1997)**	**Learning Task (LGC, a figure (diagram), a problem-solving question)**	**Example of Posting scripts from respondents**
Declarative/ Conceptual	Sharing	Share their existing knowledge before SLE (without YouTube)	How does a car move on the road?
	Comparing	Similarities of knowledge	How does velocity affect the acceleration of the car?
Procedural	Discovering	Search YouTube to learn about related topic	How about search from YouTube?
	Exploring	Explore more knowledge through YouTube	Let's find out more from any others resource related to linear motion.
Argumentative	Negotiating	Discuss different ideas to achieve an agreement	How do we discuss the differences of displacement versus time graph?
Metacognitive	Evaluating	Synthesize all the LGC and diagrams of displacement versus time (=velocity)	How do we combine all the learning content and diagrams of displacement versus time?
	Applying (new knowledge)	Design highway with Linear motion knowledge. Summarize the whole topic and relate it to the specific objectives of linear motion	How do we apply this new knowledge in the engineering field?

The Gunawardena, Lowe and Anderson (1997) model has been used in several empirical studies (Marra Moore and Klimczak, 2004; Schelllens and Valcke, 2005; Schellens, Van Keer and Valcke, 2005; De Wever *et al.* 2006, 2008). This model is a holistic view of discussion flow and knowledge construction (Marra *et al.*, 2004). Schelllens and Valcke (2005) claimed that validity of the instrument of Gunawardena, Lowe and Anderson (1997), especially the first three levels of knowledge construction, are similar to Veerman and Veldhuis-Diermanse (2001). Furthermore, there are advanced KCL in Gunawardena, Lowe and Anderson's model, such as applying newly constructed knowledge in coding the discussions. It is found that a discussion of the content analysis scheme of Gunawardena, Lowe and Anderson can support interaction, together with a discussion of coding.

Thus, the researcher uses the Gunawardena, Lowe and Anderson (1997) model to identify engineering students' KCL. It is related to collaborative assignment and problem-solving assignments, like a question.

As shows in Table 3.22, there is frequency of posting scripts from the respondents which comprise of level of knowledge construction. The data would be transferred to Table 3.23 to determine the percentage of each level of knowledge construction based on the Gunawardena, Lowe and Anderson (1997) model.

Table 3.22 : Summary of posting scripts on Facebook discussions based on Gunawardena, Lowe and Anderson (1997)

Episode	Level of Knowledge Construction	Elements of learning activities	Number of Posting Scripts						Sum
			Team 1	Team 2	Team 3	Team 4	Team 5	Team 6	
1		Assign grouping, role, task							
2a	Declarative	Sharing and comparing							
2b	Procedural	Discovering and exploring							
2c	Argumentative	Argumentative / Negotiation of meaning							
2d	Metacognitive	Synthesis / application of new knowledge in Engineering field							
	Total								

n= number of teams

Table 3.23 : Summary of posting scripts in percentage based on Gunawardena, Lowe and Anderson (1997) for Task 1 (LGC project)

Episode	Level of Knowledge Construction	Elements of Learning Activities	Number of Percentage in Posting Scripts						Sum
			Team 1	Team 2	Team 3	Team 4	Team 5	Team 6	
2a	Declarative	Sharing and comparing							
2b	Procedural	Discovering and exploring							
2c	Argumentative	Argumentation / Negotiation of meaning							
2d	Metacognitive	Synthesis / application of new knowledge in Engineering field							
	Total								

Thus, the researcher used one (1) online expert with technology, employed to check the online discussions content to get percentage of agreement from two or more examiners.

3.7.3 Analysis of Qualitative Data Collection: Online Collaboration on LGC Assignment and Problem-Solving Assignment (a problem-solving question)

In order to analyze research question 2 after conducting online web-based instructional scaffolding, the researcher needed to conduct interviews with engineering students. Thus, an interview script was used. The interview session was audiotaped and transcribed into a thematic analysis, based on instruction by Braun and Clarke (2006). The transcript would explain how instructional scaffolding in the SCL environment cognitively steers engineering students towards knowledge construction.

In order to analyze research question 3, the researcher used similar steps as stated previously in analysis research question 2. The finding from thematic analysis can determine how SCL environment guided with instructional scaffolding as an important factor that stimulates engineering students into a higher level of knowledge construction.

3.7.4 Analysis on Qualitative Data Collection: Content Analysis by Using Outline Mapping Concept and Thematic Analysis Based on Braun and Clarke (2007)

Coding is the initial steps of qualitative analysis (Punch, 2005). There are different types of coding:

- In vivo codes: focusing on what is in the data (researcher needs to focus (1) on instructional scaffolding that can cognitively steer engineering students and (2) on engineering students reaching a higher level of knowledge construction).
- Open codes: discovering abstract concepts in the data (the researcher has labelled data from the interview transcripts)
- Axial codes: discovering connections between abstract concepts (the researcher has to find out and see the patterns and connections between instructional scaffolding and engineering students' level of knowledge construction)
- Selective coding: raising the level of abstraction again to the core category

Figure 3.6, illustrated the different types and level of coding. Thus:

- The first level of coding: first level descriptive and low inference.
- The second level of coding: higher level analysis and high inference, as well as finding the patterns and/ or interpretation.

Table 3.24 shows an example of relationships between open coding, selective coding, core category, as well as an examples of interview statement to construct theme building (Punch, 2005).

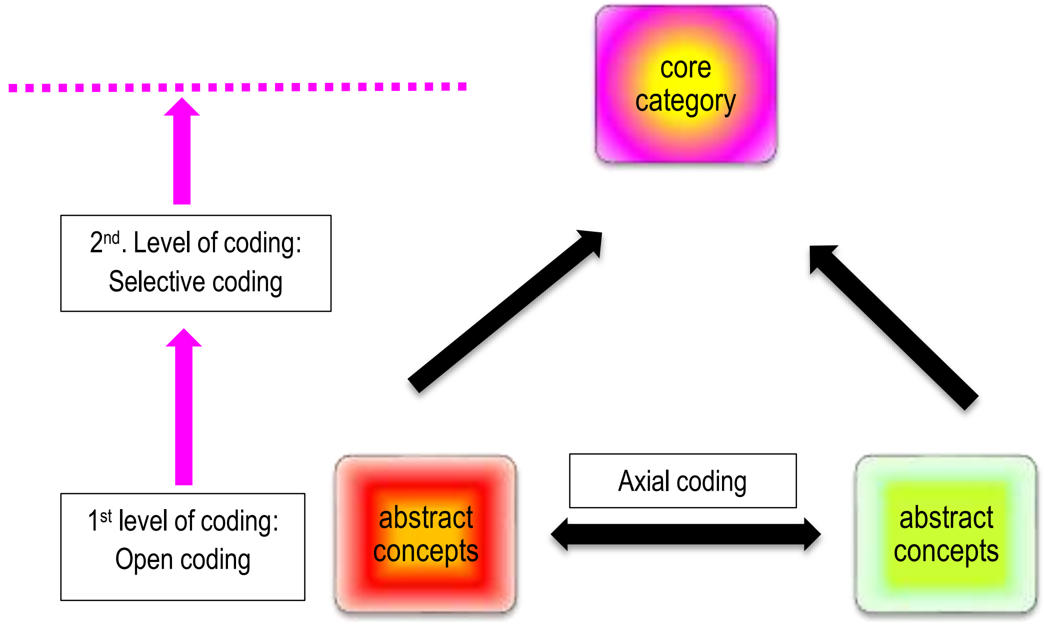


Figure 3.6 Different types and levels of coding (Source: Punch, 2005)

Table 3.24 : Inter correlation between open coding, selective coding, core category and examples of interview statement in theme building

Core category	Selective coding	Description	Open coding	Examples of interview statement
Students' cognitive Pre-engagement	Benefits	Asking group member to engage in the learning tasks	Learning via collaboration	What are the benefits when you are provided guidelines (see Appendix A (learning/learner generated content) and Appendix K (Learning activity Task 2) for all the learning tasks and collaborative learning activities via Facebook discussions?
				How does it affect your knowledge construction?

The qualitative data analysis and interpretation are from the content analysis by using outline mapping and thematic analysis of the structured interviews. Then, the researcher entered the text into MS Word for data analysis. The researcher conducted a “line-by-line” analysis of the transcripts. After that, the transcripts were coded. Each coding (or category) was constructed directly into themes.

Coding is used to construct description and themes. Each theme represents both specific quotes and subthemes. The results and findings are obtained through interpretation of this study. However, there are no limitations of the study and suggestions for future research (Creswell, 2014).

The data from the test, field notes and transcribed data have been reviewed several times. Data from different data collections in the groups were compared, sorted and coded into the initial list of thematic categories based on emerging themes, keywords and phrases using the layering themes (Creswell, 2014). According to Creswell (2014), the coding process is an inductive process that reduces the initial list of categories into a few central themes.

The researcher used computer software (Mindjet Mind Manager) to analyze the transcribed interviews to get usable information. This addressed the qualitative analysis steps of sorting, organizing, assigning codes and themes to understand the central phenomenon of the study (Creswell, 2014).

In order to construct the core category, there are several processes for researcher to implement:

- **Summative Content analysis (Probing or Key words)**

After conducting the interview, the recording was transcribed into Microsoft Word, with date and time, name and contact number of interviewees and questions, for each interview question statement. After transcribing all the discourse or dialogue, researcher played again the audiotape to prove the Word transcription is free of any mistake or any error in data entry. The content analysis scheme is applied to analyze the transcripts in order to look for similar probing words to construct theme or core category for each interview statement. The guidelines on how to conduct the summative content analysis can be referred to in Appendix K. Next, the transcripts were coded independently.

- **Content review**

After the coding activity, the researcher worked with coding through Mindjet Mind Manager's software to produce an outline map to figure out interviewees' ideas on the eight (8) elements of instructional scaffolding (Hogan and Pressley, 1997) (see Appendix Q).

An overview outline map was drawn for the qualitative data collection process for ten (10) interviewees to figure out details in interview as shows in Appendices Q and R. These map comprised interviewees' ideas on instructional scaffolding processes embedded in SCL environment cognitively steer engineering students towards knowledge construction, important and less important essential elements of instructional scaffolding, as well as their opinions on characteristics of SCL (C3I: condition, interactions, immediacy and intimacy) when the researcher implemented learning activity via Facebook discussions.

In order to determine qualitative reliability on open coding, selective coding and core category or theme, the researcher had invited second coder to check the theme for inter-rater reliability before looking for patterns (paradigm) across interview. Results show 90% and above of the probing words or keywords are same as the researcher's. This means second coder agreed with researcher's analysis on the field note.

Meanwhile, the interviewees were requested to examine the raw data again after the researcher had done the correction based on their feedback to determine the accuracy and reliability of data. The researcher also used the post positivist lens or systematic paradigm to carry out the validity of qualitative analysis as summarized in Table 3.25. In addition, the researcher used thematic analysis to find out the core category which would be discussed in the next section.

Table 3.25 : Validity procedures and paradigm assumptions
(Source: Adapted from Creswell and Miller, 2010)

Paradigm assumption/Lens	Lens of the Researcher	Lens of Participants or Interviewees	Lens of People External to the Study (Reviewers, Readers such as supervisor)
Post positivist or Systematic Paradigm	Triangulation	Member checking	The audit trail

Thematic analysis

The researcher utilizes inductive approach relying on codes, categories or themes directly drawn from the field. Inductive method is used to draw generalizations. Reflect and elaborate the process of interaction in the field note. Thus, the researcher does thematic analysis based on Braun and Clarke (2007). There are several steps when implementing this analysis to form major theme or concept (core category):

1. Familiarising with the data

   Keep on 'repeatedly read' the data in an active way comprising meaning search, patterns and so on.

2. Generate the initial codes

   The essential idea is about what the data is related to and what it is interesting about. Raw data can be evaluated in a meaningful way of the phenomenon (Boyatzis, 1998).

3. Searching for the theme or category

   Collect all the relevant codes data within the identified theme. Then, use the table or mind-maps to visualize and represent the data in order to sort the different codes into themes. Then, start to think about the relationship between codes, between themes and between different levels of themes.

Simultaneously, the researcher has a sense of whether the theme needs to be combined, refined and separated or eliminated from the code list.

4. Reviewing the theme

   Justify the categories whether internal homogeneity or external homogeneity. The data within the theme should link together and form a coherent pattern. Then, theme the code into second level and relate it to the entire data set.

5. Defining and naming theme

   The researcher needs to define and refine the theme again from the second level of theme. It means identifying the gist (essence) of what each theme is about.

6. Producing the report

   A full set of worked out theme is produced by the researcher. Then, write up a story about data within and intercourse (interconnect) themes, providing a concise, coherent, logical, non-repetitive and interesting topic to the research question two.

Memos Linkages

A memo linkage is a set of quotations and codes. This network view can be interpreted as follows: what researcher writes in this memo is illustrated well by those eight (8) quotations and they are related to the concepts represented by these codes. See Figure 3.7.

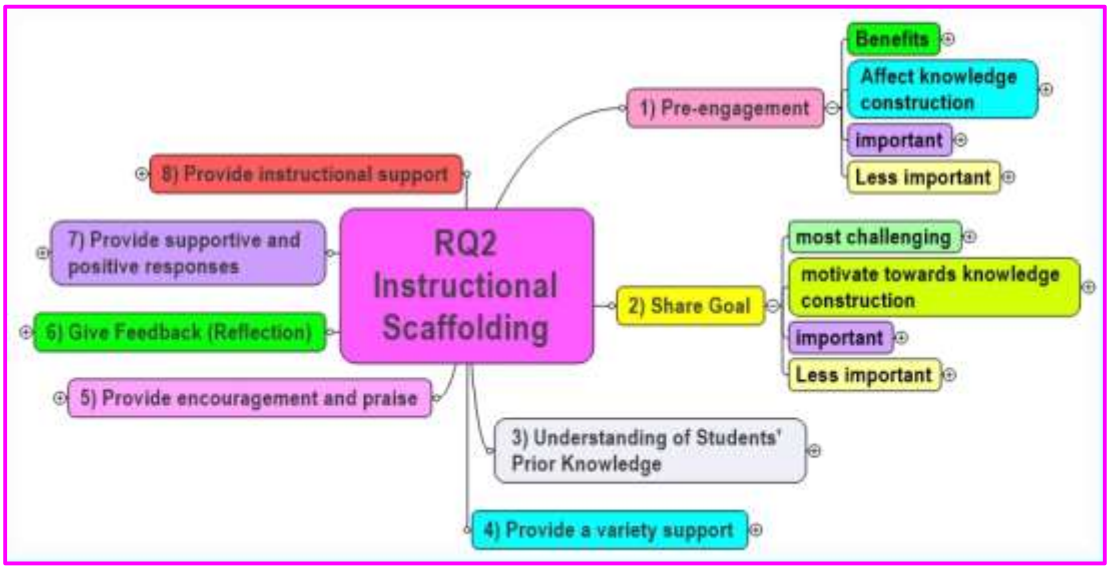


Figure 3.7 Network view of a memo

Representations connecting codes to codes, and quotations to quotations, can bring out the meanings. This network view represents a meaning that the researcher has defined through interpretation. Thus, the establishment of these linkages is an intrinsic component of the qualitative data analysis process whereby the researcher has to determine the way in which concepts, themes (category) and the words of the interviewers relate to each other.

See Figure 3.8, it is a concept map representing the researcher's understanding of instructional scaffolding affecting engineering students' knowledge construction processes, derived from the analysis of the raw data.

On the other hand, the network view representation of quotation to quotation linkages (hyperlink's) resembles an argumentation map. That is, the network view shows how arguments relate to each other. There are several questions such as:

- How do study interviewees (participants) construct their argument (important, less important or neutral of instructional scaffolding elements)?
- How do arguments contradict other arguments (if they do at all)?
- How do they support each other?
- Is what one interviewee is saying expanding upon what the other interviewee is saying? If so, how?
- How do some arguments illustrate other arguments?

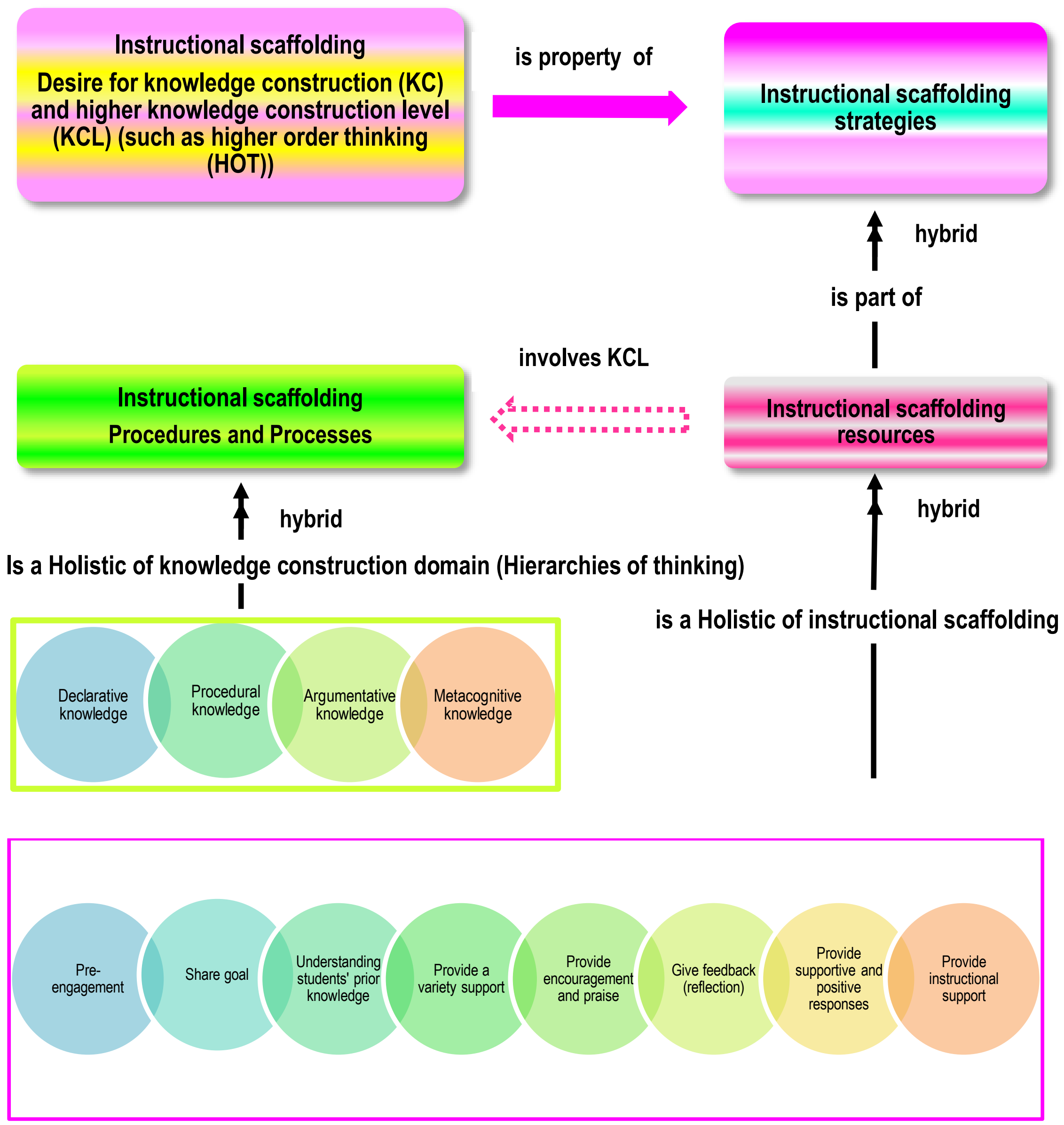


Figure 3.8 Network view showing code to code sematic linkage

In conclusion, it is important to visualize researcher's works in the form of network views because through them researcher may have insights that might not have been able to have looking at fragments, at pieces disconnected from each other. Those insights constitute the core of an analysis process. Through them researcher can construct the holistic representation of researcher data from field work (raw data) that is essential in every qualitative data analysis process.

3.7.5 Analysis of Knowledge Construction Model

Regarding the outcomes of knowledge construction model in this study, the researcher gathered the data collection from research questions 1, 2 and 3. Then, the researcher would build the theme with a content analysis scheme. It was applied to analyze the transcripts of the discussion groups related to the collaborative assignment on LGC and the problem-solving assignments. From the theme building, the researcher was able to find the core category from open coding and selective coding to see the pattern of knowledge construction model (KCM), knowledge construction level and the elements need to consist of KCM.

Therefore, there are several elements in this predicted knowledge construction model:

1) Instructional scaffolding (IS)

   The uses of scaffolding to support, motivate, encourage and guide the facilitator to enable engineering students to acquire new knowledge via problem solving

2) Characteristic of SCL

   The researcher would concern about C3I (condition, interaction, immediacy and intimacy) when conducting learning activities to the engineering students for discuss their LCG task. They negotiate the learning content and actively engaged in the process of knowledge construction. They can also self-reflect about learning related to the contents of the Engineering Science course.

3) Knowledge construction levels

   There are two categories of cognitive domain: low and high, which consist of different classifications of knowledge construction such as those declarative or conceptual, procedural, argumentative, and metacognitive. Each type of knowledge construction has its own role in the process of learning domain.

3.8 Summary

Overall, the research methodology consists of the research design, made up of two (2) phases (collaborative learning and social learning) of set up the online social collaborative learning environment. Then, the research procedure and sampling are explained. This is followed by conducting research instruments, which involves four (4) types of instrument: pre and post-test, online collaborative assignments on LGC and problem-solving questions of linear motion experiment through AOD on Facebook group discussions, questionnaire as well as structured interviews.

To obtain certain information on the actual field study, a pilot test to be conducted. The aim of the pilot test is to detect weaknesses of the research design. This means that correction can be made before the actual study is carried out at the field research (Zainudin Awang, 2012). This will be discussed in detail in the chapter 5 Data Analysis and Finding.

CHAPTER 4

DESIGN OF SOCIAL COLLABORATIVE LEARNING ENVIRONMENT

4.1 Introduction

The researcher has given attention to the design of systematic learning strategies or learning environments. This chapter comprises two sections. The first section describes the setting of hybrid learning environments. It covers collaborative learning (Dillebourg *et al.*, 1996), social learning (Tu and Corry, 2001) and social presence (Reio and Crim, 2013). In the second section, the researcher further discusses the setting of hybrid learning activities for learners or learning generated content (LGC) tasks for an engineering science course via Facebook discussions.

4.2 Setting a Learning Environment in the Engineering Context

In order to develop a social collaborative learning (SCL) environment to apply to engineering students, the researcher has manipulated the characteristics of (a) conditions (b) interactions (Dillebourg *et al.*, 1996), (c) social context (informal) (d) online communication (e) interactivity (Tu and Corry, 2001); (f) immediacy and (g) intimacy (Reio and Crim, 2013) when implementing the learning activities with them.

Thus, the researcher has provided the guidelines as presented in Appendix A to enable the engineering students to carry out the LGC task smoothly. These guidelines were posted on a Facebook platform. The engineering students were required to deploy these guidelines to carry out their task via Facebook discussions.

4.2.1 Characteristic 1: Conditions

There are several elements of the conditions parameter, as given:

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

Students demonstrated successful task engagement in the SCL environment that allowed them to work together, as illustrated in Figure 4.1. For instance, engineering students can generate new ideas when they discuss a subject together in a group via the Facebook platform. Facebook is a social media platform which involves students sharing and comparing their points or ideas through asynchronous online discussion (AOD). It also works as a means of asynchronous collaboration. This means that engineering students can help their peers to solve tasks through Facebook discussions. They share YouTube videos with each other. At the same time, they can also watch and discuss them in order to construct their knowledge. This can lead them to acquire new knowledge. In addition, working together can assist them in solving the ill-structured problem questions in Engineering Science tasks given by facilitators or instructors.

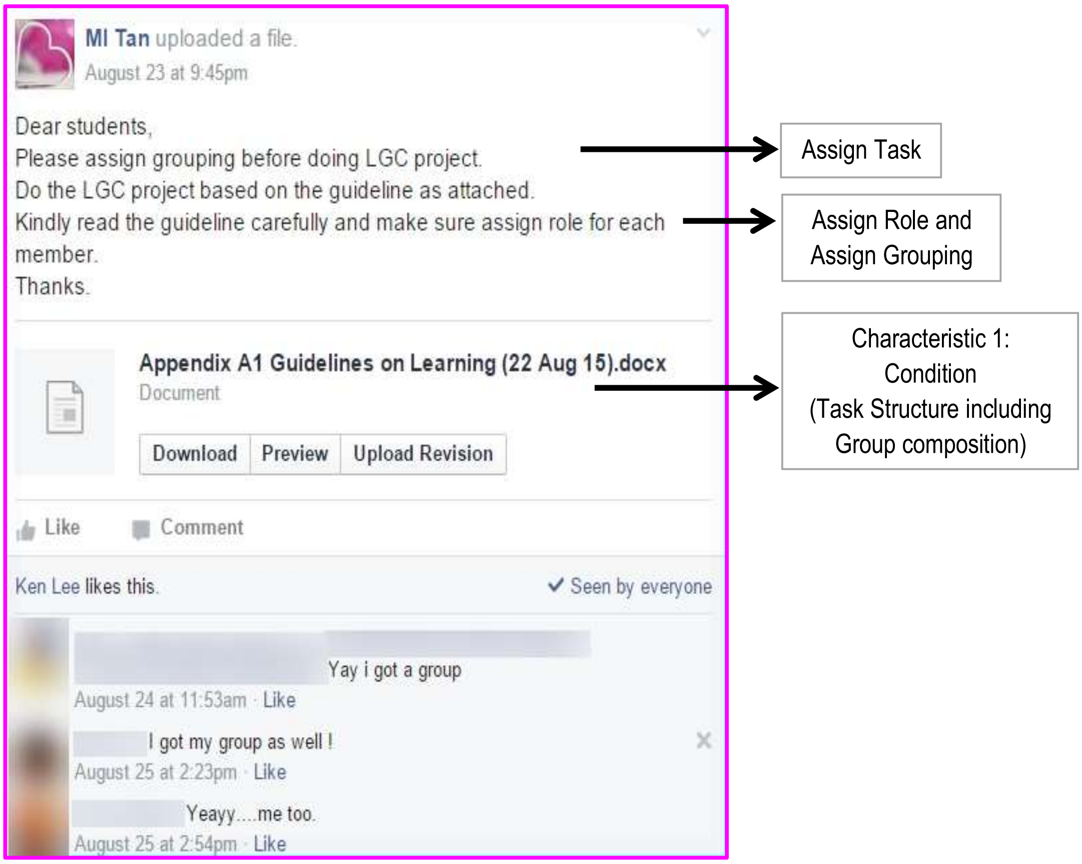


Figure 4.1 Guideline posted on the Facebook discussions (Conditions: group composition and task structure) (Team 1)

Figure 4.2 shows that the researcher has adopted a collaborative context to lead engineering students to become active learners. They can further discuss the learning content, which is to clarify the misconception in the learning process, notably in the Engineering Science course. Moreover, the one-content-fits-all approach of T&L has been gradually replaced in the SCL environment. Such an environment brings benefits to students, who can better understand their knowledge construction when implementing it through Facebook discussions. Moreover, engineering students can learn better if they interact regularly in an online learning environment (Yeo, 2013).

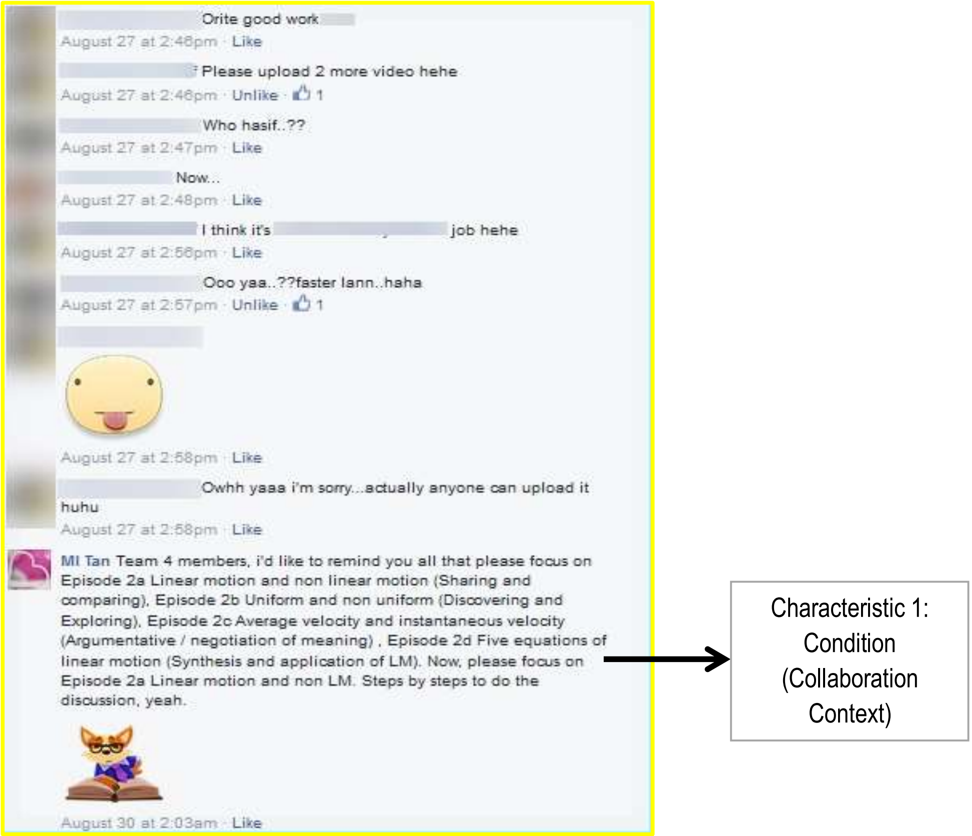


Figure 4.2 Collaboration context posted on the Facebook discussions (Team 4)

On the other hand, the engineering students faced a challenge as to how to communicate effectively with their peers when conducting LGC tasks in Facebook discussions. Hence, the researcher needed them to communicate in English. They would get forfeits if they used any other language when discussing their learning content. Figure 4.3 shows an example of a student reminding his peers to adopt English to carry out their discussions through Facebook towards knowledge construction.

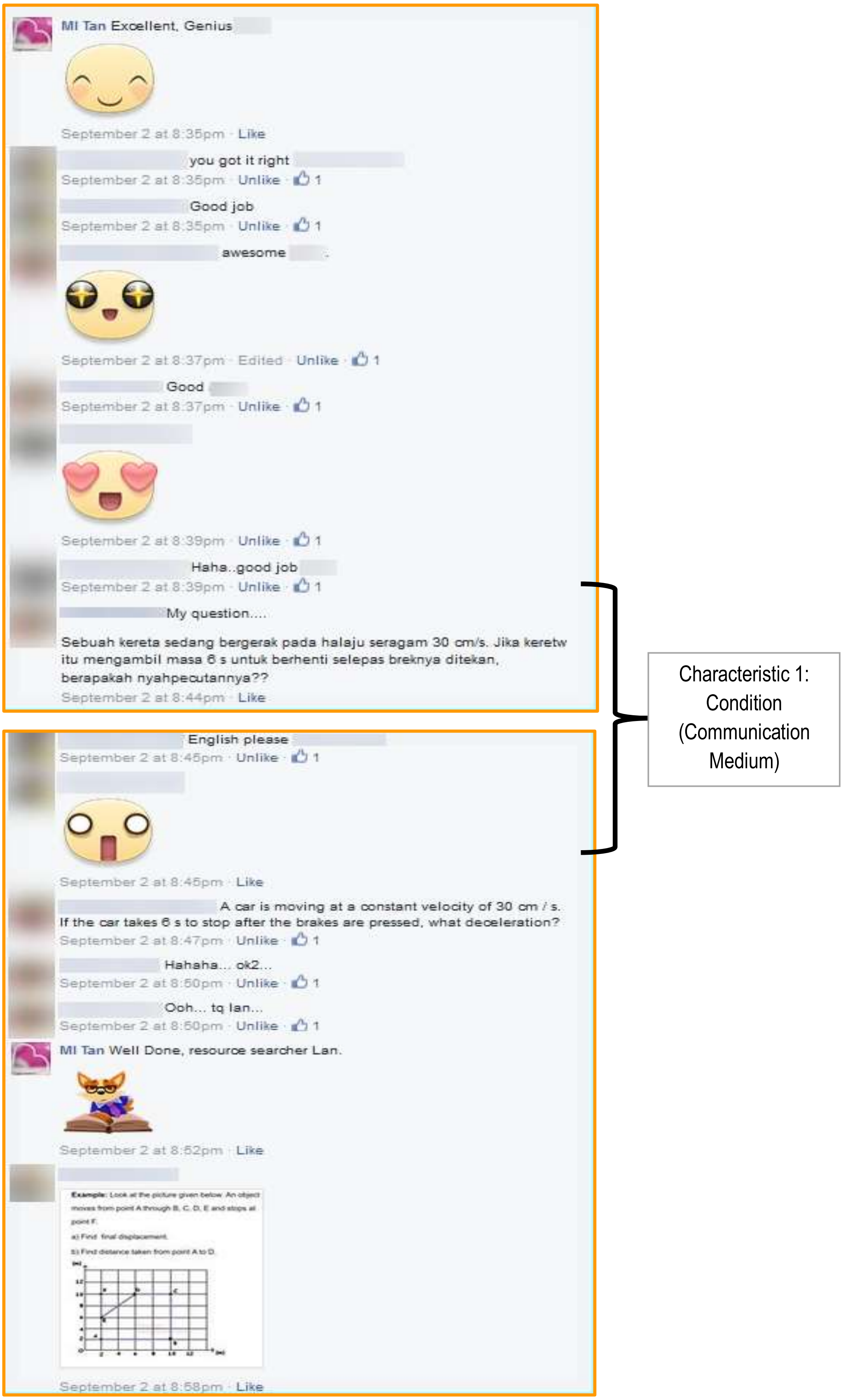


Figure 4.3 An example of a communication medium posted on the Facebook discussions (Team 4)

4.2.2 Characteristic 2: Interactions

In order to make engineering learning more enjoyable and meaningful in knowledge construction, the researcher needs to integrate several elements of interaction for students when implementing metacognitive activities in asynchronous online discussions.

Interactions may be related to the learning condition and learning outcomes, which consist of certain elements, as stated below:

i. Elaborate explanation
ii. Control
iii. Socio-cognitive conflict
iv. Negotiation
v. Argumentation

(Dillebourg *et al.*, 1996)

These elements represent the essence of the communicative link between the student, his or her peers and the instructor in the Facebook discussions. Thus, they must actively participate in the learning process towards knowledge construction. Figure 4.4 shows how the instructor gives a more elaborate explanation of two concepts of velocity, namely instantaneous velocity and average velocity, in order to improve students' understanding of the linear motion topic.

Figure 4.4 The elaborate explanation posted on the Facebook discussions (Team 1)

In addition, the instructor or facilitator has the potential to influence the students' knowledge construction via learning environments (Entmalonwistle and Tait, 1995). During the engineering lesson, students have the passion to construct their knowledge. One of the elements of interactions that must be considered is control. This means that the instructor should monitor comprehensively the metacognitive activities and instructional scaffolding applied in the Facebook discussions. The outcome can be seen in Figure 4.5, which shows how the instructor controls the interaction. The main purpose of instructional scaffolding is to encourage interaction between peers and with the instructor in the SCL environment to construct knowledge. In other words, instructional scaffolding can promote students to generate their knowledge from general to detailed knowledge in the process of knowledge construction and increase learning through social interaction, involving negotiation of learning contents and understanding of the students' needs.

Figure 4.5 An example of the control element posted on the Facebook discussions (Team 6)

The third element of interaction is socio-cognitive conflict. It makes the discussion very impressive by enabling instructor-student and student-student interaction to take place in the SCL environment. As demonstrated in Figure 4.6, engineering students continue to discover and explore the knowledge in order to gain higher levels of knowledge construction more effectively when they face the social-cognitive conflict effect. In order to address this situation, the instructor or facilitator needs to design the SCL environment to support and lead them to understand the topic better and to improve their level of knowledge construction. Typically, scaffolding is also defined as being "guided by others" (Stone, 1998) in order to complete complex tasks in the Engineering Science course.

Furthermore, interaction involves the parameter of negotiation. This might comprise negotiation of meaning in order to achieve agreement between the instructor and the student as well as between peers. Thus, the engineering students have to reflect or give feedback when discussing engineering knowledge in the process of knowledge construction. The SCL environment can therefore be improved with “reflection”, which provides engagement to enable them to learn the content, and has a positive impact towards knowledge construction. Reviewing Figure 4.7, there are some examples of negotiation elements posted on the Facebook discussions.

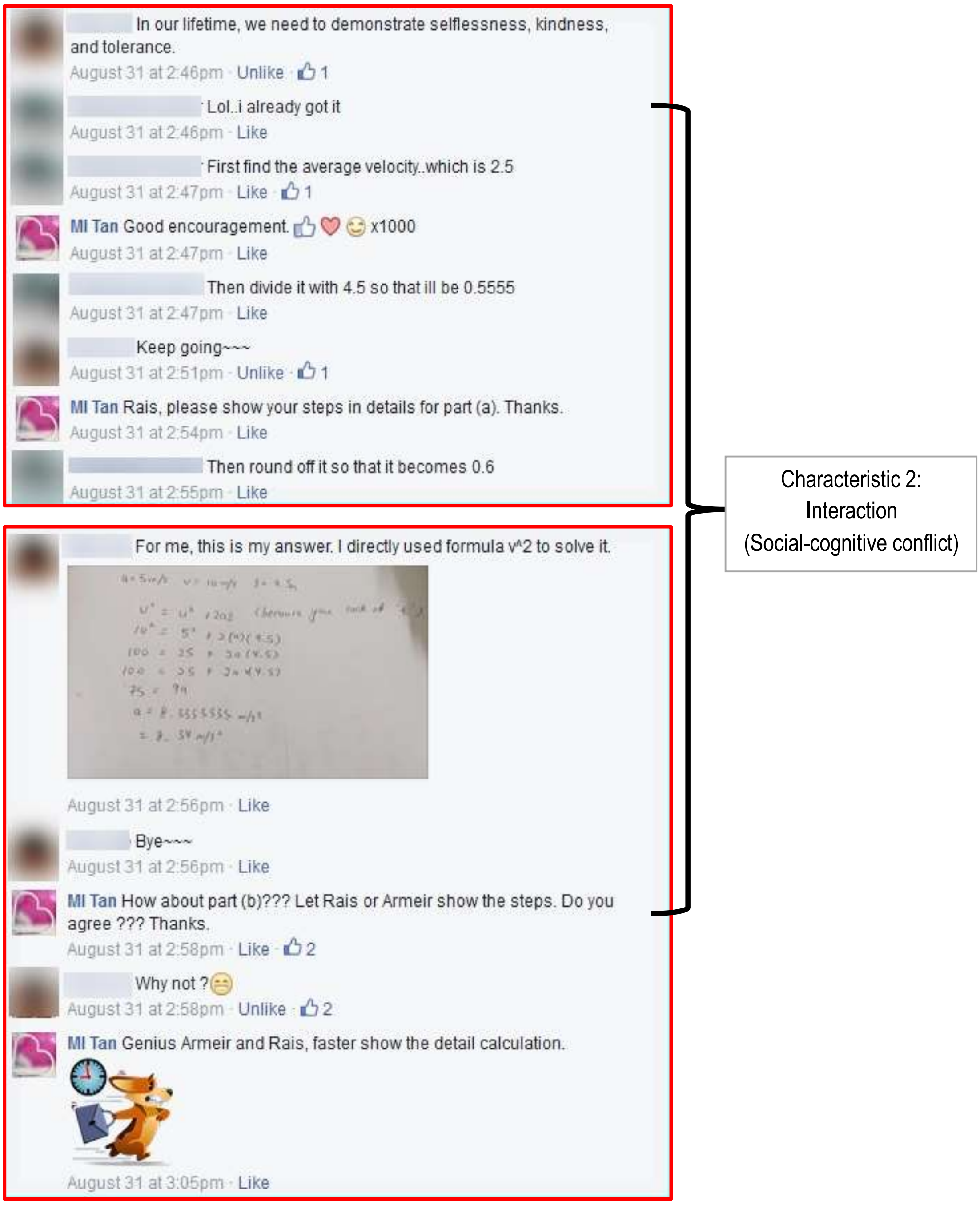


Figure 4.6 An example of social-cognitive conflict posted on the Facebook discussions (Team 1)

Figure 4.7 Some examples of negotiation elements posted on the Facebook discussions (Team 2)

Figure 4.8 Examples of inviting argumentation of meaning posted on the Facebook discussions (Team 5)

Argumentation is one of the elements in the interaction parameter. Argumentative discussion about the learning content enables learners to incorporate different ideas from their peers when conducting a discussion through Facebook (see Figure 4.8). Moreover, they may know how to differentiate the meanings of terminology in the linear motion topic, such as distance and displacement, speed and velocity, instantaneous velocity and average velocity, among others. Thus, argumentation can help them to conduct their analysis better towards knowledge construction while providing scope for discussion in the SCL environment.

4.2.3 Characteristic 3: Social Context (Informal)

In light of the above, it appears that engineering students are able to construct their knowledge in informal learning environments such as online learning, also known as social learning (Yeo, 2013). They have more choices of what to learn, how to learn and when to learn, as shown in Figure 4.9. They can perform well in constructing knowledge in their learning process, particularly in the SCL environment. They see and learn from their peers through the various social media technology (SMT) applications (Maloney, 2007). Web 2.0 is participatory and collaborative in nature, enabling students to learn by doing. Engineering students can gain and construct knowledge and skills from their daily experience and social environment.

Furthermore, the social or online learning needs to be implemented and applied among engineering students to support them to increase their competence in knowledge construction. In other words, instructors should be able to set up appropriate learning environments such as SCL to assist engineering students in constructing knowledge. They will thus be able to acquire new, higher levels of knowledge as well as meaningful cognitive outcomes.

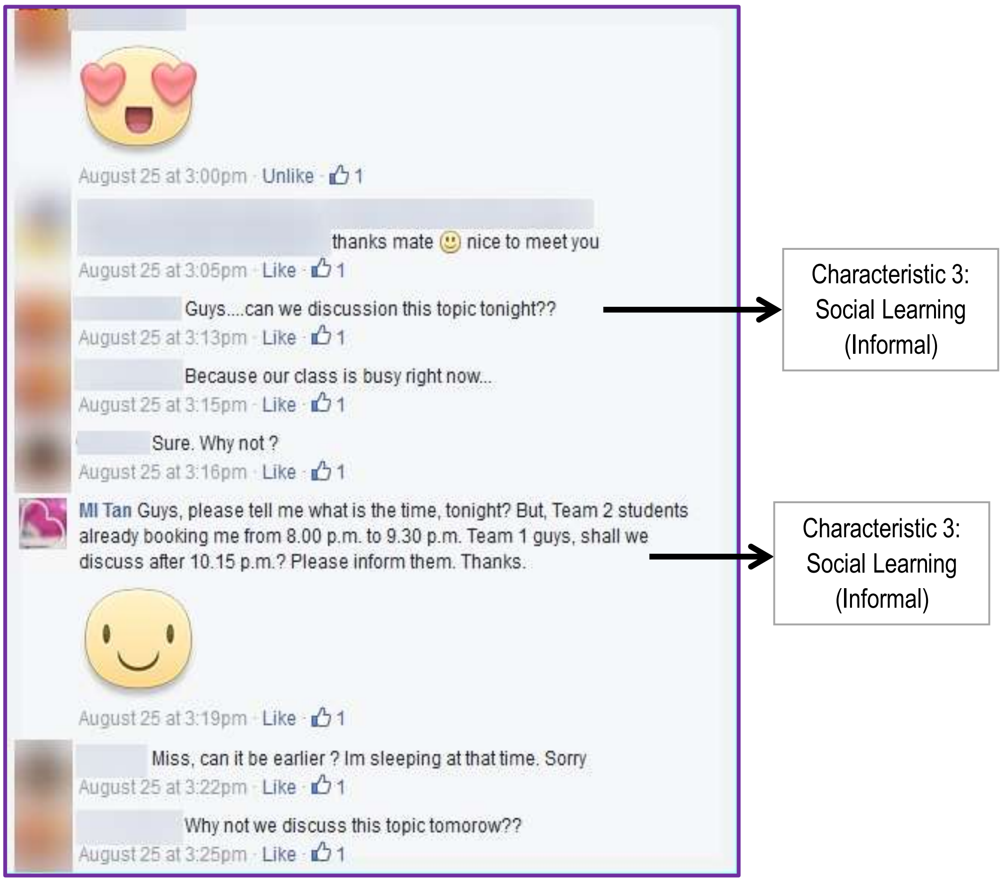


Figure 4.9 An example of social context (informal) posted on Facebook discussions (Team 1)

4.2.4 Characteristic 4: Online Communication (Real Time Discussion)

Online communication is a form of socio-cognitive experience (McLoughlin and Luca, 2011). The social learning (SL) environment is part of the socio-cultural environment (Vygotsky, 1978). It also emphasizes socially shared discussions in constructing knowledge. It has a positive impact on students' learning and collaboration (McLoughlin and Luca, 2011) where metacognitive activities will become a group activity rather than individuals' performance. Engineering students love using YouTube videos to solve the learning tasks. They discover and explore these videos via Facebook discussions. They can enjoy studying and solving the problems (tasks) when they engage in AOD with their peers to gain higher levels of knowledge construction in the SCL environment. Figure 4.10 illustrates the real-time discussion when they promptly feed-back the learning activity to their instructor and teammates. This can engage them in the Facebook discussions in order to construct knowledge, although the discussion (communication) is asynchronous.

The social learning environment is a resource of shape, thought and action through the use of social media technology (SMT) tools. This means that SL can enhance forethought, performance control and self-reflection (Pifarre and Cobos, 2009). Thus, the researcher integrates with SMT to enhance engineering students' achievement of higher levels of knowledge construction.

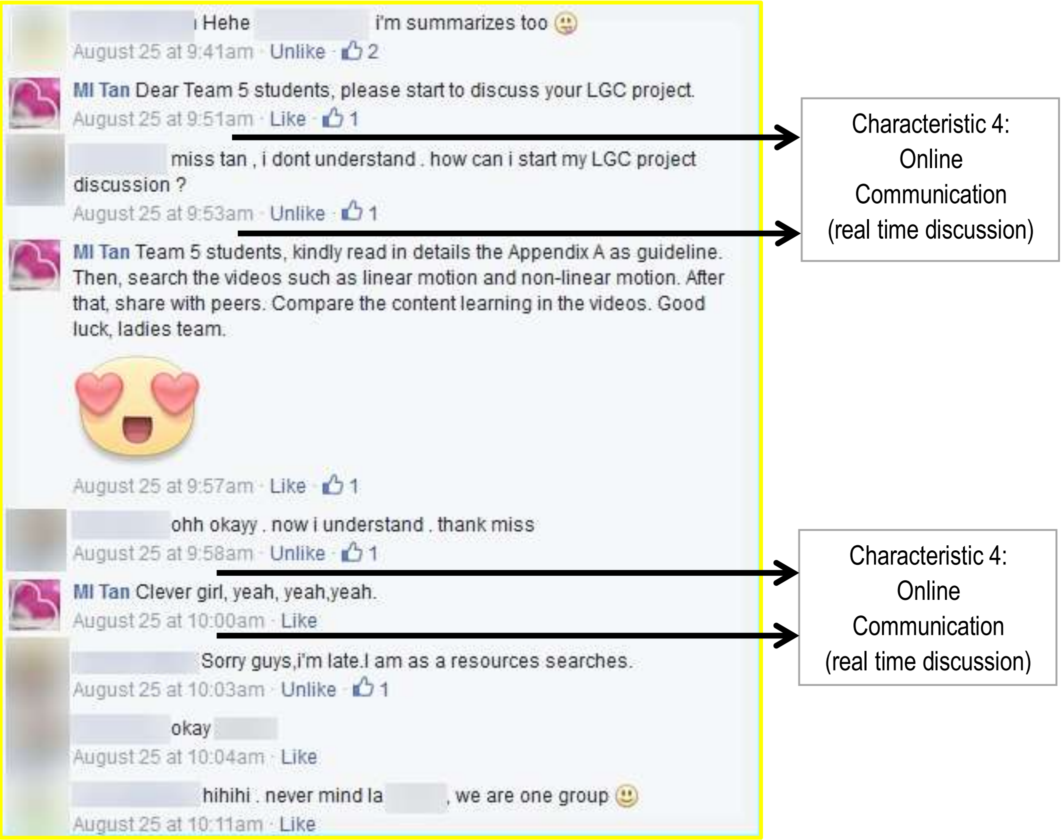
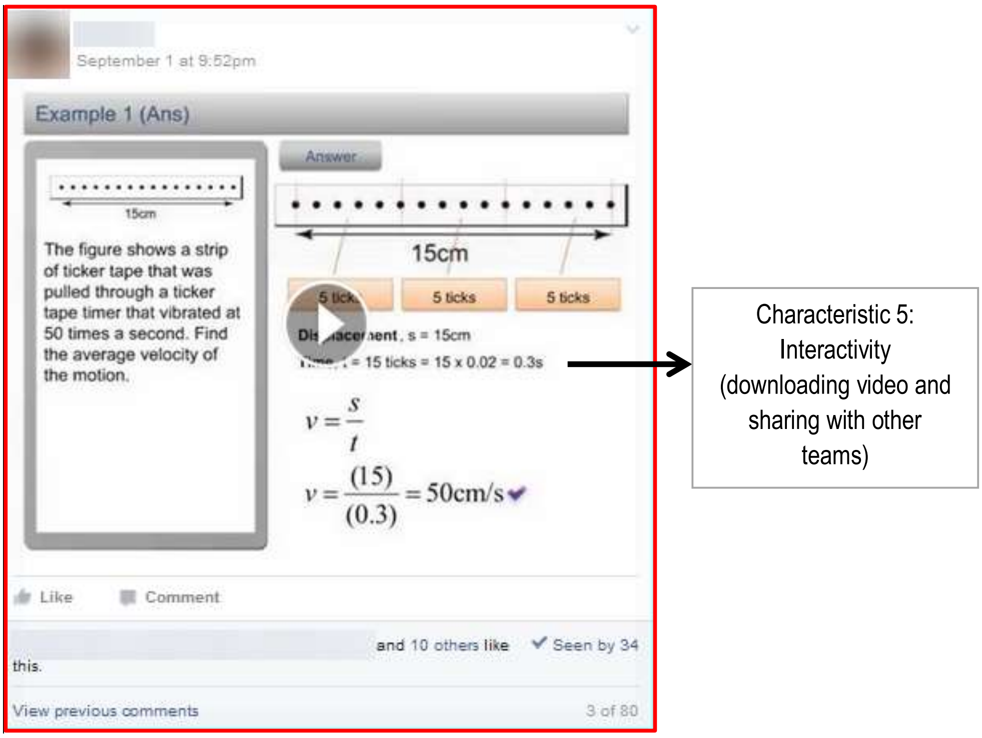


Figure 4.10 An example of online communication (real time discussion) posted on the Facebook discussions (Team 5)

4.2.5 Characteristic 5: Interactivity

The researcher set task 2 to enhance collaborative peer-to-peer knowledge construction in order to encourage engineering students to actively participate in AOD. The guidelines for this learning activity are set out in Appendix L. With reference to Figure 4.11, Ken Lee and Fatin Najihah downloaded and posted videos through the Facebook platform. The researcher needed them to interact with each other, which involved sharing and comparing views (points or opinions), as well as discovering and exploring resources from YouTube, Search Engines and Wikipedia to solve difficult tasks in the Engineering Science course.

On the other hand, students can interact with social media in order to come together to discuss the learning content via Facebook. In this way, the quality of the interaction between instructors and students as well as among students can be ensured. Some of the engineering students spend their free time explaining difficult and ill-structured problems to others. Further, they are more likely to enjoy being taught. This type of interactivity makes the process of knowledge construction more fun.



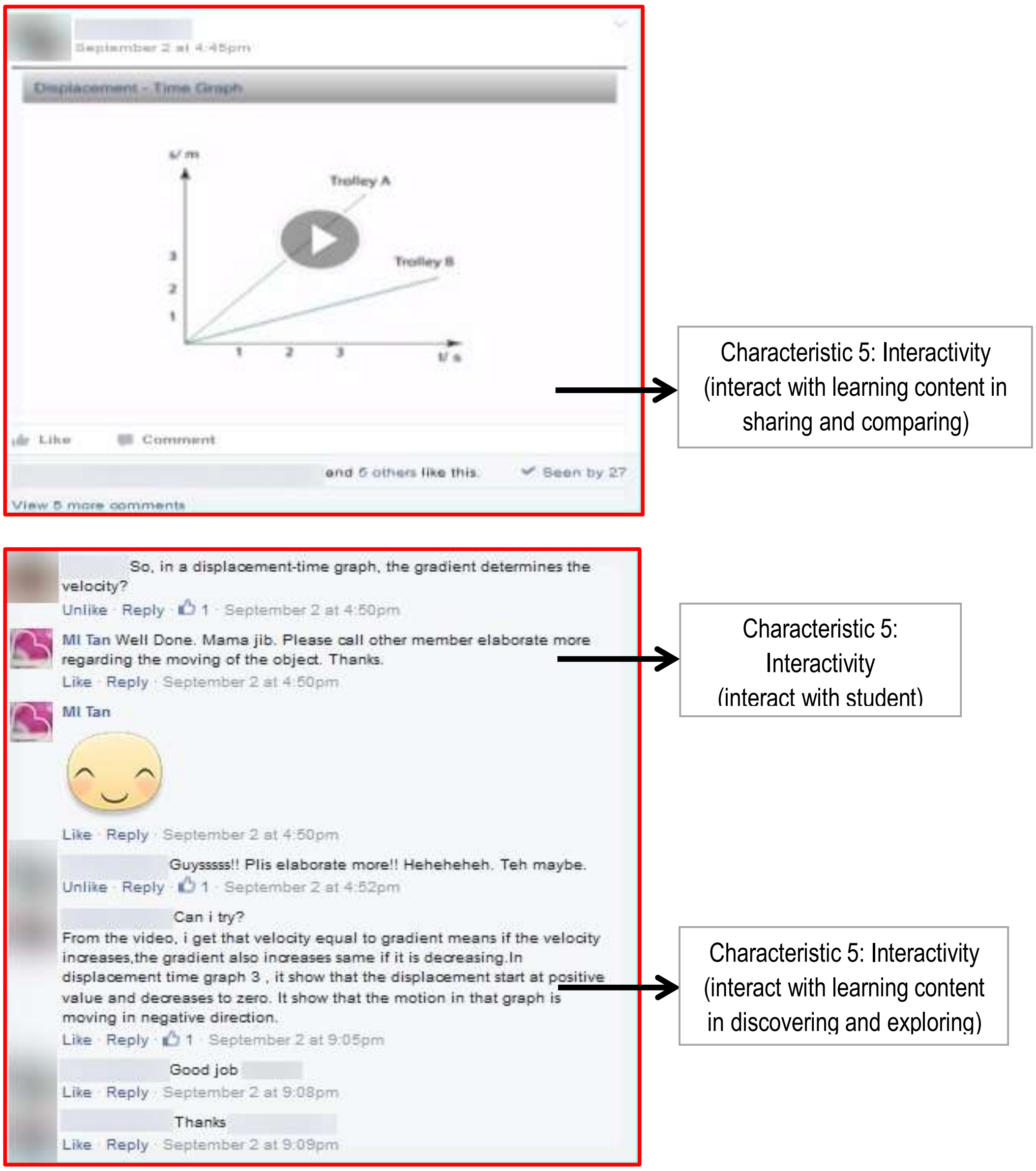


Figure 4.11 Several examples of interactivity posted on the Facebook discussions (6 teams)

4.2.6 Characteristic 6: Immediacy

In an asynchronous online discussion (AOD), social presence involves two concepts, namely immediacy and intimacy. It involves asynchronous discussion (distance between communication or delayed discussion) and the ability to exchange information rapidly. Immediacy can increase group participation in order to reduce isolation in learning towards knowledge construction (see Figure 4.12). It can engage the discussion between instructors and students, and among students, to produce a high quality of discourse.

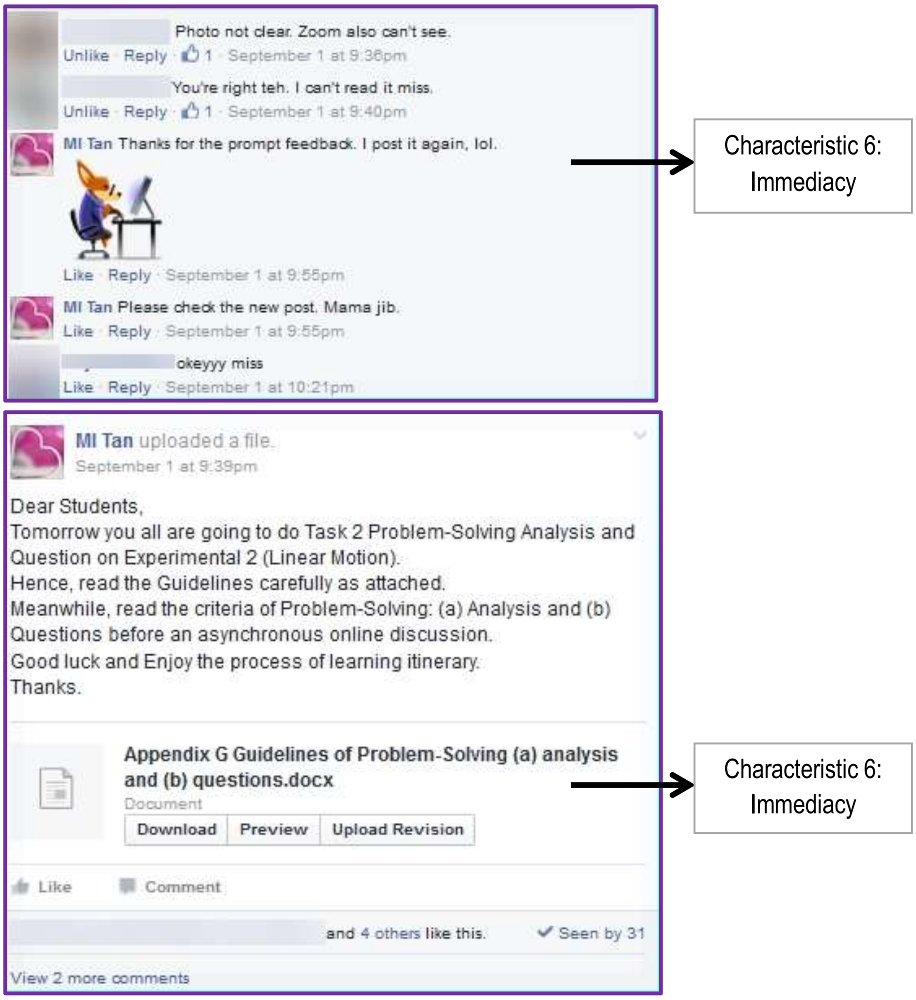


Figure 4.12 Some examples of immediacy posted on the Facebook discussions (6 teams)

4.2.7 Characteristic 7: Intimacy

Intimacy is a sense of close feeling (salience) and use of emoticons to express social-emotional experience (Reio and Crime, 2013). It may positively affect the engineering students' sense of successful interaction in Facebook discussions. It also creates and fosters good relationships between instructors and engineering students. Reviewing Figure 4.13, the researcher has posted emoticons when discussing content learning in order to encourage the students to continue to learn towards knowledge construction. Additionally, they feel satisfaction in the process of learning to achieve higher levels of knowledge construction in the SCL environment.

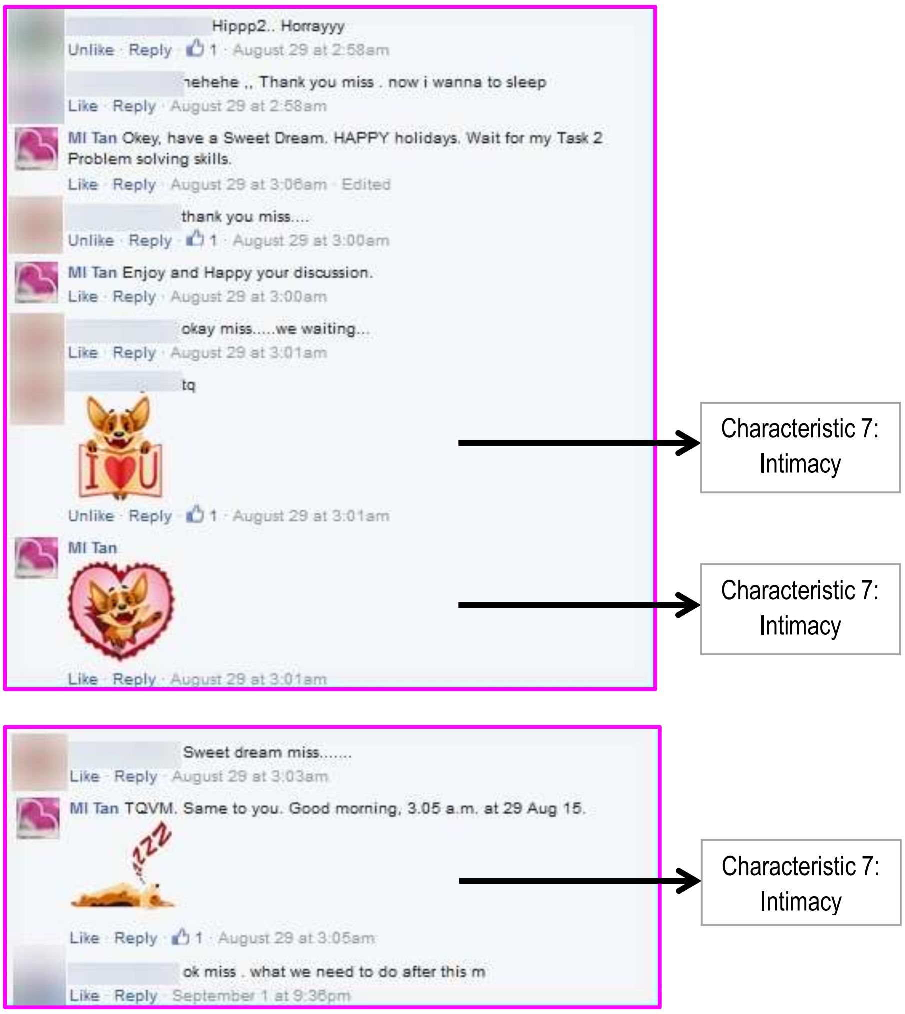


Figure 4.13 Some examples of intimacy posted on the Facebook discussions (Team 6)

4.3 Application of Instructional Scaffolding in Learning Activity Flow in Web-based Asynchronous Online Discussions

The section is classified into two parts. The first part examines how to conduct the learning activity through Facebook discussions. It involves eleven steps and relies on asynchronous online discussions (AOD) of the linear motion topic of the DBS1012 Engineering Science course. Meanwhile, the researcher integrated eight essential elements of instructional scaffolding (adapted from Hogon and Pressley, 1997) to support engineering students' learning during AOD in order to achieve effective knowledge construction.

Subsequently, the engineering students had to find their own team members to assign roles before completing the LGC task through Facebook discussions. They were expected to set up their own roles in the SCL environment. The discussion team set up five roles for students, as follows (De Wever *et al.*, 2008):

- Starter: to start a discussion, to construct new ideas and motivate other peers.
- Moderator: to monitor the discussion, respond to critical questions and solve contradicting opinions among peers.
- Theorists: to introduce the theory of information. To ensure that all relevant theoretical concepts have been used in the discussion.
- Resource searcher: to search for external information about the discussion topics. This is to stimulate peers to go beyond the scope of work.
- Summarizer: to record a summary of the current interim and final synopsis of the discussion. They also focus on identifying discrepancies between the messages and conclusions.

Gray (2009) claims that the role of moderators is vital in online learning. Furthermore, Strijbos, Martens and Jochems (2004) point out that when setting the students' roles, several elements need to be taken into account, such as students' prior knowledge, experience and collaboration skills, as used in the online SCL environment. The roles include those of the starter, summarizer and moderator, coupled with the roles of the resource searcher and theoretician. Generally, all students were authorized to carry out all these activities. However, students with assigned roles were asked to pay explicit attention to these roles on a regular basis in relation to the ongoing activities (De Wever, 2008). Meanwhile, the instructor or facilitator was required to judge the quality of scaffold responses via AOD to support students' co-construction of knowledge. The designed scaffolding might improve the students' motivation and cognition (Belland, Kim and Hannafin, 2013). Likewise, engineering students also need the instructional scaffolding to support their learning process so that they can gain higher levels of knowledge construction.

The benefits of using instructional scaffolding include (i) pre-engagement; (ii) shared goals; (iii) understanding students' prior knowledge; (iv) providing a a variety of support (for instance: questions, prompt reply and monitor comprehensively); (v) providing encouragement and praise; (vi) giving feedback; (vii) providing supportive and positive responses; and (viii) providing instructional support when conducting discussions through Facebook to provide opportunities for the networkers (engineering students) to complete their learning tasks. In other words, students may use networks to reflect their learning itinerary in the process of knowledge construction. They can also assist them to develop these relationships into higher levels of knowledge construction.

Since prior research has found that students are less satisfied with the asynchronous learning experience, such as group interaction processes and the quality of group discussions (Tu and Corry, 2001), the researcher integrated instructional scaffolding into the SCL environment when conducting learning activities through Facebook discussions. The following sections show how the researcher injected elements of instructional scaffolding based on the work of Hogan and Pressley (1997) during her students' discussion of the learning content via Facebook. There are several characteristics of instructional scaffolding, as set out below.

4.3.1 Pre-engagement

The researcher utilized the pre-engagement element of instructional scaffolding to encourage the engineering students to be active in constructing their knowledge, notably those students who might lack the collaboration experience in the process of learning. In Figure 4.14, as presented below, the researcher required the engineering students to assign roles to each member based on Appendix A. The instructor clarified the guidelines that had been provided to them. Then, they were asked to start to discuss the linear motion topic through Facebook.

Figure 4.14 Examples of the pre-engagement element posted on the Facebook discussions (Team 3)

4.3.2 Shared Goals

The engineering students are prepared to learn. The second characteristic of instructional scaffolding is that it provides shared goals in order to lead them to construct knowledge. In the meantime, they can share the YouTube videos with other peers in order to complete the learning tasks within the set time-frame. Figure 4.15 illustrates the researcher's integration of the shared goal elements into the Facebook discussions.

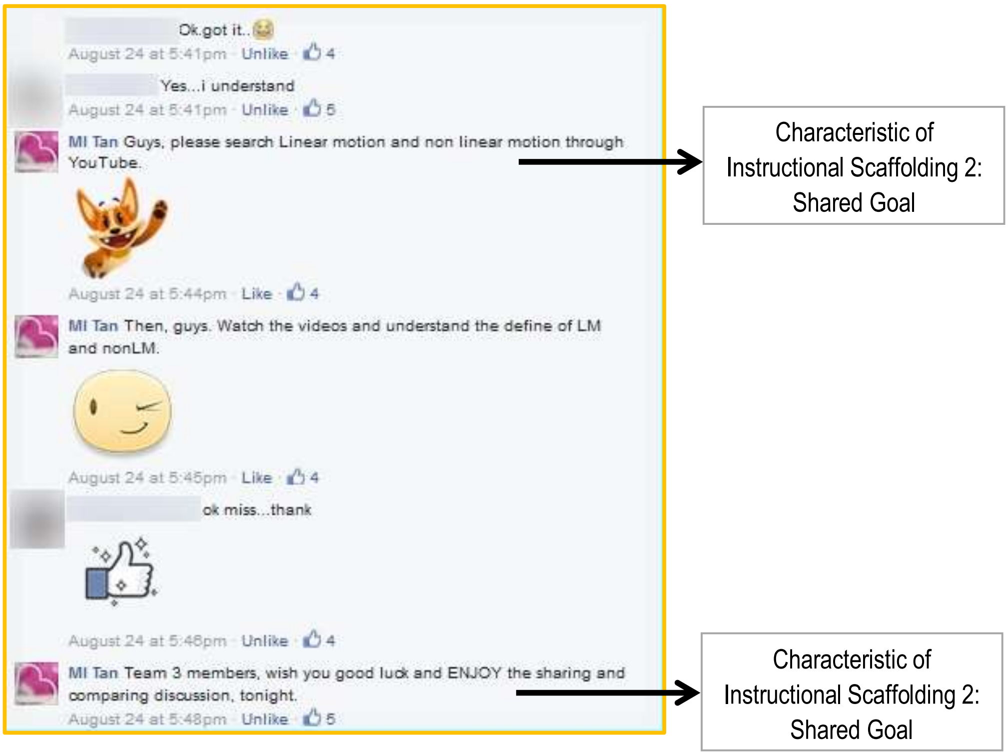


Figure 4.15 Several examples of shared goals posted on the Facebook discussions (Team 3)

4.3.3 Understanding students' prior knowledge

The engineering students were willing to share their existing knowledge and experience with their teammates. The instructor presented a new topic of linear motion as a treat for them. At the same time, it was necessary to make sure that their background knowledge was sufficient to achieve this learning task, which means that they can handle and complete the LGC task and construct new knowledge through Facebook discussions in the SCL environment. With reference to Figure 4.16, the instructor sought to understand students' prior knowledge to assess whether or not they can achieve the learning task, such as the LGC project (task).

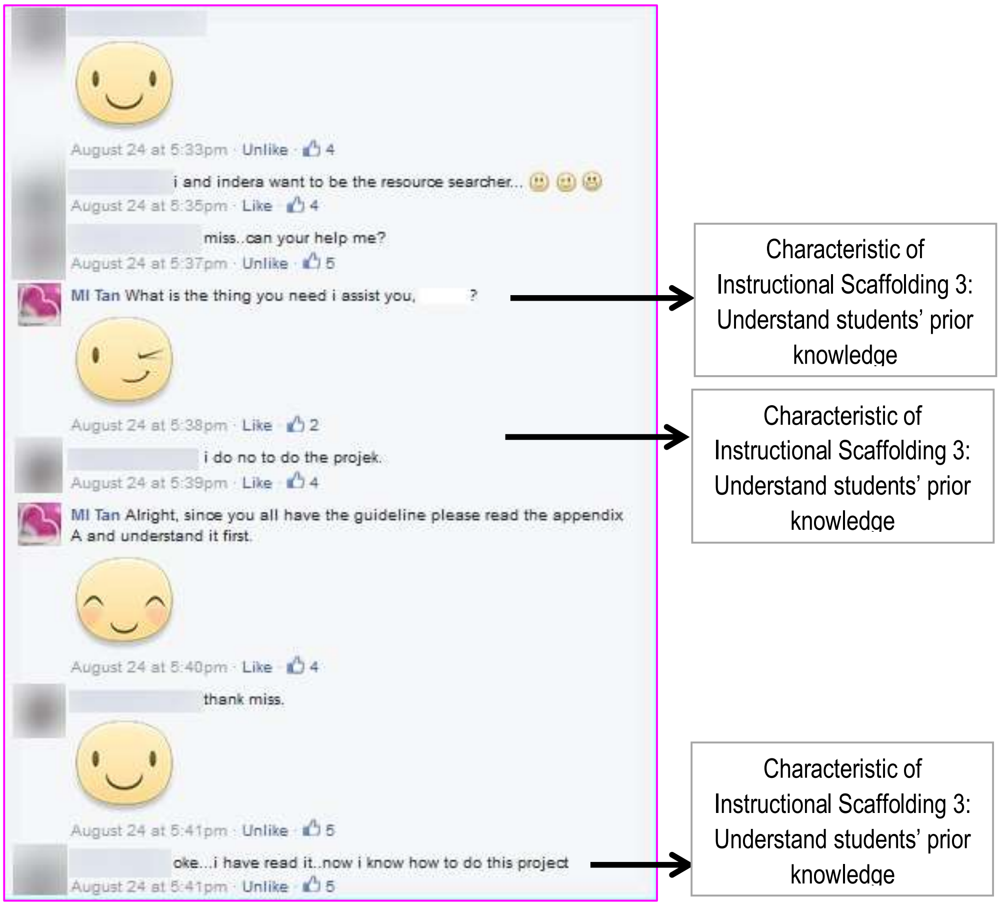


Figure 4.16 Three examples of understanding students' prior knowledge posted on the Facebook discussions (Team 3)

4.3.4 Providing a variety of support

The engineering students have to understand and accommodate divergent opinion from their peers. They elaborate explanations and develop new ideas, raise reasoned arguments and counter-challenge each other's opinions. Thus, the researcher provides a variety of support to lead engineering students to continue their discussion, even when they have lost direction and face problems in terms of constructing their knowledge. As we can see from Figure 4.17, the researcher provides a variety of support to engineering students in order to ensure that they do not feel frustrated in the process of knowledge construction. They integrate and generally accept the argumentation or negotiation of meaning about linear motion terminology. They recapitulate the main points of the argument on the linear motion topic. They also have to draw conclusions about the learning content.

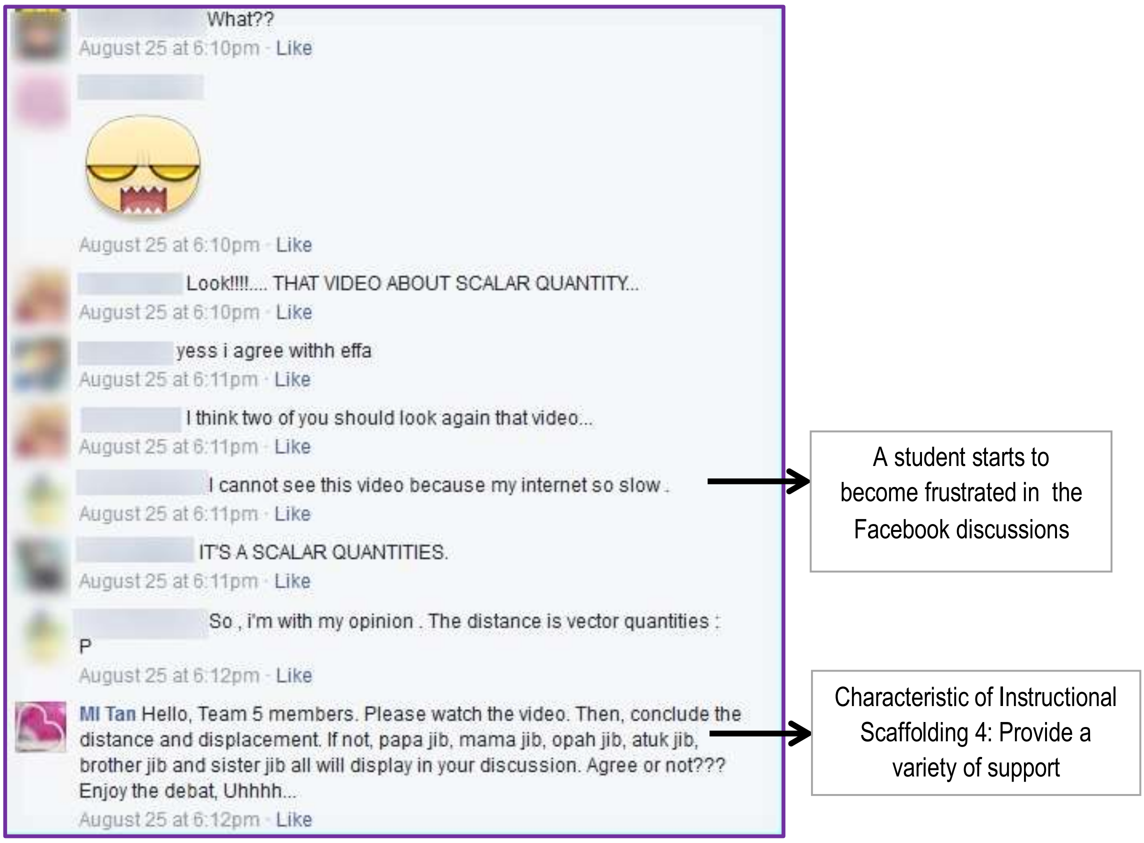


Figure 4.17 An example of the element of providing a variety of support posted on the Facebook discussions (Team 5)

4.3.5 Providing encouragement and praise

The engineering students need encouragement and praise to optimize their learning when they work hard to finish their learning task. Meanwhile, they need encouragement to participate in AOD in the SCL environment. Complimentary statements can enhance engineering students' knowledge construction and make them more excited about learning and continuing the discussion. The researcher praised Faizal in order to make him want to continue with the discussion about the linear motion topic (see Figure 4.18).

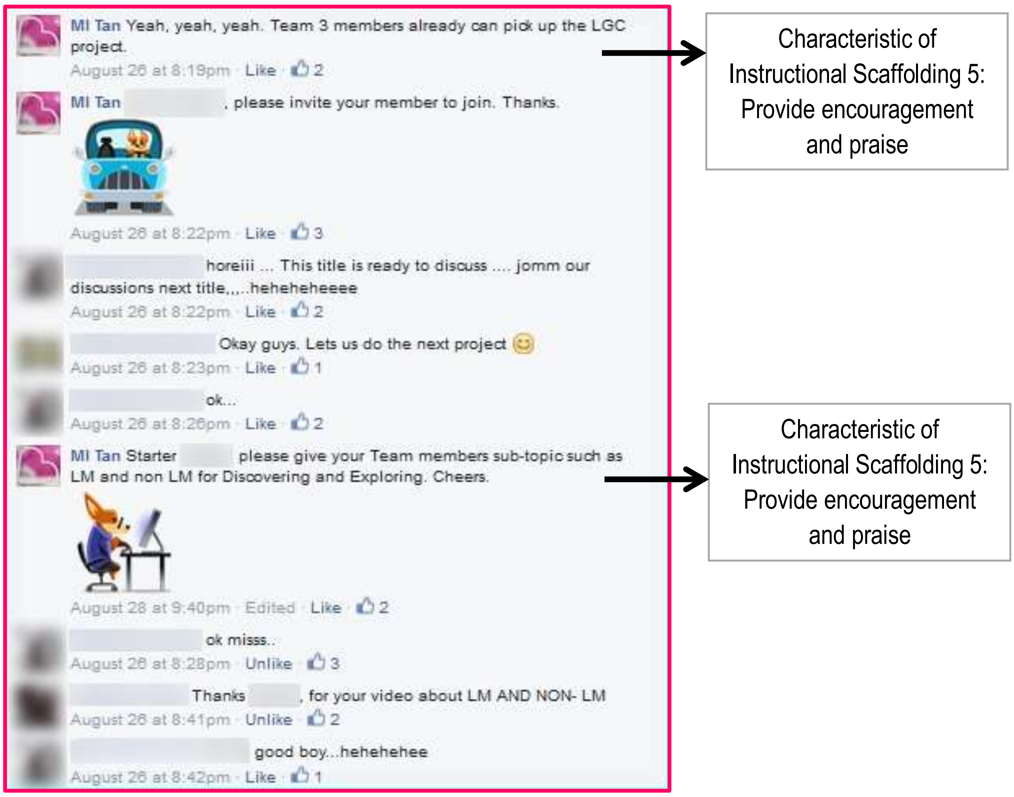


Figure 4.18 Some examples of encouragement and praise posted on the Facebook discussions (Team 3)

4.3.6 Give feedback

One of the characteristics of instructional scaffolding is the provision of feedback, whether from the instructor or peers, when engineering students exchange information or ideas about learning content via Facebook discussions. Students feel that the instructor's feedback is helpful in knowledge construction. In Figure 4.19, below, the instructor helps students to apply what they have already learned: the application of newly constructed knowledge is vital in the engineering field.

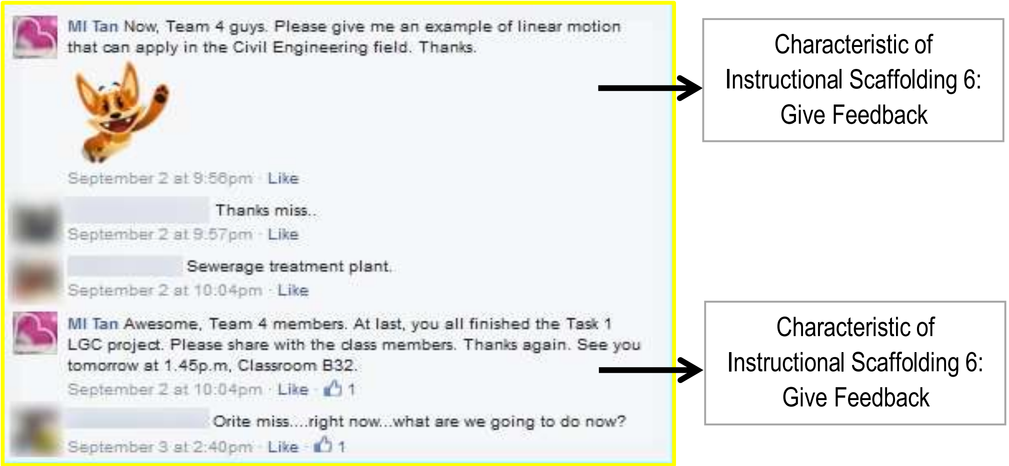


Figure 4.19 Examples of giving feedback to engineering students posted on the Facebook discussions (Team 4)

4.3.7 Provide supportive and positive responses

Simultaneously, the instructor provides supportive and positive responses to help the engineering students to improve their knowledge construction. To successfully deploy instructional scaffolding to support engineering students' learning, several responses were used in this study. Referring to Figure 4.20, the instructor provides a variety of positive and supportive responses to encourage the engineering students' knowledge construction. As a result, they feel more comfortable and find studying in an SCL environment more enjoyable.

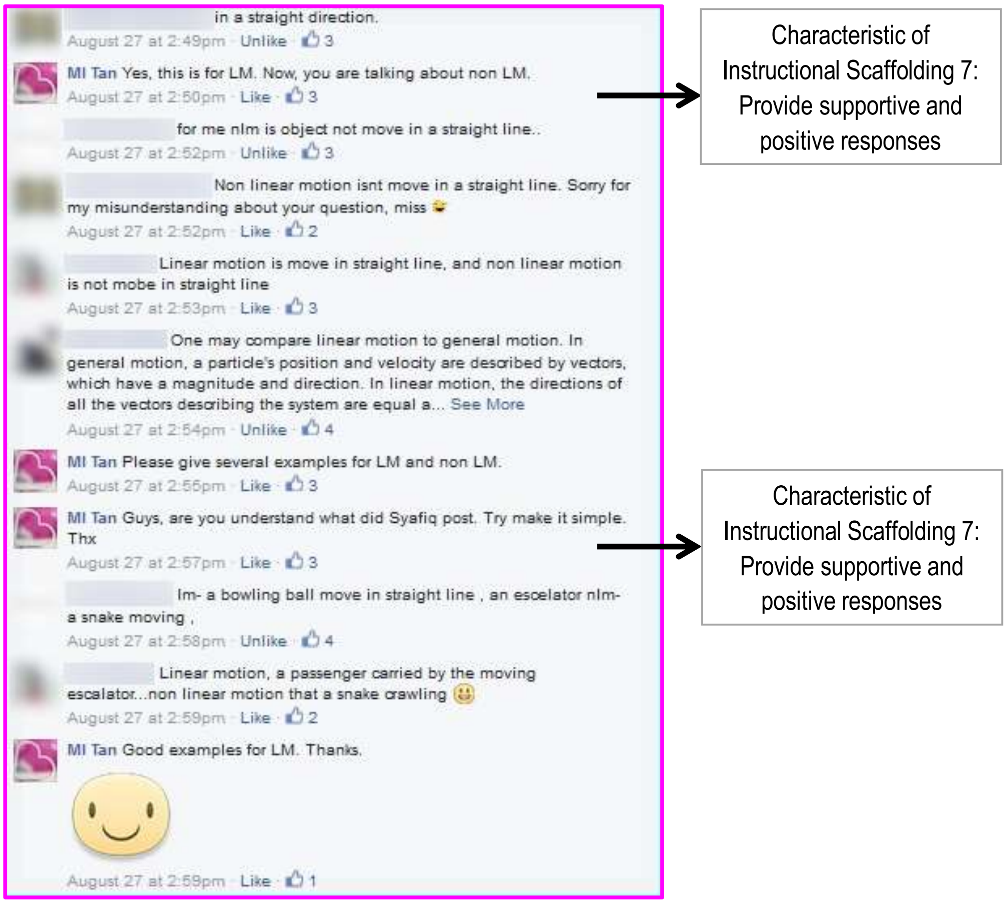


Figure 4.20 Two examples of providing supportive and positive responses to engineering student posted on the Facebook discussions (Team 3)

4.3.8 Provide instructional support

The engineering students summarized the topic. They produced an LGC hand out and were able to solve the ill-structured questions in order to construct higher levels of knowledge. The instructor delivered a lesson on classification via Facebook discussions in the SCL environment. Moreover, it was relevant to help them to perform in the construction of knowledge. Figure 4.21 shows that the researcher also provided instructional support for engineering students' knowledge construction and illustrates how the students interacted with others.

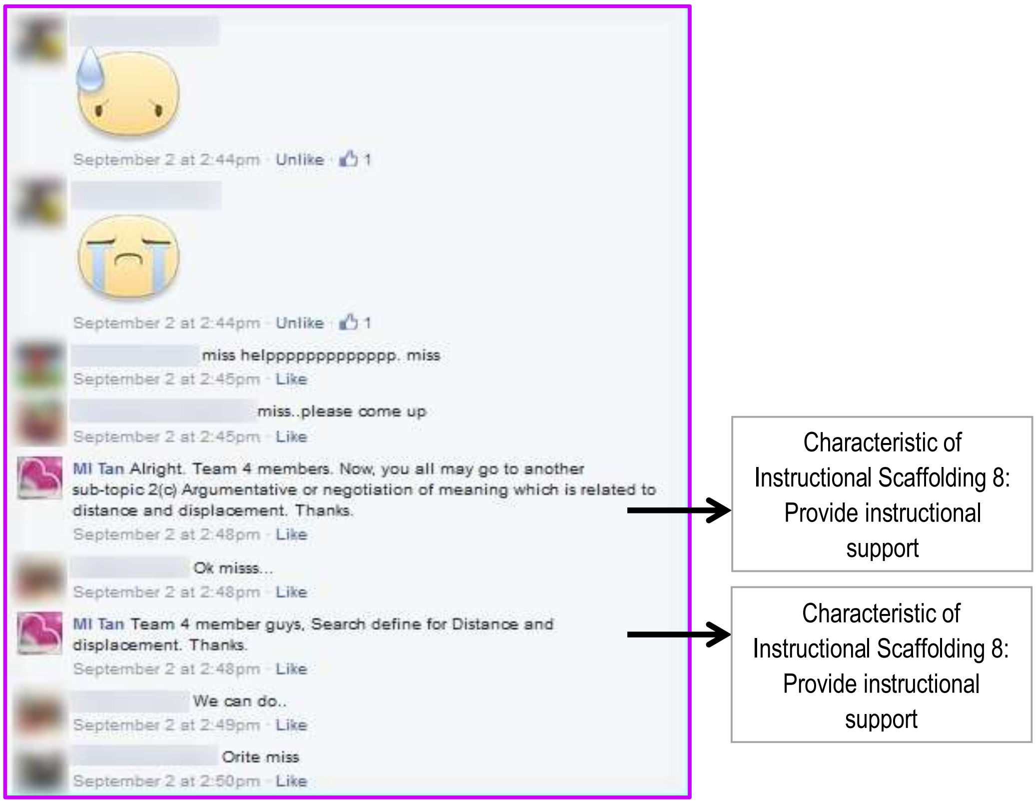


Figure 4.21 Two examples of the provision of instructional support to engineering student posted on the Facebook discussions (Team 4)

Since this section is about the design of the learning flow activity for web-based asynchronous online discussions (AOD) in an SCL environment for LGC tasks, the researcher will elaborate a little on the steps involved in producing an LGC hand-out for a social collaborative learning (SCL) environment.

The steps are outlined in Figure 4.22. There are three periods in a week. The first period is for discussing the assigning of groupings, roles and tasks for each team member, whereas the second period is for discussing ill-structured cases of the five equations of the linear motion topic. The ill-structured cases are presented in the form of YouTube videos through Facebook discussions in the SCL environment. In the third period, there is no discussion, but only evaluation of the construction of outcomes of the LGC task.

The Facebook discussions started with the guidelines in Appendix A, as in Figure 4.1. The engineering students were given the opportunity to search the internet via their smart phones or laptops. They carried out a resource search and discussed it through the Facebook platform. The first period was between 9 a.m. on Monday and 9 a.m. on Thursday. On Wednesday at 9 a.m., two of the engineering students had to summarize the discussion of the learning content. The date for summarizing the constructed summaries of the first period was Friday at 9 a.m. In the second period, the ill-structured cases (YouTube episodes) were discussed through Facebook in the SCL environment. The instructor's guiding questions were posted on Facebook for discussion on Thursday at 9 a.m. As a result, the second period of the discussion began and continued until Friday at 9 a.m. The engineering students participated in this discussion after watching the YouTube videos or reading the discourse on the episodes.

One of the engineering students was given the task of summarizing the Facebook discussions carried out in the second period on Friday at 9 a.m. The summaries would last until Saturday at 9 p.m. In the last period, the linear motion notes (handouts) were written up by one of the engineering students, who was chosen based on the discussion during the first two periods. The Facebook discussions scores for the LGC task were announced on Friday at 9 a.m. The student submitted the linear motion handout to the instructor on Sunday at 9 a.m. The instructor published the student's hand out on the course site on Monday at 9 a.m., after checking the content according to the syllabus of DBS1012 Engineering Science.

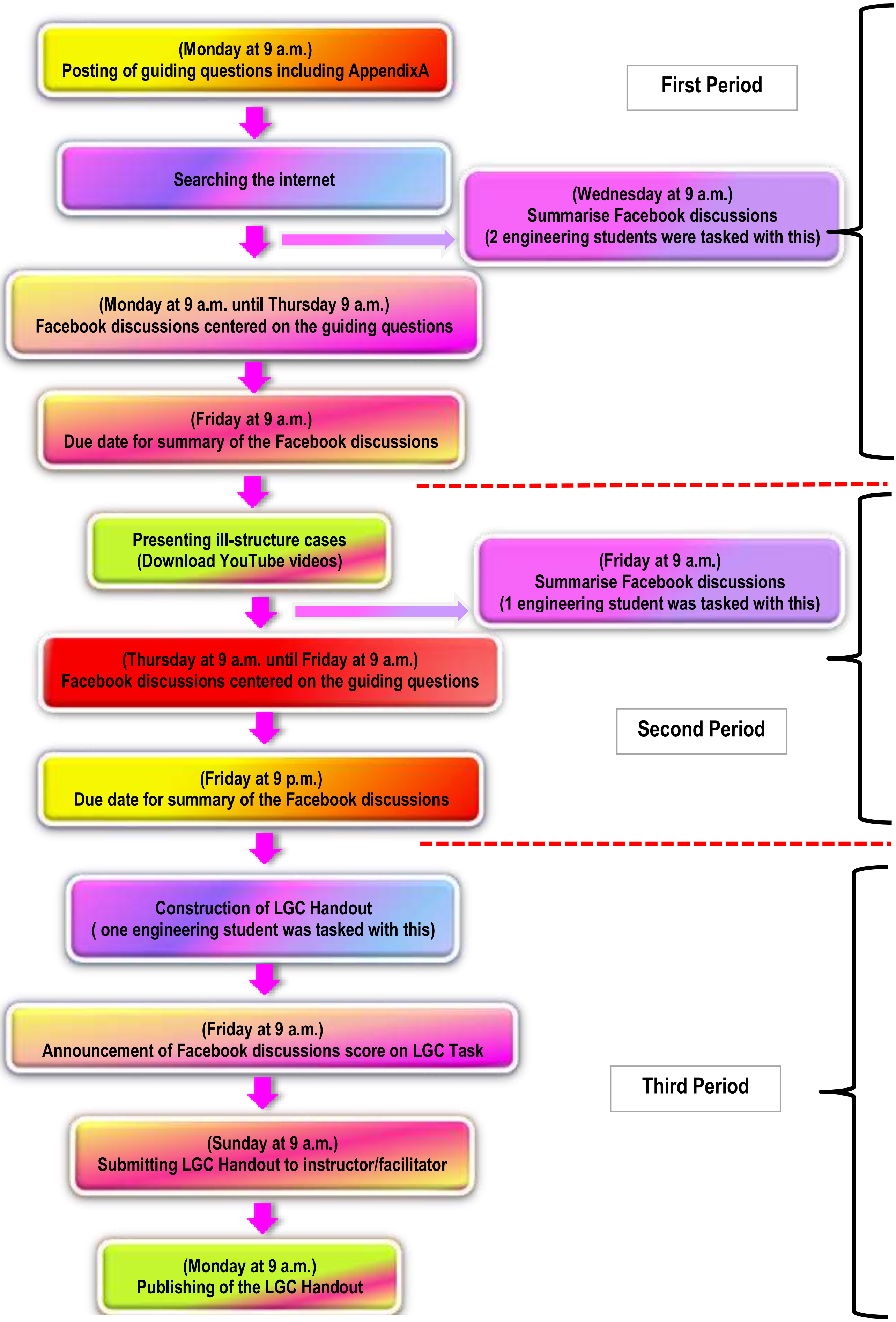


Figure 4.22 An overview of the learning activity flow on web-based asynchronous learning for online instructional scaffolding

4.4 Summary

In conclusion, this chapter has discussed how to set up the SCL environment as an input phase and conduct a learning activity involving web-based asynchronous online discussions via the Facebook platform. Simultaneously, the researcher has used a variety of characteristics of instructional scaffolding to promote and engage the engineering students' learning towards knowledge construction in the SCL environment in order to construct higher levels of knowledge through Facebook discussions. In the next chapter, the researcher will focus on the data analysis and findings of this study.

CHAPTER 5

RESEARCH FINDINGS

5.1 Introduction

The researcher has focused on engineering students' performance or achievement in tests and their higher level of knowledge construction in order to analyze research question 1. By comparing the engineering students' results, the researcher worked towards developing interventions to address the engineering students' knowledge construction, which is deemed a major issue; this contributed to the analysis of research question 2. The online (web-based) instructional scaffolding (IS) for this study is illustrated in Figure 4.22. From the analysis of IS processes, the researcher gained insights into two differences between important and less important elements of IS when integrating them into engineering students' knowledge construction (KC). Furthermore, the researcher has designed and set up an online SCL environment to support engineering students in reaching a higher level of KC in their learning itinerary. Thus, this chapter comprises three sections of results and data analysis for research questions 1, 2 and 3. The finding is pre-engagement, the provision of a variety of support mechanism and providing the students with supportive and positive responses as necessary. Meanwhile, the characteristics of immediacy and intimacy are vital nurture engineering students' active engagement in the learning itinerary. From these research findings, the researcher has produced a knowledge construction model (KCM) to answer research question 4.

5.2 Result of Choosing Appropriate Samples (Control and Experimental Groups/Classes) for Conducting Achievement in Tests

All thirty-eight (38) mechanical engineering students (control group) completed the tasks in the conventional collaborative learning (CCL) environment, which was conducted in the engineering classroom. Meanwhile, thirty-six (36) civil engineering students (experimental group) completed the learning activities tasks in the social collaborative learning (SCL) environment through Facebook discussions supported by IS.

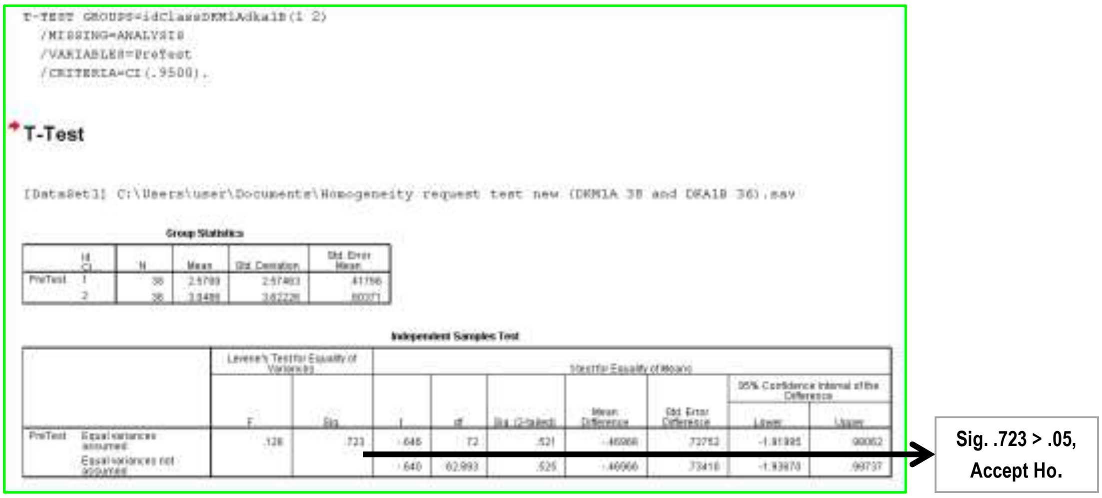
The demographic information of both classes is outlined in Table 5.1. The participants were in first year engineering science undergraduates. Most of them reported having the same age, level of prior knowledge, and background in both the control and experimental groups. The researcher conducted the quasi-experiment in two different departments in order to minimize the interaction among the engineering students. In addition, the researcher also conducted the post-test for both groups on the same day, at the same time, and in the same place so that the participants did the test together.

Table 5.1 : Demographic information of the control and experimental groups

Group	Learning Environment	Sample (N)	Gender (Frequency)		Gender (Percentage, %)	
			Male	Female	Male	Female
Control	Conventional collaborative learning	38	28	10	73.68	26.32
Experimental	Social collaborative learning with instructional scaffolding	36	28	8	77.78	22.22

The result of the pre-tests for assessing the homogeneity of the control and experimental groups is given in Figure 5.1. Levene's test of equality of sample variances showed whether the variances for the groups were equal before the researcher conducted the post-test for the two groups. The Levene test is a test to be used with one or more groups to show whether one group is different from the others. The null hypothesis (Ho) states that the variances of all the groups are equal.

As seen in Figure 5.1, the independent-sample t test indicated that there was no difference in the Levene's Test for equality of variances (P, Sig. = .723>alpha, α (0.05). Thus, Ho is accepted. This means that it is statistically significant that there are no differences of variance (variability) between the control and the experimental (treatment) groups.



```
T-TEST GROUPS=idClassDKM1Adka1B(1 2)
  /MISSING=ANALYSIS
  /VARIABLES=PreTest
  /CRITERIA=CI(.9500).
```

T-Test

[DataSet1] C:\Users\user\Documents\Homogeneity request test new (DKM1A 38 and DKA1B 36).sav

Group Statistics

	Id Cl	N	Mean	Std. Deviation	Std. Error Mean
PreTest	1	38	2.5789	2.57483	.41766
	2	38	3.0488	3.62226	.60371

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
PreTest	Equal variances assumed	.128	.723	-.646	72	.521	-.46966	.72752	-1.91995	.98062
	Equal variances not assumed			-.640	62.993	.525	-.46966	.73416	-1.93670	.99737

Figure 5.1 The results of homogeneity

5.3 Impact of Instructional Scaffolding on Engineering Students' Achievement in Tests and Knowledge Construction Levels

In order to determine the engineering students' achievement in the test and their level of knowledge construction through pre and post-tests, quantitative analysis was applied to answer research question 1. This quantitative approach focuses on analysing the large amount of scores (marks) collected from the control class (mechanical engineering students) and the experimental class (civil engineering students).

The large data set of scores (marks) allowed the researcher to perform statistical tests to compare the two different conditions of conventional CL and online SCL environments with instructional scaffolding.

5.3.1 Results on Engineering Students' Achievement in Tests

In order to evaluate the impact of IS in an online SCL environment on engineering students' achievement in tests and knowledge construction level (KCL), the researcher focused on the results between the pre and post-test. It is implemented on the control and experimental classes for comparing the two different learning environments. There were thirty-six (36) respondents in the experimental class and thirty-eight (38) respondents in the control class.

Table 5.2 illustrates the differences in the results between the pre and post-test for the experimental group. Meanwhile, the differences in the results for the control group between the pre and post-test are outlined in Table 5.3. Overall, the table shows that the engineering students demonstrated a significant increase in scores (marks) in the test (see Table 5.4) after experiencing online (web-based) IS in an online SCL environment. The experimental group is better than control group regarding the score.

Table 5.2 : The distribution of scores in pre and post-test for the experimental group

(Student, S) Respondent	Pre Test Scores, p	Post Test Scores, q	Difference in Scores, r=p-q
S1	0.00	12.00	**12.00**
S2	3.50	14.00	**10.50**
S3	6.50	14.00	**7.50**
S4	0.00	12.00	**12.00**
S5	0.00	16.00	**16.00**
S6	2.00	17.00	**15.00**
S7	3.00	18.00	**15.00**
S8	2.50	16.00	**13.50**
S9	0.00	10.00	**10.00**
S10	5.50	19.00	**13.50**
S11	1.00	15.00	**14.00**
S12	0.00	15.00	**15.00**
S13	0.00	16.50	**16.50**
S14	4.00	14.50	**10.50**
S15	2.00	16.00	**14.00**
S16	2.00	14.00	**12.00**
S17	20.50	23.75	**3.25**

S18	2.50	14.00	**11.50**
S19	4.50	17.50	**13.00**
S20	4.25	12.00	**7.75**
S21	2.00	14.00	**12.00**
S22	1.50	8.50	**7.00**
S23	2.00	14.00	**12.00**
S24	0.00	9.50	**9.50**
S25	5.00	7.00	**2.00**
S26	5.00	20.00	**15.00**
S27	2.00	13.00	**11.00**
S28	0.00	8.00	**8.00**
S29	5.50	13.00	**7.50**
S30	0.00	11.00	**11.00**
S31	3.50	15.50	**12.00**
S32	2.00	9.00	**7.00**
S33	2.00	10.00	**8.00**
S34	4.00	18.00	**14.00**
S35	4.50	20.00	**15.50**
S36	7.00	8.50	**1.50**

N=36 and Full marks = 25

Table 5.3 : The distribution of scores in pre and post-test for the control group

Respondent (Student, S)	**Pre Test Scores, p**	**Post Test Scores, q**	**Difference in Scores,, r=p-q**
S1	0.00	6.50	**6.50**
S2	0.00	9.00	**9.00**
S3	3.00	13.00	**10.00**
S4	1.00	10.50	**9.50**
S5	0.00	5.50	**5.50**
S6	2.50	9.00	**6.50**
S7	1.00	12.00	**11.00**
S8	4.50	9.00	**4.50**
S9	8.50	15.00	**6.50**
S10	0.00	11.50	**11.50**
S11	0.00	12.00	**12.00**
S12	0.00	10.00	**10.00**
S13	6.00	9.50	**3.50**
S14	0.00	10.00	**10.00**
S15	0.00	8.00	**8.00**
S16	3.50	11.00	**7.50**
S17	2.00	14.00	**12.00**

S18	6.00	9.00	**3.00**
S19	0.00	11.50	**11.50**
S20	2.00	12.00	**10.00**
S21	4.50	12.00	**7.50**
S22	2.50	15.00	**12.50**
S23	2.00	14.00	**12.00**
S24	1.50	15.00	**13.50**
S25	3.00	16.00	**13.00**
S26	9.50	11.50	**2.00**
S27	0.00	4.00	**4.00**
S28	1.00	13.00	**12.00**
S29	4.00	9.00	**5.00**
S30	2.00	16.00	**14.00**
S31	3.50	11.00	**7.50**
S32	1.50	12.00	**10.50**
S33	7.00	12.00	**5.00**
S34	6.00	11.00	**5.00**
S35	1.00	11.00	**10.00**
S36	5.50	16.00	**10.50**
S37	0.00	10.00	**10.00**
S38	3.50	11.50	**8.00**

N=38 and Full marks = 25

Table 5.4 : Tabulation of engineering students' achievement in test (control and experimental groups)

Achievement in Test	**Number of respondents, n**		**Percentage (%)**
	Control group	**Experimental group**	
Improve	38/38	36/36	100
Regress	0/38	0/36	0

Next, additional analyses were performed on the two different research learning environments using an SPSS t-test. The results of the pre and post-test are presented in Figures 5.2 and 5.3. The pair-samples t-test was chosen because the independent variable (learning environment) has two categories (pre and post-test). The learning environment measurement is the independent variable. The samples are paired because the same engineering students took both the pre and the post-test.

Figures 5.2 and 5.3 illustrate the dependent (pair-sample) t test and indicate that there was a significant increase in the mean scores of the post-test in both the learning environments of conventional CL compared with the online SCL environment supported with IS (Pretest, M=2.58, S.D.=2.57; Post-test, M=11.26, S.D.=2.78 and Pre test, M=3.05, S.D.=3.62; Post-test, M=13.98, S.D.=3.84, respectively). The engineering students in the online SCL environment had significantly higher mean scores compared with students in the CL environment. There was a statistically significant improvement in the test from a score of 3.05 to 13.98, that is, an improvement of 10.93, for the experimental class. On the other hand, the control class showed a significant improvement of 8.68 in the test from a score of 2.58 to 11.26.

P (Sig.) = .00< alpha, α (0.05) leading to rejection of the null hypothesis (Ho) Ho=There is no significant difference between pre and post-test. This means the two different learning environments give significantly different learning outcomes. The results of the pre and the post-test are summarized in Table 5.4. The effect size (Cohen kappa, 1998) indicated significant progress in the test achievement (Cohen's d=3.11 and d=2.85. For instance, (mean $_1$ – mean $_2$)/S.D.= (3.05-13.08)/3.84=2.85.

T-Test

[DataSet2] C:\Users\user\Documents\RQ1a DKA1B achievement in test (28Nov15).sav

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	DKA1bPreTest	3.0486	36	3.62226	.60371
	DKA1bPostTest	13.9792	36	3.83889	.63981

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	DKA1bPreTest & DKA1bPostTest	36	.472	.004

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1	DKA1bPreTest - DKA1bPostTest	-1.093E1	3.83667	.63945	-12.22870	-9.63241	-17.094	35	.000

Figure 5.2 Results of experimental group in online SCL environment with IS support

T-Test

[DataSet3] C:\Users\user\Documents\DKM1A.(Pre-Post Test)(Pair-Sample t Test 28Nov15).sav

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	DKM1aPreTest	2.5789	38	2.57463	.41766
	DKM1bPostTest	11.2632	38	2.78688	.45209

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	DKM1aPreTest & DKM1bPostTest	38	.285	.083

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1	DKM1aPreTest - DKM1bPostTest	-8.68421	3.20983	.52070	-9.73925	-7.62917	-16.678	37	.000

Figure 5.3 Results of control group in conventional CL environment

Table 5.5 : Achievement in test between CCL and online SCL environments

Group	Learning Environment	Sample (N)	Pre Test		Post Test	
			Mean	Standard Deviation	Mean	Standard Deviation
Control	Conventional Collaborative learning	38	2.58	2.577	11.26	2.79
Experimental	Social collaborative learning with instructional scaffolding	36	3.05	3.62	13.98	3.84

All the pre and post-test have been validated by an expert from Department of Mathematics, Science and Computer as shown in Appendix I In order to ensure the reliability of the experimental group's post-test, the researcher obtained the second marker's consent to mark and check again the results of the test. An overview of the comments and results is given in Appendix M. From the results shown, the test is reliable based on the value of Cohen's kappa when it is higher than 0.8. (see Table 3.17). It is almost perfect which means the percentage of agreement is 1.0.

5.3.2 Results on Engineering Students' Knowledge Construction Levels

This section consists of two parts: (a) Knowledge construction levels based on test and (b) Knowledge construction based on the Facebook discussion supported by IS. The researcher has categorised the results into different sections. In addition, two types of task were given to experimental group to discuss their learning content via the Facebook platform in the online SCL environment.

5.3.2.1 Knowledge Construction Levels Based on Test

In order to clarify whether IS in an online SCL environment affects engineering students' achievement in tests and can help them gain a higher level of knowledge construction, the researcher focuses on the match between knowledge construction (KC) and the content analysis of their messages in the Facebook discussion. Table 5.6, shows an example of an engineering student's score (namely, S1) for each level of KC throughout the assessment based on Bloom's Revised Taxonomy, and each student's knowledge construction levels in the achievement test can be seen in Table 5.7.

Hierarchies of thinking, such as Bloom's taxonomy, are reflected in hierarchies of learning (knowledge construction); thus, the application of scaffolding is needed to support students' learning, as stated by Way and Rowe (2008). Moreover, Pettenati *et al.* (2007) have emphasized that the level or type of knowledge, such as conceptual or declarative knowledge, procedural knowledge, and metacognitive knowledge, is needed to construct informal online learning in several stages.

When the research is viewed in terms of hierarchies of learning (process of KC) with IS, it can be related to the level of Bloom's revised taxonomy based on the representations of the KCL by Way and Rowe (2008) and Pettenati *et al.* (2007). This means that the level of Bloom's revised taxonomy is equivalent to KCL.

Table 5.6 : Marks obtained in each level of Bloom's Revised Taxonomy (an example for S1 student)

Level of Knowledge construction	**Level of Bloom' s Revised Taxonomy**	**Question**	**Marks Obtained x**	**Question**	**Marks Obtained y**	**Sum marks x+ y =z**	**Ratio (r) = Sum marks / Total marks**
Declarative	**Remembering**	**1**	**1**			**1**	$\frac{z}{2} = \frac{1}{2} = 0.5$
Procedural	**Understanding**	**2a**	**3**	**2b**	**2**	**5**	$\frac{z}{5} = \frac{5}{5} = 1.0$
	Applying	**3**	**0**			**0**	$\frac{z}{5} = \frac{0}{5} = 0.0$
Argumentative	**Analyzing**	**4**	**3**			**3**	$\frac{z}{3} = \frac{3}{3} = 1.0$
Metacognitive	**Evaluating**	**5**	**2**			**2**	$\frac{z}{4} = \frac{2}{4} = 0.5$
	Creating	**6a**	**1**	**6b**		**1**	$\frac{z}{6} = \frac{1}{6} = 0.17$
Achievement in test for each engineering student of each level of knowledge construction (overall)							$\frac{z}{25} = \frac{12}{25} = 0.48$

Each question is indicated with the total marks, as illustrated in Table 5.6. For instance, student S1 scored one mark out of two (as total marks for question 1) on declarative knowledge. The proportional marks are based on the rubric DBS1012 Engineering Science. The total of lower order thinking (LOT) scores (marks) are 12 marks, and comprise declarative and procedural marks, and the sum of higher order thinking (HOT) scores are 13 marks, and comprise argumentative and metacognitive marks. The number of marks available for the pre and post-test was 25 marks.

Table 5.7 : Achievement in the pre and post tests for each respondent of each level of knowledge construction based on Bloom's Revised Taxonomy (experimental group)

Respondent	Achievement in Test						
(Student, S)	Remembering	Understanding	Applying	Analyzing	Evaluating	Creating	Overall
S1	0.50	1.00	0.00	1.00	0.50	0.17	0.48
S2	1.00	0.60	0.00	0.67	0.50	0.83	0.56
S3	0.50	1.00	0.00	0.33	0.75	0.67	0.56
S4	0.50	1.00	0.00	0.67	0.50	0.33	0.48
S5	1.00	1.00	0.00	0.67	1.00	0.50	0.64
S6	1.00	0.80	0.00	1.00	1.00	0.67	0.68
S7	1.00	1.00	0.00	1.00	0.75	0.83	0.72
S8	0.50	0.80	0.00	1.00	1.00	0.67	0.64

S9	1.00	1.00	0.00	1.00	0.00	0.00	0.40
S10	1.00	1.00	0.00	1.00	1.00	0.83	0.76
S11	1.00	1.00	0.00	1.00	0.50	0.50	0.60
S12	1.00	1.00	0.00	0.67	1.00	0.33	0.60
S13	0.75	0.60	0.00	1.00	1.00	0.83	0.66
S14	0.50	1.00	0.00	0.50	1.00	0.83	0.66
S15	1.00	1.00	0.00	0.67	0.50	0.83	0.64
S16	1.00	0.40	0.00	1.00	1.00	0.50	0.56
S17	1.00	1.00	1.00	0.92	1.00	0.83	0.95
S18	1.00	1.00	0.00	1.00	1.00	0.00	0.56
S19	1.00	0.80	1.00	0.50	0.50	0.50	0.70
S20	1.00	0.60	0.00	1.00	0.25	0.50	0.48
S21	0.50	1.00	0.00	1.00	0.50	0.50	0.56
S22	0.00	0.60	0.00	0.50	0.50	0.33	0.34
S23	1.00	1.00	0.00	1.00	0.50	0.33	0.56
S24	1.00	0.40	0.00	0.50	0.50	0.33	0.38
S25	0.00	0.40	0.00	0.33	0.50	0.33	0.28
S26	1.00	1.00	0.00	1.00	1.00	1.00	0.80
S27	1.00	1.00	0.00	0.33	0.50	0.50	0.52
S28	0.50	0.40	0.00	0.67	0.25	0.33	0.32
S29	0.50	0.60	0.00	1.00	1.00	0.33	0.52
S30	0.00	0.60	0.00	1.00	0.50	0.50	0.44
S31	1.00	0.60	0.00	1.00	0.88	0.67	0.62
S32	0.50	0.80	0.00	0.33	0.50	0.17	0.36
S33	0.75	0.80	0.00	0.50	0.50	0.17	0.40
S34	0.00	1.00	1.00	1.00	1.00	0.17	0.72
S35	1.00	1.00	1.00	1.00	0.50	0.50	0.80
S36	0.00	1.00	0.00	0.00	0.50	0.25	0.34

On the other hand, the researcher conducted the same process in order to obtain the achievement in the test for each respondent of each level of knowledge for the control group.

Consequently, Tables 5.9 and 5.10 present the number of engineering students and the percentage of respondents that demonstrated good achievement in the test for each level of KC for the experimental and control groups respectively based on Table 5.8. One form of evidence can be conjectured on the levels of KC reflected in the achievement in the test. As shown in Table 5.11, showing the level of Bloom's elements of understanding and evaluating encouraged the respondents in the experimental group to perform well in their test. Meanwhile, understanding and analysing the level of Bloom's elements encouraged the control group's respondents to perform well in the test. Based on Table 5.8, only 3 students (8.33%) achieve 0.8 ratio (the sum marks over total marks) in experimental group and none of the students achieve in control group respectively.

Table 5.8 : Speculating engineering students' achievement in test

Ratio (r)	**Achievement in Test**
0.8<**r**≤1.0	High (H)
0.40<**r**≤0.8	Medium (M)
r<0.40	Low (L)

Table 5.9 : Number and percentage of respondents with good achievement in the post test (experimental group)

Level of Bloom's Revised Taxonomy	**Number of respondents with good Achievement in Test**			**Percentage of respondents who achieved well in the post test**
	High (H)	Medium (M)	Low (L)	
Remembering	22	11	3	22/36 x 100%=61.11
Understanding	36	0	0	36/36 x 100%=100.00
Applying	4	0	32	4/36 x 100%=11.11
Analyzing	20	11	5	20/36 x 100% = 55.56
Evaluating	31	0	3	31/36 x 100% = 86.11
Creating	8	13	15	8/36 x 100%=22.22
Overall	3	27	6	3/36 x 100%=8.33

Table 5.10 : Number and percentage of respondents with good achievement in the post test (control group)

Level of Bloom's Revised Taxonomy	**Number of respondents with good Achievement in Test**			**Percentage of respondents who achieved well in the post test**
	High (H)	Medium (M)	Low (L)	
Remembering	21	13	4	21/38 x 100%=55.26
Understanding	27	9	2	27/38 x 100%=71.05
Applying	0	0	38	0/38 x 100% = 0.00
Analyzing	23	9	6	23/38 x 100% = 60.53
Evaluating	5	29	4	5/38 x 100% = 13.16
Creating	0	2	36	0/38 x 100% = 0.00
Overall	0	28	10	0/38 x 100% = 0.00

Table 5.11 : Comparison of percentage of respondents who achieved well in the post test

Level of Bloom's Revised Taxonomy	**Percentage of respondents who achieved well in the post test**	
	Experimental Group	**Control Group**
Remembering	61.11	55.26
Understanding	100.00	71.05
Applying	11.11	0.00
Analyzing	55.56	60.53
Evaluating	86.11	13.16
Creating	22.22	0.00
Overall	8.33	0.00

Table 5.12 shows the declarative knowledge, procedural knowledge, argumentative knowledge, and metacognitive knowledge hierarchically nested within the measurement of KCLs for the experimental group. Meanwhile, information regarding the control group can be seen in Appendix N. The passing marks is 50%. The number of engineering students who passed each level of KC in the achievement test is summarized in Table 5.13 (experimental group) and Table 5.14 (control group).

Table 5.12 : Number of students' passes in each level of knowledge construction (experimental group)

Respondent	Declarative		Procedural		Argumentative		Metacognitive	
(Student, S)	Pre Test Score	Post Test Score	Pre Test Score	Post Test Score	Pre Test Score	Post Test Score	Pre Test Score	Post Test Score
S1	0	1 (pass)	0	5 (pass)	0	3 (pass)	0	3
S2	0	2 (pass)	0	3	0	2 (pass)	3.5	7 (pass)
S3	1 (pass)	1 (pass)	2	5 (pass)	0	1	3.5	7 (pass)
S4	0	1 (pass)	0	5 (pass)	0	2 (pass)	0	4
S5	0	2 (pass)	0	5 (pass)	0	2 (pass)	0	7 (pass)
S6	0	2 (pass)	0	4	0	3 (pass)	2	8 (pass)
S7	0	2 (pass)	1	5 (pass)	0	3 (pass)	2	8 (pass)
S8	0.5	1 (pass)	0	4	0	3 (pass)	2	8 (pass)
S9	0	2 (pass)	0	5 (pass)	0	3 (pass)	0	0
S10	0.5	2 (pass)	0	5 (pass)	1.5 (pass)	3 (pass)	3.5	9 (pass)
S11	0	2 (pass)	0	5 (pass)	0	3 (pass)	1	5 (pass)
S12	0	2 (pass)	0	5 (pass)	0	2 (pass)	0	6 (pass)
S13	0	1.5 (pass)	0	3	0	3 (pass)	0	9 (pass)
S14	0.5	1 (pass)	0	5 (pass)	1.5 (pass)	1.5 (pass)	2	7 (pass)
S15	2 (pass)	2 (pass)	0	5 (pass)	0	2 (pass)	0	7 (pass)
S16	0	2 (pass)	0	2	0	3 (pass)	2	7 (pass)
S17	2 (pass)	2 (pass)	7 (pass)	10 (pass)	1.5 (pass)	2.75 (pass)	10 (pass)	9 (pass)
S18	0	2 (pass)	0	5 (pass)	0	3 (pass)	2.5	4
S19	1 (pass)	2 (pass)	0	9 (pass)	0	1.5 (pass)	3.5	5 (pass)
S20	0	2 (pass)	0	3	0.75	3 (pass)	3.5	4
S21	0	1 (pass)	0	5 (pass)	0	3 (pass)	2	5 (pass)
S22	0	0	0	3	0	1.5 (pass)	1.5	4
S23	0	2 (pass)	2	5 (pass)	0	3 (pass)	0	4
S24	0	2 (pass)	0	2	0	1.5 (pass)	0	4
S25	0	0	3	2	0	1	2	4
S26	0	2 (pass)	0	5 (pass)	1.5 (pass)	3 (pass)	3.5	10 (pass)
S27	0	2 (pass)	0	5 (pass)	0	1	2	5 (pass)
S28	0	1 (pass)	0	2	0	2 (pass)	0	3
S29	0	1 (pass)	4	3	0	3 (pass)	1.5	6 (pass)

S30	0	0	0	3	0	3 (pass)	0	5 (pass)
S31	1 (pass)	2 (pass)	0	3	0	3 (pass)	2.5	7.5 (pass)
S32	0	1 (pass)	0	4	0	1	2	3
S33	0	1.5 (pass)	0	4	0	1.5 (pass)	2	3
S34	0.5	0	1	10 (pass)	1.5 (pass)	3 (pass)	1	5 (pass)
S35	1 (pass)	2 (pass)	0	10 (pass)	1.5 (pass)	3 (pass)	2	5 (pass)
S36	0.5	0	3	5 (pass)	0	0	3.5	3.5

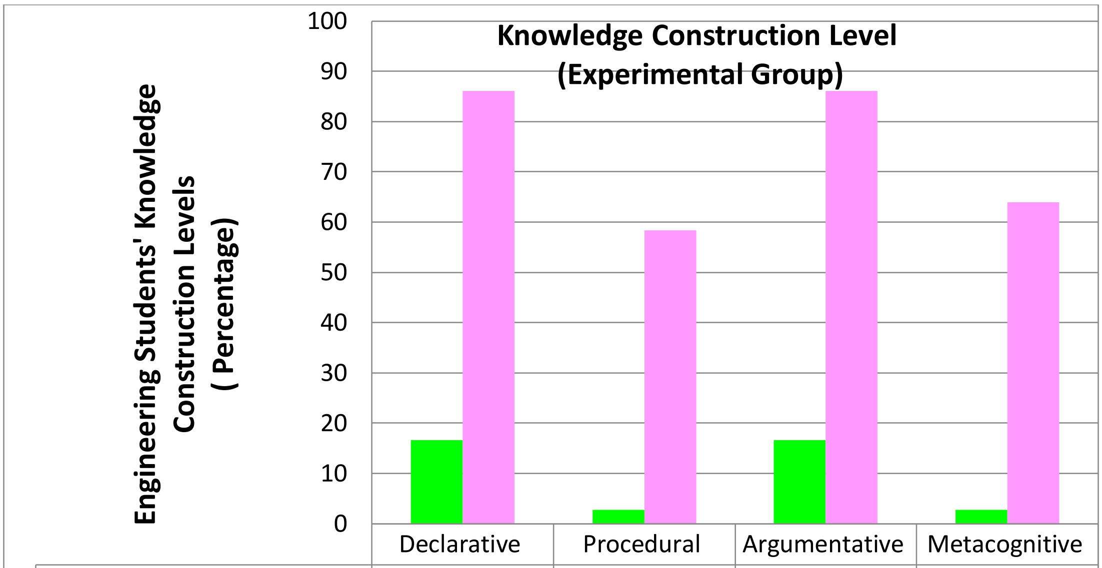
Table 5.13 : Summary of number of students' passes in each level of knowledge construction (experimental group)

Knowledge Construction Level	Pre-Test (Pass)		Post-Test (Pass)	
	Number of Students	Percentage	Number of Students	Percentage
Declarative	6	16.67	31	86.11
Procedural	1	2.78	21	58.33
Argumentative	6	16.67	31	86.11
Metacognitive	1	2.78	23	64.00

Table 5.14 : Summary of number of students' passes in each level of knowledge construction (control group)

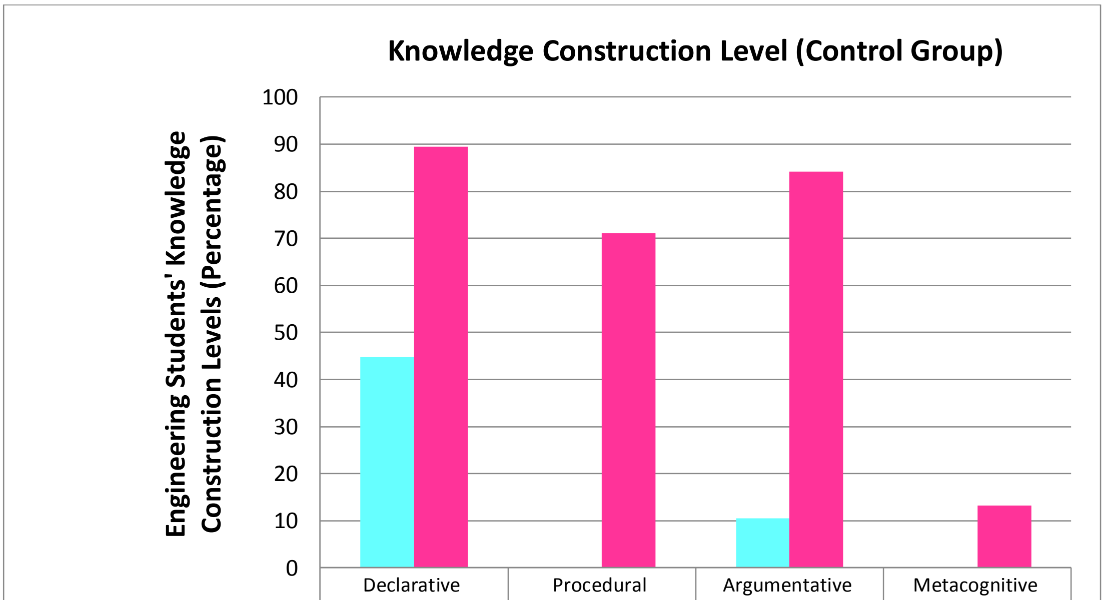
Knowledge Construction Level	Pre-Test (Pass)		Post-Test (Pass)	
	Number of Students	Percentage	Number of Students	Percentage
Declarative	17	44.74	34	89.47
Procedural	0	0.00	27	71.05
Argumentative	4	10.53	32	84.21
Metacognitive	0	0.00	5	13.16

The histogram Figures 5.4 and 5.5 show in each level of KC in percentages. A different score was calculated in Figure 5.4 for the experimental group and Figure 5.5 for the control group. Consequently, the comparison of the histograms of the control group with that of the experimental group is outlined in Figure 5.6. Regarding the scores of the five elements in the learning activities in the LGC task, there was a significant increase in each level of KC. The difference before and after experiencing IS via the Facebook discussion of this topic can be seen. Some of the engineering students gained a higher level of knowledge during the interaction between instructor-students and student-student in the online SCL environment; this indicates that there is a positive impact of IS to steer engineering students towards KC.



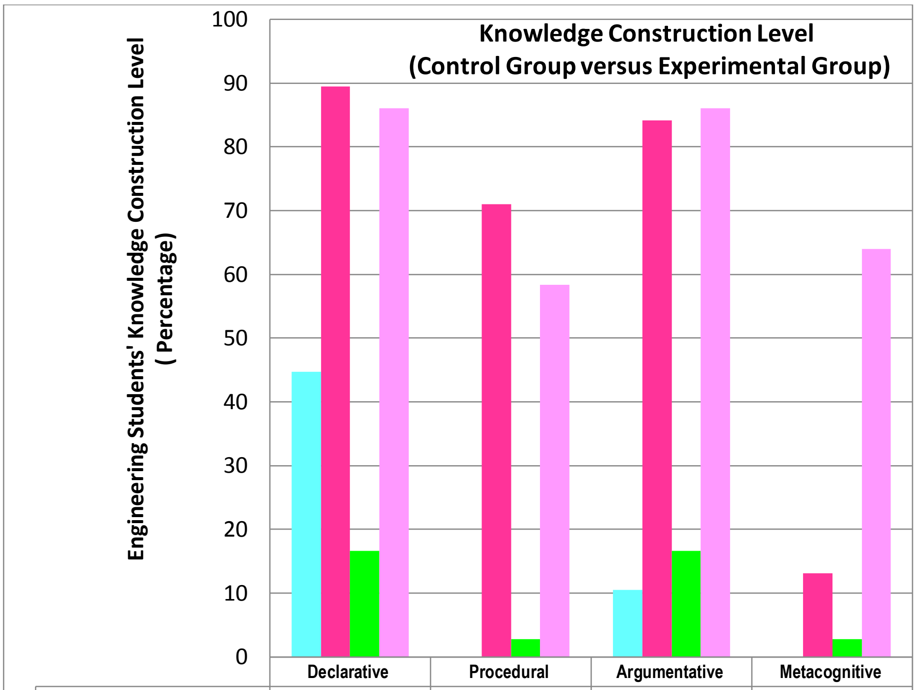
	Declarative	Procedural	Argumentative	Metacognitive
Percentage Pre-Test (Pass)	16.67	2.78	16.67	2.78
Percentage Post-Test (Pass)	86.11	58.33	86.11	64.00

Figure 5.4 Result in percentage of knowledge construction level for experimental group (histogram)



	Declarative	Procedural	Argumentative	Metacognitive
Percentage Pre-Test (Pass)	44.74	0.00	10.53	0.00
Percentage Post-Test (Pass)	89.47	71.05	84.21	13.16

Figure 5.5 Result in percentage of knowledge construction levels for control group



	Declarative	Procedural	Argumentative	Metacognitive	
Percentage Pre-Test (Pass)	44.74	0.00	10.53	0.00	Control Group
Percentage Post-Test (Pass)	89.47	71.05	84.21	13.16	
Percentage Pre-Test (Pass)	16.67	2.78	16.67	2.78	Experimental Group
Percentage Post-Test (Pass)	86.11	58.33	86.11	64.00	

Figure 5.6 Combination of results in percentage of knowledge construction levels (control group versus experimental group)

5.3.2.2 Knowledge Construction Level Based on Facebook Discussions with Instructional Scaffolding in Online Social Collaborative Learning Environment

The engineering students participated actively via a Facebook discussion in order to complete the LGC task or project. There were interactions between the students and the instructor and between peers. Thus, they had to discuss the learning content within the scope given by the instructor in their learning process towards KC.

As shown in Tables 5.15 and 5.16, scripts were posted from each team member when the engineering students completed task 1. A total of 2,428 messages were posted from the members of six teams in this learning activity, which consisted of several elements, such as assigning groups, assigning roles, assigning tasks, sharing and comparing, discovering and exploring, argumentation and negotiation of meaning, and synthesis and application of the new knowledge in the engineering field.

Moreover, the results give some more information about intimacy. A feeling of closeness (salience) and the use of emoticons can engage engineering students in asynchronous online discussion (AOD) and enhance their participation. They were constructing and developing the knowledge as well as acquiring new engineering knowledge via the Facebook discussions with IS in the online SCL environment.

In view of the impact of the total number of posting scripts on learning performance, the correlations between the number of emoticon and total posting scripts were analysed. The results regarding the number of emoticons showed that Team 5 had the highest number of posting scripts (594) when they completed their LGC learning task via the Facebook discussions, as illustrated in Table 5.15. This means that emoticons can lead to intimacy, which helps to sustain participants to continue the asynchronous discussion in order to reach a higher level of KC. Meanwhile, it can also reduce the number of isolated learners in the process of KC via the Facebook discussions.

Table 5.15 : Summary of posting scripts through Facebook discussions (Task 1 LGC Project)

	Experimental Group (Class DKA1B)		**Team 1**		**Team 2**		**Team 3**	
Episode	Level of Knowledge Construction	Elements of learning activities	Number of posting scripts	Number of emoticon (intimacy)	Number of posting scripts	Number of emoticon (intimacy)	Number of posting scripts	Number of emoticon (intimacy)
1		Assign grouping, role, task	17		21		24	
2a	Declarative	Sharing and comparing	30		29		64	
2b	Procedural	Discovering and exploring	75	37	15	22	69	81
2c	Argumentative	Argumentative / Negotiation of meaning	134		165		122	
2d	Metacognitive	Synthesis / application of new knowledge in Engineering field	143		128		24	
	Total		399		358		303	

	Experimental Group (Class DKA1B)		Team 4		Team 5		Team 6	
Episode	Level of Knowledge Construction	Elements of learning activities	Number of posting scripts	Number of emoticon (intimacy)	Number of posting scripts	Number of emoticon (intimacy)	Number of posting scripts	Number of emoticon (intimacy)
1		Assign grouping, role, task	22		31		34	
2a	Declarative	Sharing and comparing	11		59		157	
2b	Procedural	Discovering and exploring	61	25	76	158	89	76
2c	Argumentative	Argumentative / Negotiation of meaning	54		168		145	
2d	Metacognitive	Synthesis / application of new knowledge in Engineering field	74		260		127	
	Total		222		594		552	

Table 5.16 : Summary of posting scripts based on Gunawardena, Lowe and Anderson (1997)

Episode	Level of Knowledge Construction	Elements of learning activities	Number of Posting Scripts						Total of comments
			Team 1	Team 2	Team 3	Team 4	Team 5	Team 6	
1		Assign grouping, role, task	17	21	24	22	31	34	149
2a	Declarative	Sharing and comparing	30	29	64	11	59	157	350
2b	Procedural	Discovering and exploring	75	15	69	61	76	89	385
2c	Argumentative	Argumentative / Negotiation of meaning	134	165	122	54	168	145	788
2d	Metacognitive	Synthesis / application of new knowledge in Engineering field	143	128	24	74	260	127	756
	Total		399	358	303	222	594	552	2428

As shown in Figure 5.7, the characteristic of immediacy and intimacy can be essential for pre-engagement in the online learning between instructor-student and student-student to produce a good quality discussion so that the engineering students could know the key features of a good argumentative and metacognitive KC and be able to gain a higher level of KC. The results clearly indicate that the students were engaged in the discussion and negotiation of meaning as well as the synthesis and application of new knowledge in the engineering field during the ongoing discussion via Facebook supported by IS in the online SCL environment.

Thus, Team 5 scored 168 messages and Team 6 scored 145 messages in this learning activity in order to gain argumentative knowledge construction. Simultaneously, Team 5 scored 260 messages and Team 6 scored 127 messages in the learning activities as synthesis of the new knowledge for application in the engineering field due to their metacognitive knowledge construction. Meantime, Team 4 also scored the lowest overall in the five elements of learning activities, as outlined in Figure 5.7.

Intimacy involved an element of feeling close to something real from the engineering students using emoticons to show facial expressions in the Facebook discussions. It may have affected their immediate exchange of information in their learning process. Table 5.15 illustrated each group used the number of emoticons. Team 5 had the highest emoticons that scored 158 number during their AOD via Facebook platform. Meanwhile, Team 3 had 81 number of emoticons which is second higher scored in this learning activity.

On the other hand, Table 5.17 shows in percentages the posting scripts of each level of knowledge construction. The total of 212.60 scores in the argumentative level of KC means that the engineering students were more engaged in argumentative knowledge and negotiation of meaning for constructing a higher level of KC. They constructed the knowledge within the discussion groups via the Facebook platform with online IS in the SCL environment. The histogram in Figure 5.8 shows Team 3 has the lowest score (8.60) in the metacognitive level of knowledge construction compared to other teams. This indicates that Team 3 and Team 4 lacked any active learning via the Facebook discussions. When the scores of the five elements were linked to the engineering students' KCL and KC performance, it was found that the students' achievement in the test was much better if they had been involved in online SCL environment.

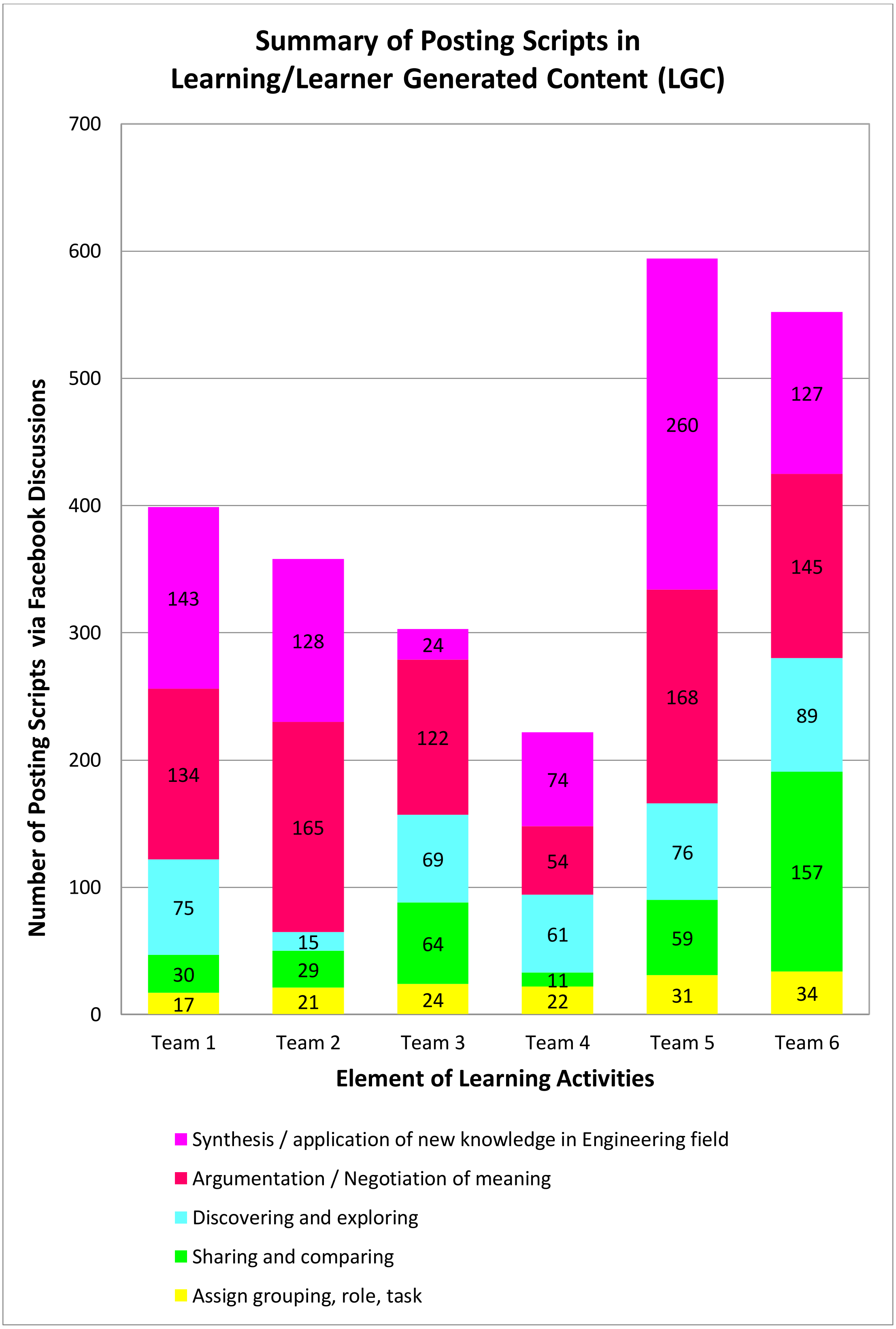


Figure 5.7 Results of learning activities for each team

Table 5.17 : Summary of posting scripts in percentage based on Gunawardena, Lowe and Anderson (1997) for Task 1 (LGC project)

Episode	Level of Knowledge Construction	Elements of Learning Activities	Number of Percentage in Posting Scripts						Sum
			Team 1	Team 2	Team 3	Team 4	Team 5	Team 6	
2a	Declarative	Sharing and comparing	7.85	8.61	22.94	5.50	10.48	30.31	85.69
2b	Procedural	Discovering and exploring	19.63	4.45	24.73	30.50	13.50	17.18	110.00
2c	Argumentative	Argumentation / negotiation of meaning	35.08	48.96	43.73	27.00	29.84	27.99	212.60
2d	Metacognitive	Synthesis / application of new knowledge in engineering field	37.43	37.98	8.60	37.00	46.18	24.52	191.72
	Total		100	100	100	100	100	100	600.00

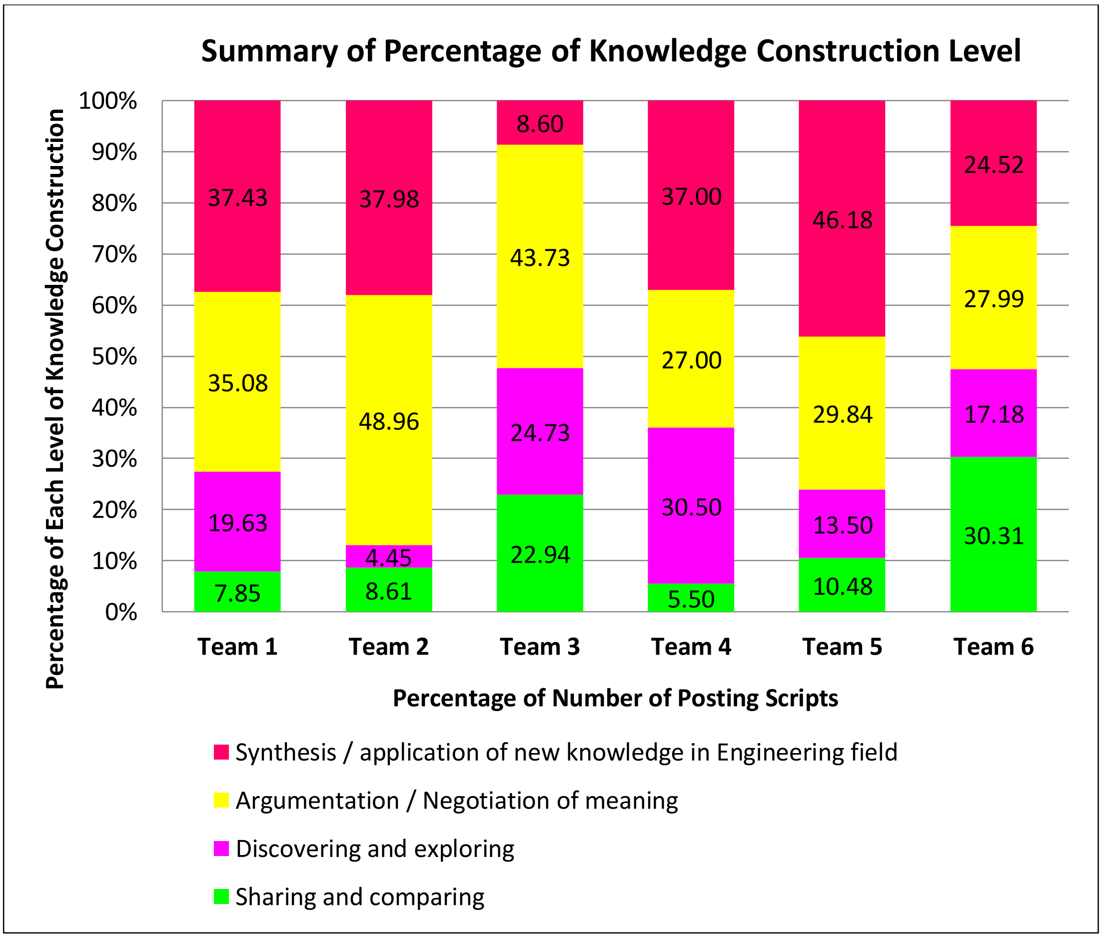


Figure 5.8 Results of percentage of each knowledge construction level for each team

Regarding the second learning activity, the engineering students had to solve the analysis of the ill-structured questions in Experiment 2, the Linear Motion topic. They had to conduct discussions between groups via Facebook in order to address the ill-structured problem question. The 36 civil engineering students participated in Task 2. The number of posting scripts is summarized in Table 5.18. It indicates that metacognitive knowledge construction level has the highest score compared with declarative KCL. The engineering students shared and compared the information in this learning task via Facebook discussions supported with online IS in the SCL environment.

Table 5.18 : Summary of Posting Scripts via Facebook Discussions (Task 2 - to Address Ill-structured question (a) Analysis part and (b) Questions in Experiment 2 Linear Motion

Episode	Experimental Group (Class DKA1B) Discussion Between Groups	Level of Knowledge Construction	Total of Comments
	Elements of Learning Activities		
1	Assign task		10
2a	Analysis on Ticker Timer Tape (Sharing and comparing)	Declarative knowledge	80
2b	Compare Graph 1 and Graph 2 between Teams 1, 2, 5 and 6 (Discovering and Exploring)	Procedural knowledge	34
2c	Displacement versus time graphs (Argumentation / negotiation of meaning)	Argumentative knowledge	8
2d	Star to join in the Task 2 (Team 3 and Team 4 are late get into the discussions)		10
2e	Combine Team 3 and Team 4 to solve analysis part and ill-structured questions in Experiment 2 Linear motion (synthesis/application of new knowledge in engineering field)	Metacognitive knowledge	119
	Total		261

Besides, Figure 5.9 presents the percentage of knowledge construction levels in Task 2. It shows that the engineering students participating in the content learning discussion had 45 percent metacognitive knowledge construction. The connection between problem-solving and knowledge construction activities reflected in research question 1 was also analyzed, as shown in Tables 5.2 to 5.18 and Figures 5.2 to 5.9. All the learning activities were validated by an online expert from the Department of

Multimedia Information and Communication Technology (ICT), as shown in Appendix J.

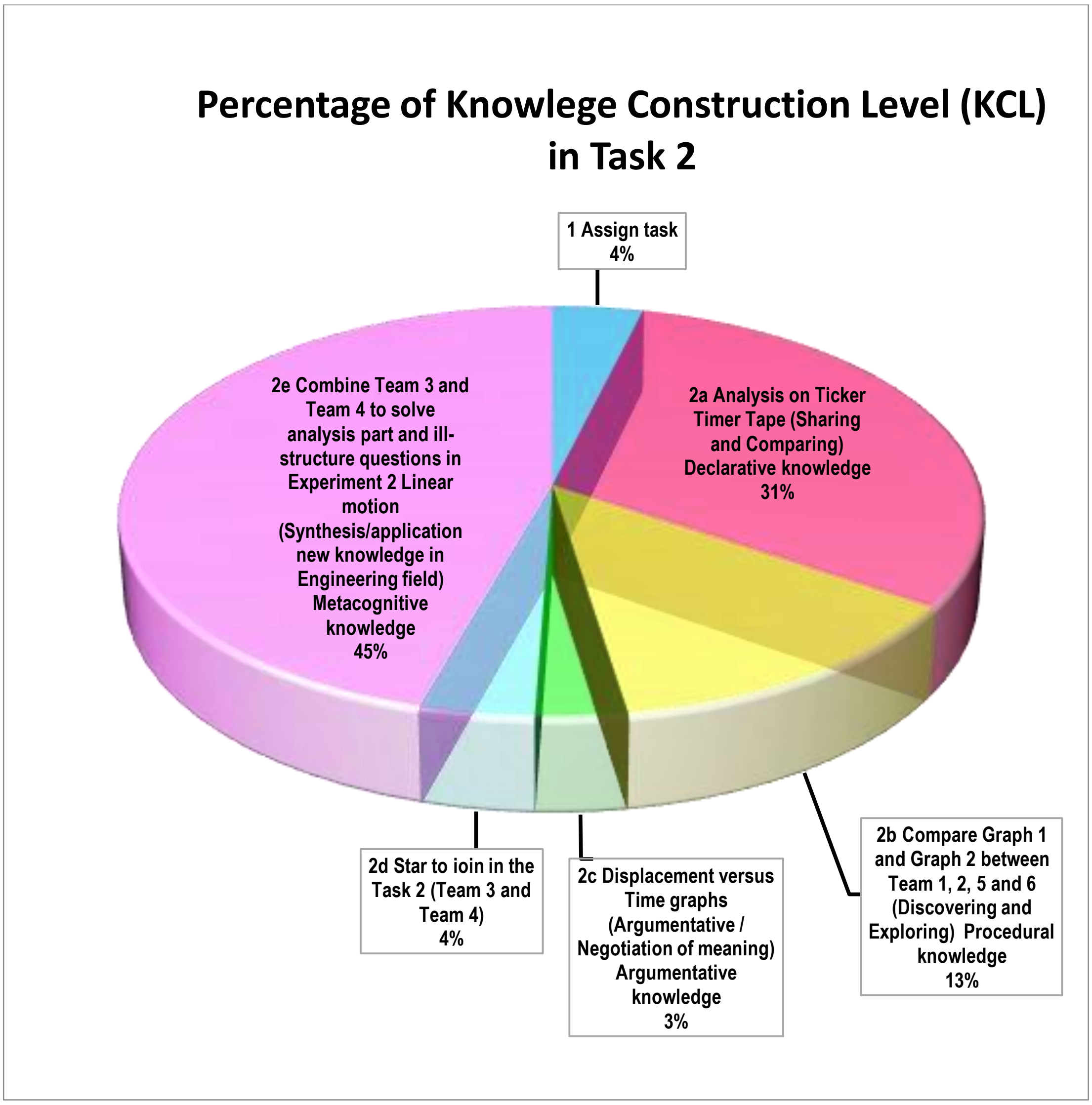


Figure 5.9 Percentage of knowledge construction level in task 2 to address ill-structured (a) analysis and (b) questions in experiment 2 linear motion

5.4 Findings on how Instructional Scaffolding in an Online Social Collaborative Learning Environment Cognitively Steers Engineering Students towards Knowledge Construction

The second research question focuses on how IS can cognitively scaffold (strengthen) engineering students' KC, which is hybrid in the online SCL environment when the researcher conducted learning activities via the Facebook discussions. In the meantime, the researcher also focused on how IS can engage and enhance engineering students' KC at a higher level.

Apparently, in order to investigate whether engineering students are able to construct their knowledge when experiencing IS in an online SCL environment, the researcher focuses on eight essential elements of IS. Thus, a qualitative analysis was applied for research question 2.

In practice, the researcher had first-hand experience of the online SCL environment, which is described in Chapter 4 as a designed learning environment. Then, the researcher conducted interviews on what happened. There are certain steps involved for conducting interviews regardless of research question 2. The researcher needed to follow the process and procedure for conducting structured interviews as outlined in Appendix H.

In order to make sure the interviewees would be able to understand the protocol of the interview questions, two (2) engineering students from the experimental group were randomly chosen to do the pilot test on the questions before the researcher conducted the interviews. The findings were also utilized to assess the reliability.

Before starting the interview session, the researcher had to identify five (5) interviewees who had performed the test and who had significantly improved their scores (marks) in their achievement test, and five (5) other interviewees who had actively participated in the learning activity via the Facebook discussions and so were supported with IS in the online SCL environment. The results are illustrated in Table 5.19.

Subsequently, the researcher interviewed them in accordance with the opening→introduction→transition→key→closure (OITKC stages) from Krueger (1998), as stated in detail in Chapter 3. These interviews generally lasted an average of 30 minutes depending on the interviewees, and they were audiotaped for later transcription. The researcher used an open-ended question transcript (see Appendix O) as the interview instrument to obtain qualitative data. The full set of protocol interview transcripts for the ten (10) interviewees as verified by them can be referred to in Appendix P. They had viewed the raw data (transcriptions of field notes) and commented on them to verify that the overall interview transcript was realistic and accurate.Thus, the researcher analysed research question two on how instructional scaffolding cognitively steers engineering students' knowledge construction by following the process of conducting the content analysis and thematic analysis as stated in Chapter 3 (3.7.4 part).

Table 5.19 : Summary of selecting interviewees

Criteria of Selecting	Improvement scores (marks) between pre and post-test				
Students	HM1	HM2	HM3	HM4	HM5
Outcomes	16.5 m	16.0 m	15.5 m	15.0 m	15.0 m

HM = High marks

Criteria of Selecting	Actively participated in Facebook discussions supported with instructional scaffolding in online SCL environment and as long as improvement scores (marks) between pre and post-test were satisfactory				
Students	MM1	MM2	MM3	MM4	MM5
Outcomes	114 comments 11.5 m	112 comments 14.0 m	107 comments 12.0 m	103 comments 15.0 m	70 comments 15.0 m

MM = Moderate marks

5.4.1 Findings on how Instructional Scaffolding Steers Engineering Students' Knowledge Construction

The purpose of the interview was to find out what the engineering students' feelings and thinking were when the researcher implemented the instructional scaffolding via the Facebook discussions in the online SCL environment. The researcher has discussed data-level of work in Chapter 3 Methodology (see Figure 3.2 an Overview of Application Design) and has highlighted the benefits of IS that cognitively steers engineering students' knowledge construction in an online SCL environment. There are several analyses in this subtopic.

Analysis 1 Pre-engagement: extract students' cognitive pre-engagement theme

Figure 5.10, a picture quotation, illustrates what the interviewees said on how the pre-engagement element of IS affected their KC, which was provided by the instructor (researcher). In addition, it was the opinion of one of the interviewees, which was supported by another interviewee talking about the same sub topic, that is, how pre-engagement helped them to understand the learning content better by generating the knowledge from a general level to a more detailed level. These were the factors affecting their KC.

The following are typical of interviewees' answers:

HM3: "I discovered a lot of new knowledge about linear motion with guidelines for my learning. I can learn very well. In fact, they are very good guidelines. Before that, I did not know how to start my learning. I can get knowledge from the learner or learning generated content (LGC) task and also increase my problem solving skills. I learnt a lot of new knowledge via the Facebook discussions. For example, I can understand about instantaneous velocity and average velocity with help from Miss Tan during the discussion."

HM4: "The guidelines provided by the instructor enabled me to understand the topic I am studying now. For example, the instructor said, "Please elaborate more about average velocity and instantaneous velocity. Watch the video again, Team 1 guys." Such words would inspire me to explain more about the velocity. Now, I am able to apply the knowledge in construction."

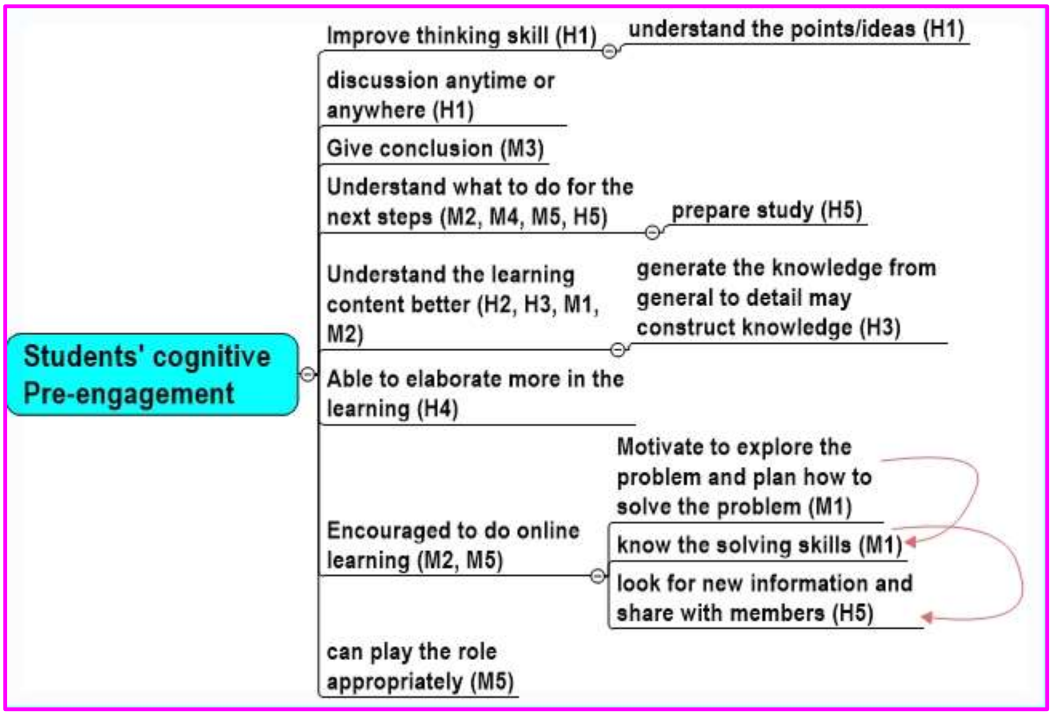


Figure 5.10 A part of the network diagram of the pre-engagement affecting knowledge construction (10 interviewees) [Note: H=HM, M=MM]

Analysis 2 Share goal: extract out motivation theme

Reviewing Figure 5.11, the researcher could see that the shared goal motivated interviewees to change their ideas towards KC in the online SCL environment. This is how an IS factor can cognitively strengthen engineering students' KC.

The following are typical of the engineering students' replies:

HM1: "Yes, it motivated me to change my ideas in a group discussion. For example, I accepted the concept that physical motion comprises uniform and non-uniform motions. This motivated me to work hard to find out more information about the topic."

HM4: "I was always ready to answer my peers when they posted questions to me. It got the team members to work together at the same time. It motivated me to be a better thinker when my peers gave me a variety of questions."

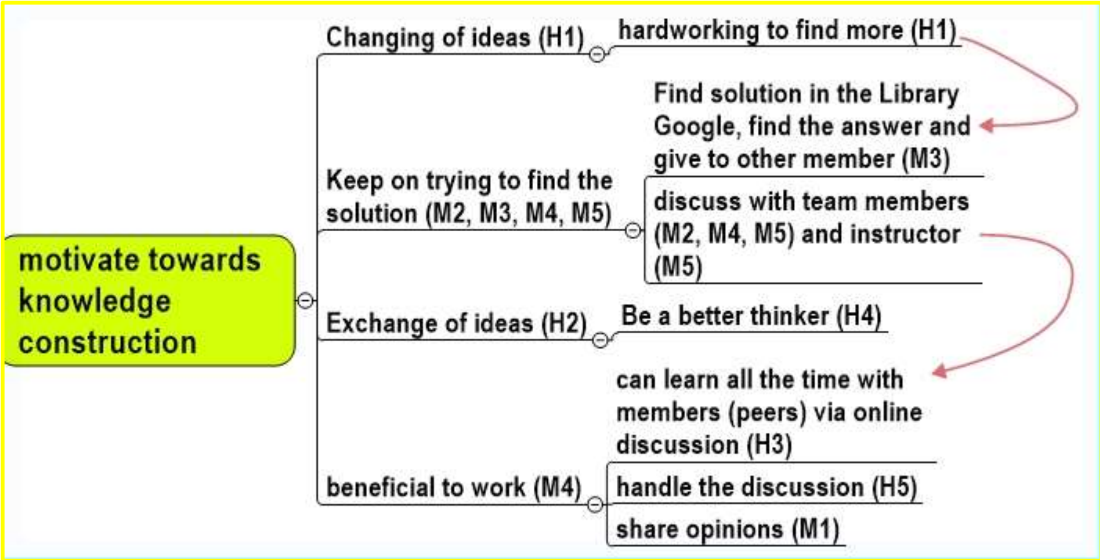


Figure 5.11 A part of the network diagram of the shared goal (MM2, MM3, MM4 and MM5 of 10 interviewees) [Note: H=HM, M=MM]

Analysis 3 of Understanding of students' prior knowledge: extract of engagement and enhancement theme

As Figure 5.12 shows, the engagement and enhancement elements led the engineering students to become active learners in their process of the learning journey. The elements of IS encouraged them to construct knowledge in order to understand students' prior knowledge.

The following is feedback from the engineering students:

HM4: "I had seen the animation video on Facebook, which made me understand the topic further. I downloaded the YouTube video and shared it with my friends to let them understand more about the topic."

HM5: "There are many types of video. They helped me in AOD on Facebook. They made me understand the topic more. For example, Miss Tan posted, "Please search or read from your notes. Find more videos related to the topic.""

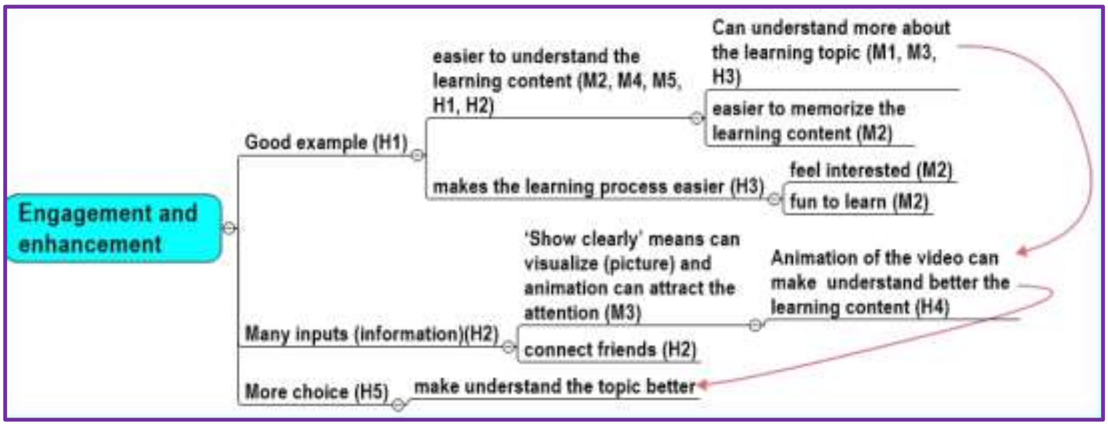


Figure 5.12 A part of the network diagram of understanding of students' prior knowledge (MM2, MM4, MM5, HM1 and HM2 of 10 interviewees)
[Note: H=HM, M=MM]

Analysis 4 and Analysis 6 of providing a variety of support and giving feedback: extract of explanation and guide theme (Axial coding)

Figures 5.13 and 5.14 indicate that the explanation and guide elements of IS help and cognitively steers engineering students' KC in the online SCL environment. They felt it was easier to learn new knowledge when the instructor gave a detailed explanation and guided them in their learning itinerary. All the interviewees felt the instructor's feedback could lead them towards KC. This feedback would assist engineering students to construct new knowledge. The qualitative data showed that the variety of support and feedback provided are the two elements of intercourse (merge and blend). Thus, one axial coding is focused on for explanation and to guide the theme in this study.

Hence, axial coding emerges from between providing a variety of support and giving feedback. It means that giving feedback inter-relates (intercourse or interconnection) with providing a variety of support with IS elements from the instructor. It makes engineering students feel a degree of confidence, enabling them to acquire new knowledge, in turn, would enable cognitively steers their KC into a higher level in the online SCL environment.

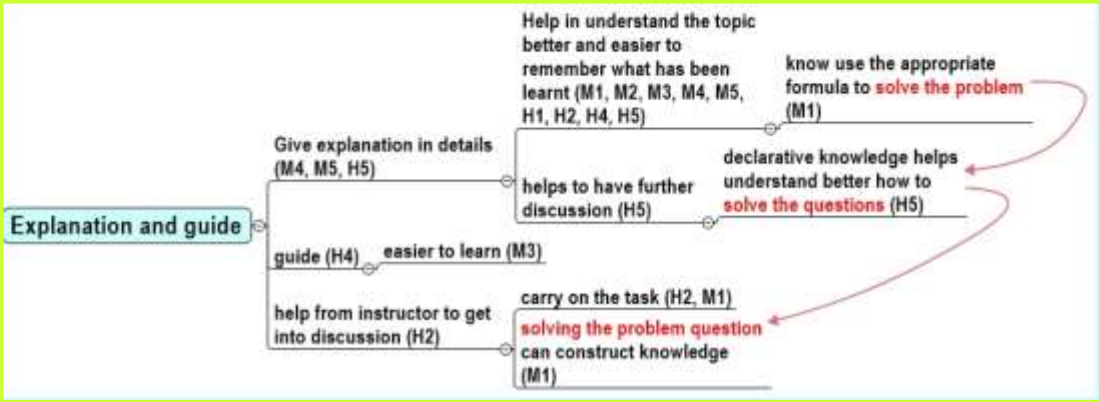


Figure 5.13 A part of the network diagram of providing a variety of support (9 interviewees except HM3) [Note: H=HM, M=MM]

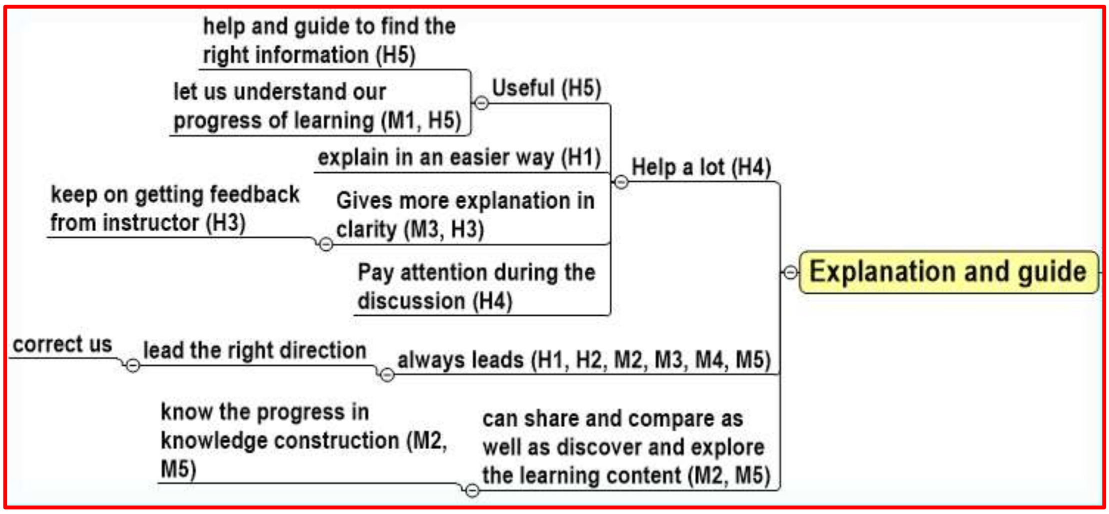


Figure 5.14 A part of the network diagram of giving feedback (10 interviewees) [Note: H=HM, M=MM]

The interviewees provided several answers:

HM4 (provide a variety of support): “I feel good. It’s easier to understand the subject. Miss Tan assisted me with appropriate statements. For example, Miss Tan posted the statement, “HM4, please explain in simple way to let your team members understand what is linear motion and non-linear motion as well as uniform motion and non-uniform motion.” This statement was useful. Miss Tan guided me to show all my teammates how to construct the knowledge.”

HM1 (give feedback): “Yes. It led me in the knowledge construction. The lecturer’s feedback, such as, ‘Explain in an easier way’, helped a lot. Another example: Miss Tan told the starter in our group/team to explain the topic again. This helped me understand more. The instructor always led us in the right direction. If we were wrong or do not get the correct answers, Miss Tan would correct us."

Analysis 5 on Provide encouragement and praise: extract of encouragement and praise theme

Figure 5.15 illustrates the findings of encouragement and praise on how IS enhanced the engineering students' KC. The complimentary statements made students feel excited in the AOD via the Facebook platform in the online SCL environment.

The interviewees provided the following responses:

HM1: "That is praise that made me more excited to continue the discussion. For example, Miss Tan gave me support like 'Well done!', or 'Good job!' I feel I want to stay on to continue with the discussion. Encouragement can make me study harder. But, praise can make me over confident to construct knowledge."

HM2: "Such compliments provide inspiration for me to study. I have a desire to study."

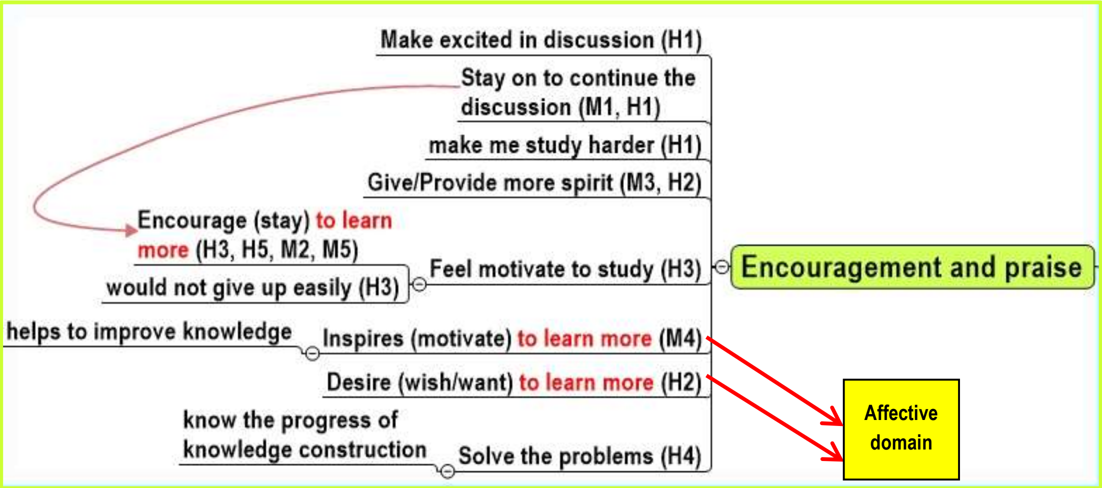


Figure 5.15 A part of the network diagram of complimentary statements (10 interviewees) [Note: H=HM, M=MM]

Analysis 7 on Provide supportive and positive responses: extract of determination (persistence) and comfort and engagement themes

There are two domains, namely, cognitive and affective, in the element of IS for providing supportive and positive responses, as presented in Figure 5.16. Hence, determination (persistence/persevere) and comfort and engagement themes are extracted from the domains of the IS model. Such IS helps and assists engineering students' KC.

These are typical reports from interviewees:

HM1: "I felt "blessed" and kept searching for points/ideas to elaborate upon during the discussion. For example, I compared the differences between uniform and non-uniform motion."

HM5: "Those kinds of responses helped me in searching for videos. The instructor told me to take my time. Therefore, I could search for the right video and share it with other members. For example, I could tell Miss Tan, "Please give me a minute." When Miss Tan gave supportive statements, I was encouraged to know more. So, I was able to learn more. Positive responses made me feel happy and encouraged me to finish the task completely."

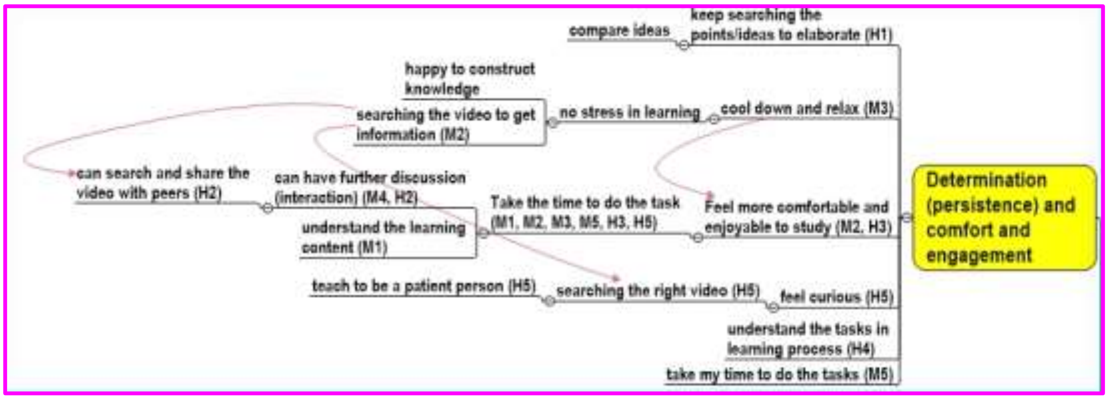


Figure 5.16 A network diagram of providing supportive and positive responses (all the interviewees) [Note: H=HM, M=MM]

Analysis 8 on Provide instructional support: extract of ease the learning process theme

Figure 5.17 gives the results of providing IS that aided the engineering students' learning process when the instructor provided appropriate clues or hints via the Facebook platform in the online SCL environment. These ISs may help them perform better in KC. They understood more of the problem-solving question and then solved it via a collaborative learning discussion. There were also interactions with the instructor to get a better understanding of the topic regarding KC.

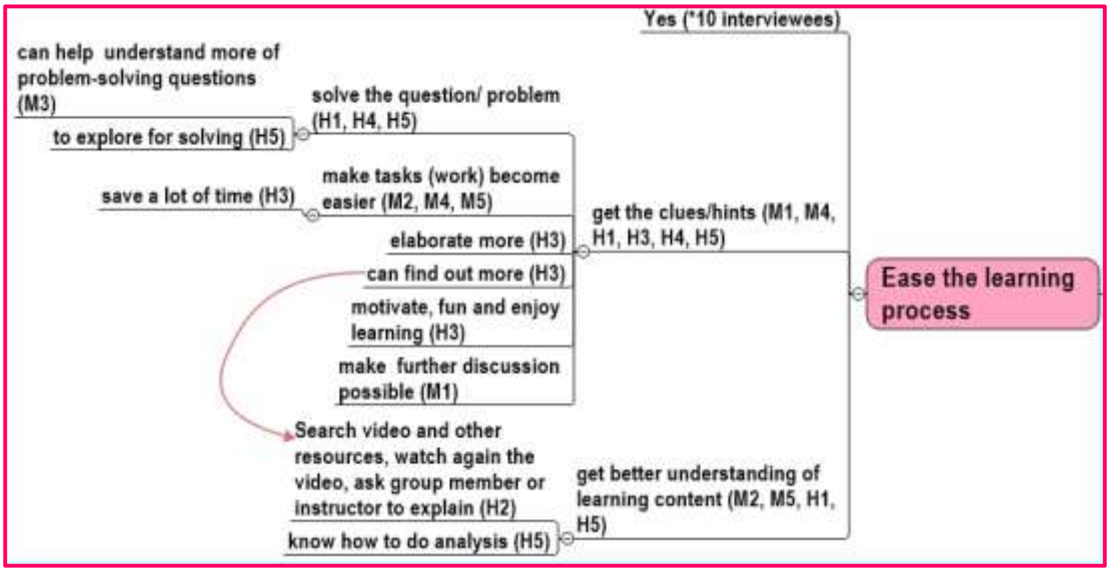


Figure 5.17 Part of the network diagram of providing instructional support (10 interviewees) [Note: H=HM, M=MM]

The following are typical of the interviewees' answers:

MM3: "Yes. For example, Miss Tan always asked me to watch the video many times. The instructor gave me keywords to help me understand well the problem-solving question."

HM5: "Yes. The instructor always gave hints and clues to help me and the team members to explore the problem-solving questions. For example, Miss Tan posted the statement: 'Please explore more YouTube videos and find the new information to get better knowledge.' Another example is, 'Tell me your data reading such as u (initial velocity), v (final velocity), a (acceleration) from Experiment 2 Linear Motion'. This would help me know how to do analysis on the problem-solving questions."

The researcher gives an overview of the mind map to provide a brief outline (network diagram) to show the interviewees' opinions about eight (8) essential elements of instructional scaffolding (see Appendix Q). Hence, Table 5.20 shows the summary of themes for research question two.

Table 5.20 : Summary of themes for eight essential elements of instructional scaffolding

Analysis	Essential element of instructional scaffolding	List of themes
1	Pre-engagement	Students' cognitive pre-engagement
2	Share goal	Motivation
3	Understanding of students' prior knowledge	Engagement and enhancement
4	Provide a variety of support	Explanation and guide (*axial coding)
5	Provide encouragement and praise	Encouragement and praise
6	Give feedback	Explanation and guide (*axial coding)
7	Provide supportive and positive responses	Determination (persistence/persevere) and comfort and engagement
8	Provide instructional support	Ease the learning process

5.4.2 Ranking the Important and Less Important Elements of Instructional Scaffolding in an Online Social Collaborative Learning Environment

The purpose of ranking the important and less important elements of IS are to understand engineering students' perception and perspective of the priority of eight (8) essential elements when the researcher implemented them in their learning itinerary via the Facebook discussions in the online SCL environment. Table 5.21 shows a comparison of the results in percentage and number of engineering students' feelings regarding the varying degrees of importance of the elements of IS. Then, from Table 5.22, an analysis of the ranking of IS can be derived, as shown in Table 5.23. The researcher combined the marks and percentage in the ranking of IS elements.

The ranking elements of instructional scaffolding in order highlights which element can best reinforce engineering students' KC in an online SCL environment. The findings, as presented in Table 5.23 and Figure 5.22, show the results of the ranking of IS elements. Subsequently, the researcher identified the engineering students' perception of how IS can cognitively steers their KC in the online SCL environment. There are three categories, namely, important, neutral, and less important, for the eight essential elements of IS in order to strengthen engineering students' knowledge construction.

Table 5.21 : Combination of the most and least important elements of instructional scaffolding in percentage and number of engineering students involved

Elements of Instructional Scaffolding	Percentage (Number of engineering students)	
	Most Important (100%)	Least Important (12.50%)
1) Pre-engagement	13.89 (5)	5.56 (2)
2) Share goal	2.78 (1)	5.56 (2)
3) Understanding of students' prior knowledge	2.78 (1)	8.33 (3)
4) Provide a variety of support	27.78 (10)	5.56 (2)
5) Provide encouragement and praise	5.56 (2)	25.00 (9)
6) Give feedback	25.00 (9)	19.44 (7)
7) Provide supportive and positive responses	19.44 (7)	5.56 (2)
8) Provide instructional support	2.78 (1)	25.00 (9)
Total	100.00 (36)	100 (36)

Table 5.22 : Sorting the ranking of the eight essential elements of instructional scaffolding

Student	Element 1	Post Test Marks	Element 2	Post Test Marks	Element 3	Post Test Marks	Element 4	Post Test Marks
S1	5	4	8	1	7	2	6	3
S2	5	4	2	7	3	6	4	5
S3	3	6	4	5	2	7	1	8
S4	2	7	4	5	6	3	3	6
S5	8	1	7	2	5	4	4	5
S6	3	6	5	4	6	3	4	5
S7	5	4	3	6	4	5	1	8
S8	1	8	2	7	8	1	7	2
S9	1	8	5	4	6	3	4	5
S10	7	2	5	4	6	3	3	6
S11	3	6	2	7	1	8	4	5
S12	8	1	4	5	7	2	1	8
S13	5	4	4	5	3	6	6	3
S14	2	7	5	4	4	5	1	8
S15	2	7	5	4	8	1	1	8
S16	2	7	5	4	4	5	1	8
S17	1	8	4	5	6	3	5	4

S18	3	6	2	7	4	5	5	4
S19	6	3	7	2	2	7	3	6
S20	5	4	7	2	4	5	3	6
S21	7	2	4	5	5	4	3	6
S22	6	3	5	4	3	6	2	7
S23	2	7	5	4	3	6	7	2
S24	2	7	5	4	3	6	7	2
S25	2	7	5	4	4	5	3	6
S26	2	7	4	5	7	2	1	8
S27	1	8	6	3	7	2	8	1
S28	6	3	7	2	4	5	3	6
S29	2	7	4	5	7	2	1	8
S30	3	6	1	8	2	7	8	1
S31	2	7	6	3	4	5	1	8
S32	1	8	2	7	4	5	5	4
S33	6	3	8	1	7	2	5	4
S34	2	7	5	4	8	1	1	8
S35	4	5	5	4	6	3	7	2
S36	2	7	3	6	5	4	6	3
Sum		**197**		**159**		**149**		**189**

Student	Element 5	Post Test Marks	Element 6	Post Test Marks	Element 7	Post Test Marks	Element 8	Post Test Marks
S1	2	7	1	8	4	5	3	6
S2	1	8	6	3	8	1	7	2
S3	7	2	6	3	5	4	8	1
S4	7	2	8	1	1	8	5	4
S5	6	3	1	8	2	7	3	6
S6	7	2	8	1	1	8	2	7
S7	7	2	8	1	2	7	6	3
S8	6	3	3	6	4	5	5	4
S9	3	6	7	2	2	7	8	1
S10	8	1	1	8	2	7	4	5
S11	8	1	5	4	6	3	7	2
S12	3	6	2	7	5	4	6	3
S13	7	2	1	8	2	7	8	1
S14	6	3	3	6	8	1	7	2
S15	6	3	4	5	3	6	7	2
S16	3	6	6	3	7	2	8	1
S17	7	2	3	6	2	7	8	1
S18	7	2	1	8	6	3	8	1
S19	8	1	5	4	1	8	4	5
S20	2	7	8	1	6	3	1	8
S21	8	1	1	8	2	7	6	3
S22	8	1	1	8	4	5	7	2

S23	6	3	8	1	1	8	4	5
S24	4	5	8	1	1	8	6	3
S25	6	3	7	2	1	8	8	1
S26	8	1	6	3	5	4	3	6
S27	5	4	4	5	2	7	3	6
S28	8	1	2	7	1	8	5	4
S29	5	4	8	1	6	3	3	6
S30	4	5	5	4	7	2	6	3
S31	5	4	3	6	7	2	8	1
S32	8	1	3	6	7	2	6	3
S33	4	5	1	8	3	6	2	7
S34	6	3	4	5	3	6	7	2
S35	8	1	1	8	3	6	2	7
S36	1	8	4	5	7	2	8	1
Sum		**119**		**171**		**187**		**125**

[Note: Rank 1= 8 scores (marks), rank 2 = 7 scores, rank 3 = 6 scores, rank 4 = 5 scores, rank 5 = 4 scores, rank 6 = 3 scores, rank 7 = 2 scores, rank 8 = 1 scores]

Table 5.23 : Ranking of elements of instructional scaffolding (IS)

Elements of Instructional Scaffolding (IS)	Post Test Marks	Percentage
Pre-engagement	197	68.40
Provide a variety of support	189	65.63
Provide supportive and positive responses	187	64.93
Give feedback	171	59.38
Share goal	159	55.21
Understanding of students' prior knowledge	149	51.74
Provide instructional support	125	43.40
Provide encouragement and praise	119	41.32

The finding in the pie chart (see Figure 5.18 in details) shows that the most important element of IS is "pre-engagement", while too much of "provide praise and instructional support" may adversely affect the engineering students' learning itinerary towards KC, as it means that they might tend to slow down their work and take longer to finish their learning task.

The second important element is "provide a variety of support", while "provide instructional support" is the second less important element in this study. The researcher also found that "provide supportive and positive responses" is the third important element of IS to cognitively steers engineering students' KC. These elements may help them upgrade their KCL to a higher level, such as analyzing, evaluating, and creating.

The quantitative data of important and less important IS elements is further supported by the interviews. The interviews were qualitatively analysed to gain insight about the eight essential elements of IS to see whether they help, guide, and support students' learning itinerary towards KC.

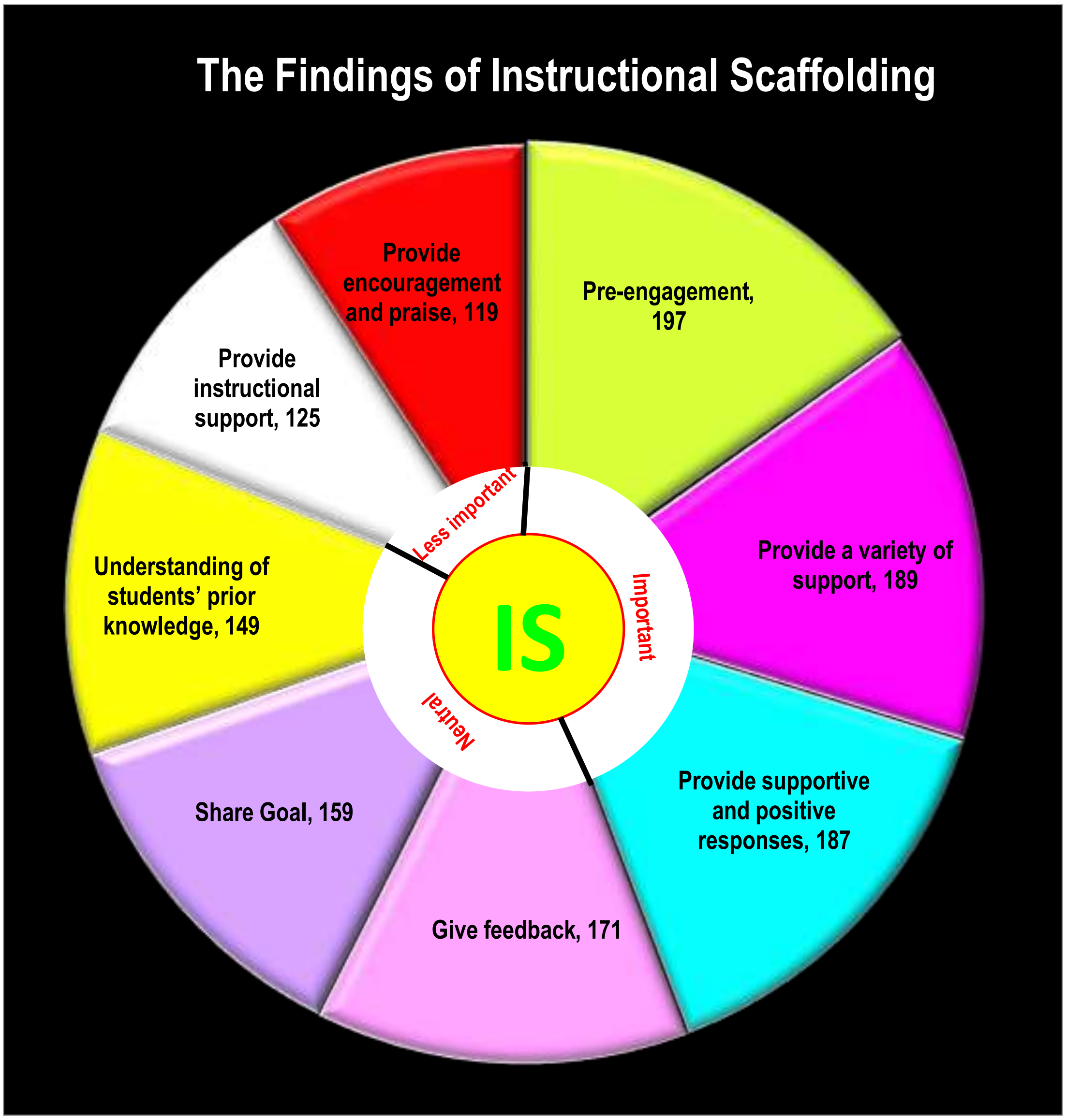


Figure 5.18 The results of raking the instructional scaffolding elements

The qualitative findings show the important and less important elements of the eight essential elements of IS. Such findings can be used to assess the validity and aid in the interpretation of quantitative results (Short, 2002) regarding the important and less important elements of IS. There are several findings on the important and less important of IS elements that can help engineering students cognitively strengthen their KC in the online SCL environment.

Finding 1 on degree of importance of pre-engagement

Figure 5.19, shows the interviewees' perception and perspective of why pre-engagement is the most important element of IS to cognitively steer engineering students' KC. It makes them work together to complete the learning or LGC task towards achieving KC. On the other hand, it also evoked contrasting opinions from two interviewees. They felt pre-engagement was not important due to their dislike of working as a starter; they believed they could carry out such a learning activity online in the online SCL environment themselves without assigning grouping.

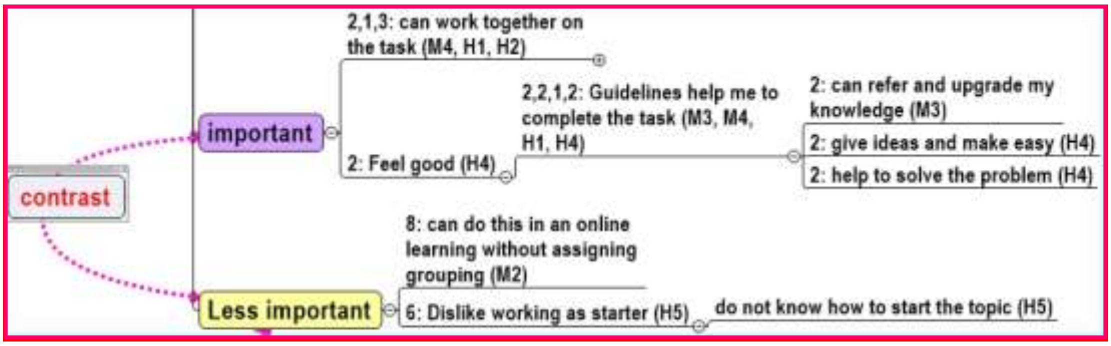


Figure 5.19 Network diagram of important and less important elements of the pre-engagement element (Important: MM3, MM4, HM1, HM2, HM4 and less important: MM2, HM5) [Note: H=HM, M=MM]

There are several answers based on the interviewees' perspective:

HM1 (important): "Good way of study. In my opinion, I can share our points (ideas) with other members. Using Facebook can improve my thinking skills. I can have a discussion any time or anywhere especially when we have a smartphone. Use it wisely. We can understand the points by watching videos, such as on linear motion on YouTube. I can use that as a guideline and complete the LGC task as well as the group discussion. My play role is as a theorist. I can add on the points/details to the topic."

HM5 (less important): "Guidelines A and L guide me to do the tasks. Guideline L motivated me to solve the problem with the members. I know how to lead and help my members. So, I can prepare what to do. I also know what to do next. I will find new information and share it with my members. For example, Miss Tan posted, "After watching the video, please synthesize the topic. Thanks!" But, I had all the work with me. I divided the learning tasks among the members. I dislike being a starter because I do not know how to start the topic."

Finding 2 on degree of importance of 'providing a variety of support'

In other cases, statements of engineering students' feelings can help them in KC, such as giving detailed explanations. The instructor providing a variety of support is a crucial element of IS that steers engineering students' KC. Meanwhile, student S6 gave his perception that he felt annoyed when he was busy doing other things and support came from his peers. The results of the important and less important elements of providing a variety of support are shown in Figure 5.20.

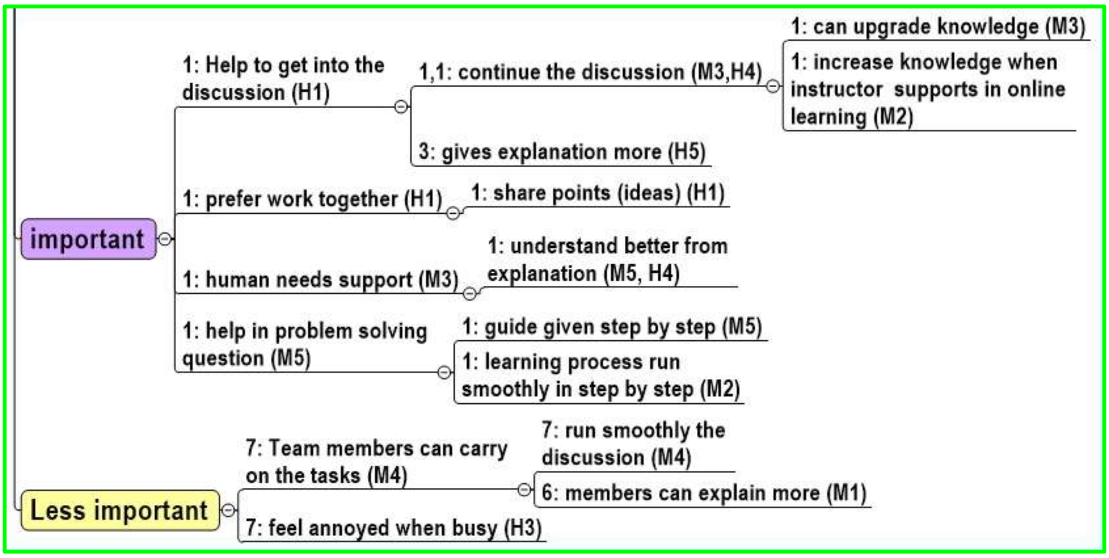


Figure 5.20 Network diagram of important and less important elements of providing a variety of support (Important: MM2, MM3, MM5, HM1, HM4, HM5 and less important: MM1, MM4, HM3) [Note: H=HM, M=MM]

The interviewees' opinions were:

HM5 (important): "I felt excited to learn because it helped me to understand better the topic I was studying. For example: Asraf (nickname) posted for me regarding the distance and displacement, acceleration and deceleration video. I could understand it better when Miss Tan gave a detailed explanation. For example, Miss Tan posted, "Since you all are not clear, let me elaborate more about distance and displacement". I could increase my knowledge when Miss Tan supported me to do problem solving questions and gave the explanation to let me understand the topic better. When I explained to my members, it helped me more in the learning process. The instructor gave the guidance step by step for a smooth discussion of the learning task."

HM3 (less important): “Whenever I faced a difficulty, I was lost. As we know, YouTube is not 100% correct. So, I could put my questions to Miss Tan. Luckily, she was very committed and assisted me by giving me correct facts. I felt very confident when instructor Miss Tan provided the “assist statement”. This made me more motivated to study. I could be certain that the statement was correct because Miss Tan guided me. I could argue about the meanings with my teammates and help them to gain knowledge. For example, the learning task in ‘Episode 2c Argumentative or Negotiation of meaning.’ Linear motion is a wide topic, and there are complex questions to be solved. So, I had to learn from the bottom. I acquired basic knowledge with the help of Miss Tan. This was very important. Then, I could learn more. Support enables students to understand the topic better. But, somehow, I feel annoyed when someone else hurries me to do the work, as I am busy searching for ideas.”

Finding 3 on degree of importance of ‘provide supportive and positive responses’

Those kinds of responses from the instructor helped the engineering students’ KC via the Facebook discussions in the online SCL environment. Figure 5.21 reveals the results regarding the importance of the ‘providing supportive and positive responses’ element of IS; those involved learned how important team work was and understood the learning topic better. However, those interviewees whose responses indicated they felt it was less important thought they could not upgrade their learning when they were not independent when it came to enhancing KC.

The following are typical of the engineering students’ replies:

HM2 (important): “I can further discuss with my members how to seek the knowledge. I can learn how important team work is through the learning activities. I know the topic well.”

HM1 (less important): “I feel that I am not using my brain enough. I am becoming less independent. And also, I cannot upgrade my learning.”

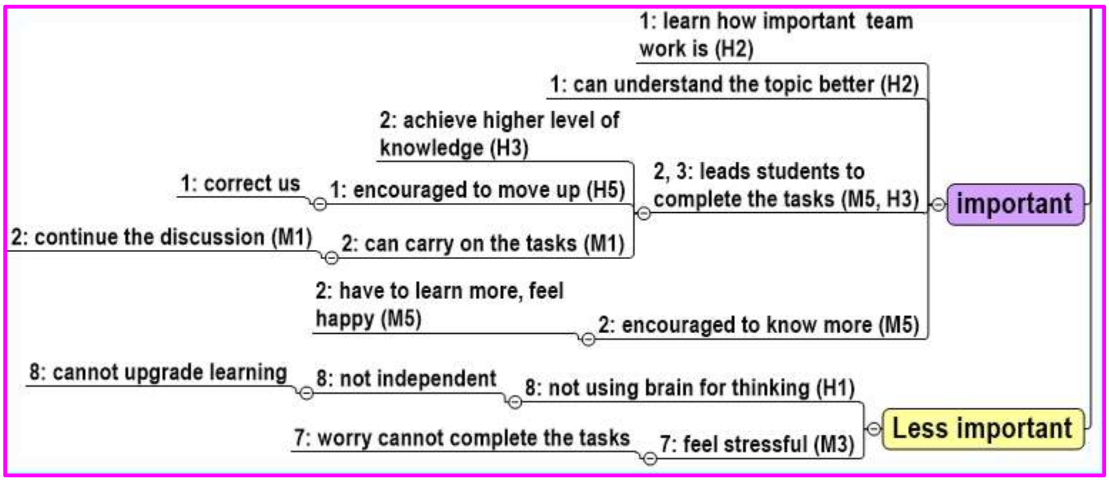


Figure 5.21 Network diagramming of important and less important element of providing supportive and positive responses (Important: MM1, MM5, HM2, HM3, HM5 and less important: MM3, HM1) [Note: H=HM, M=MM]

Finding 4 on degree of less importance of 'providing encouragement and praise'

Some interesting results emerged from the study of 'provide encouragement and praise' as reported in Figure 5.22. Some engineering students revealed that they disliked being too dependent on the instructor's praise, which to them, was a less important element of IS. Moreover, nowadays, they are excellent in online social media activities in their daily life. On the other hand, motivating engineering students' KC is an important IS element in their process of learning.

Typical interviewees' ideas were as follows:

MM2 (important): "The complimentary statements gave me encouragement to study more and better. For example, "Good job, S8"

HM5 (less important): "For example, 'Good source, excellent.' This statement was posted by Miss Tan. This encouragement supported me to find more good information to help my members. But, it made us like to chat. I like to do it myself. Not too dependent on Miss Tan's praise. I like to be independent."

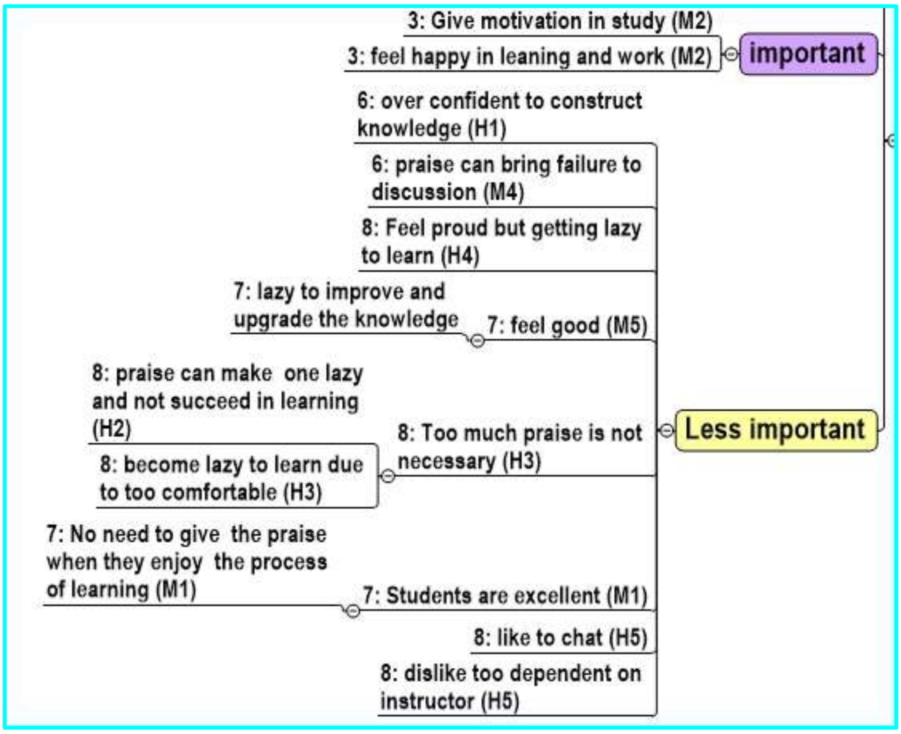


Figure 5.22 Network diagram of degree of importance of 'providing encouragement and praise' [Note: H=HM, M=MM]

Overall, of the eight (8) elements of IS, the most important, so far as improving the test results of engineering students instructional scaffolding concerned, are pre-engagement, the provision of a variety of support mechanisms and providing the students with supportive and positive responses as necessary.

5.5 Finding on how the Online Social Collaborative Learning Environment Guided with Instructional Scaffolding Support Engineering Students Reach a Higher Level of Knowledge Construction

Qualitative analysis was applied to research question 3. In order to investigate whether the characteristics of the SCL environment supported with IS helped the engineering students to reach a higher level of knowledge construction, the researcher focused on the summative content analysis and thematic analysis approaches which collected the data (transcriptions of field notes). Next, the transcripts were coded independently.

Figure 5.23 shows several SCL characteristics, such as condition, interaction, immediacy, and intimacy, which helped and enhanced the engineering students reach a higher level of knowledge construction.

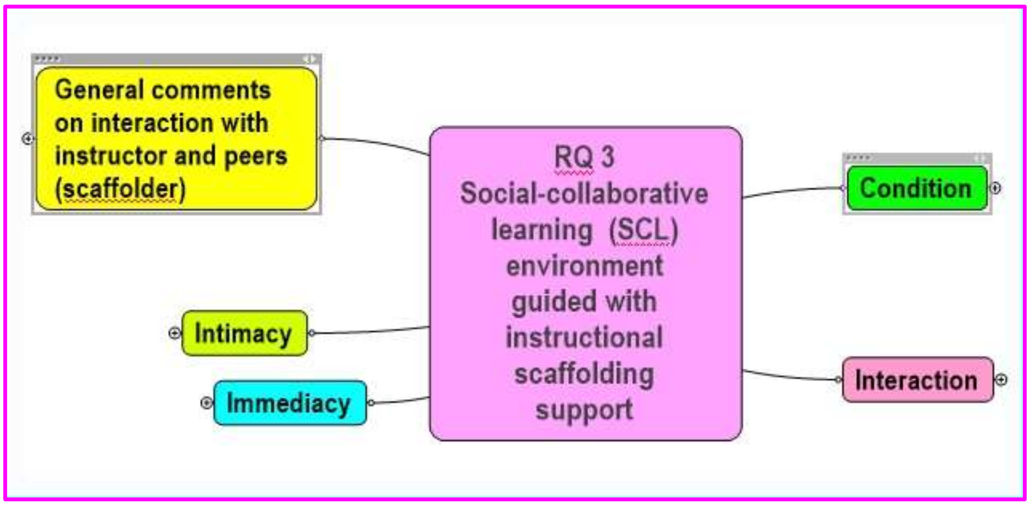


Figure 5.23 Network view of SCL characteristics

There are several analyses of how the characteristics of the SCL environment supported by IS in this subtopic help engineering students reach a higher level of KC

Analysis 1: Condition characteristic extract acquiring new knowledge, collaboration context, and group composition themes

Figure 5.24, a picture quotation, presents the results of the condition characteristic of the SCL environment supported by IS. Three themes were extracted based on the interviewees' perceptions and perspectives in order to help engineering students to reach a higher level of KC: acquiring new knowledge, collaboration context, and group composition.

There were ten interviewees who felt satisfied to acquire new knowledge when SCL characteristics were embedded in the learning itinerary via the Facebook discussions supported by IS (see Figure 5.25). They shared and compared ideas with their teammates. Subsequently, they gave supporting opinions to other members about a particular stand point. In the meantime, they got a new learning experience by searching for information from search engines. This would help engineering students reach a higher level of KC.

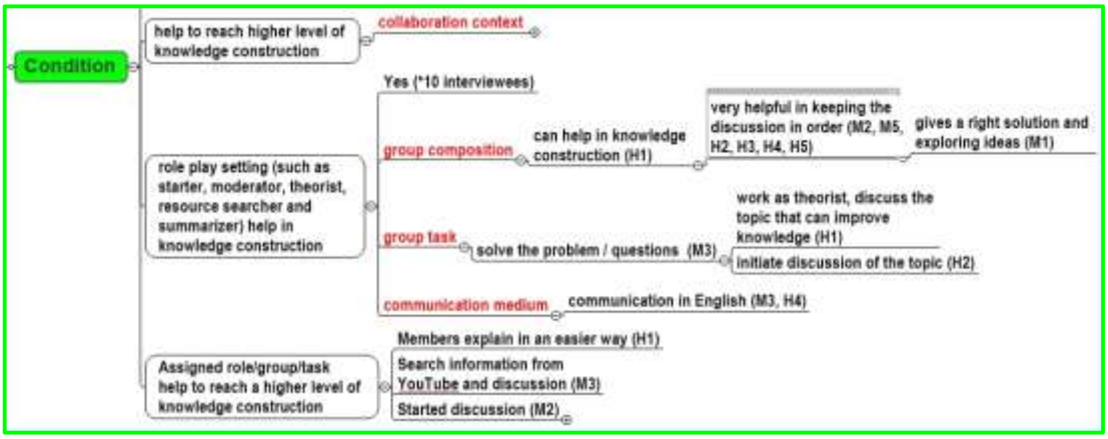


Figure 5.24 Network diagram of the condition criteria and group composition (MM1, MM2, MM5, HM2, HM3 and HM4 of ten interviewees)
[Note: H=HM, M=MM]

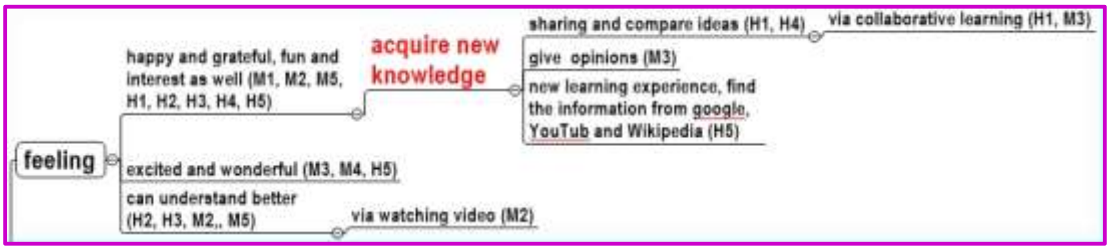


Figure 5.25 Network diagram of the element of 'acquire new knowledge' (10 interviewees) [Note: H=HM, M=MM]

One student's response was as follows:

MM4: "I feel happy and excited. I gained knowledge through the Facebook discussions, for example: learning activity 2d (synthesis and application of new knowledge in the civil engineering field). Miss Tan stated that we should think about how to apply linear motion knowledge in the civil engineering field. Because we compared our ideas, we could increase our knowledge and get more information. This is very helpful to me in reaching a higher level of knowledge construction."

Collaboration context is one of the elements of the featured task. It is a key characteristic of a shared goal as summarized in Figure 5.26. The engineering students shared ideas, gave prompt feedback, and identified the application of learning content, such as assigning roles, groups and tasks, to help them reach a higher level of KC.

There is a need for the condition characteristic supported by IS in order to help engineering students reach a higher level of KC.

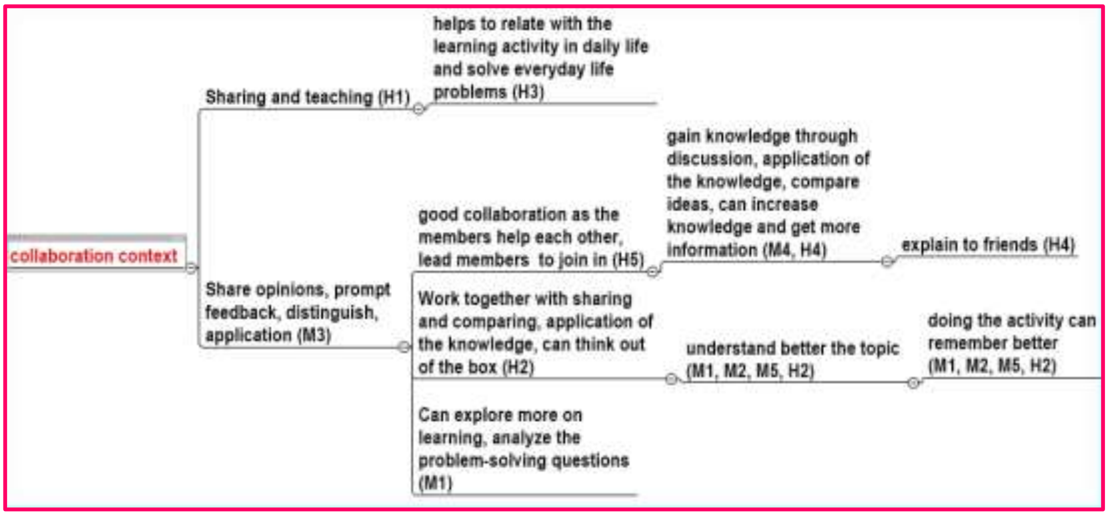


Figure 5.26 Network diagram of collaboration context (MM1, MM2, MM5 and HM2 interviewees) [Note: H=HM, M=MM]

One interviewee's idea was as follows:

HM2: "My members can work together by sharing and comparing knowledge about linear motion and non-linear motion. Miss Tan stated that we should think how we could apply distance and displacement knowledge in the civil engineering field. It helped me to understand better the topic we learnt. Participating in a learning activity can make me remember what I have learnt. I can think outside the box. I get higher level of knowledge."

Group composition comprises group size, gender distribution, and prior knowledge, as stated in the theoretical framework (see Figure 1.4). A good group composition is very helpful to keep the discussion in order as claimed by interviewees MM1, MM2, MM5, HM2, HM3 and HM4. These are the criteria that affected the engineering students' discussion via Facebook in the online SCL environment. As seen in Figure 5.24, all of the interviewees claimed that role play helped them to reach a higher level of KC. One engineering student gave the following opinion:

HM2: "Yes. I am a resource searcher. I had to search YouTube to get the information. I initiated the discussion of the topic. When my group members had started the discussion in Facebook, I shared the videos with my group members to help them understand the learning tasks. All these assigned roles helped me to discipline myself by doing my tasks and tolerating my members. I asked my group members to explain if they understood the topic. This made me reach a higher level of KC. I shared YouTube videos with my group members. For example, Miss Tan told me to find another video for the discussion about the topic. This helped me upgrade my knowledge."

Analysis 2 on Interaction characteristic: extract on themes of control self-emotion, resolve socio-cognitive conflict, and argumentation and negotiation of meaning

With reference to Figure 5.27, the themes of control self-emotion, resolve socio-cognitive conflict, and negotiation of meaning and argumentation were developed in interaction characteristics according to the interviewees' perceptions and perspectives. The engineering students pointed out that facing with disagreement with their peers in solving a learning task would help them to think maturely. This made them reach a higher level of KC.

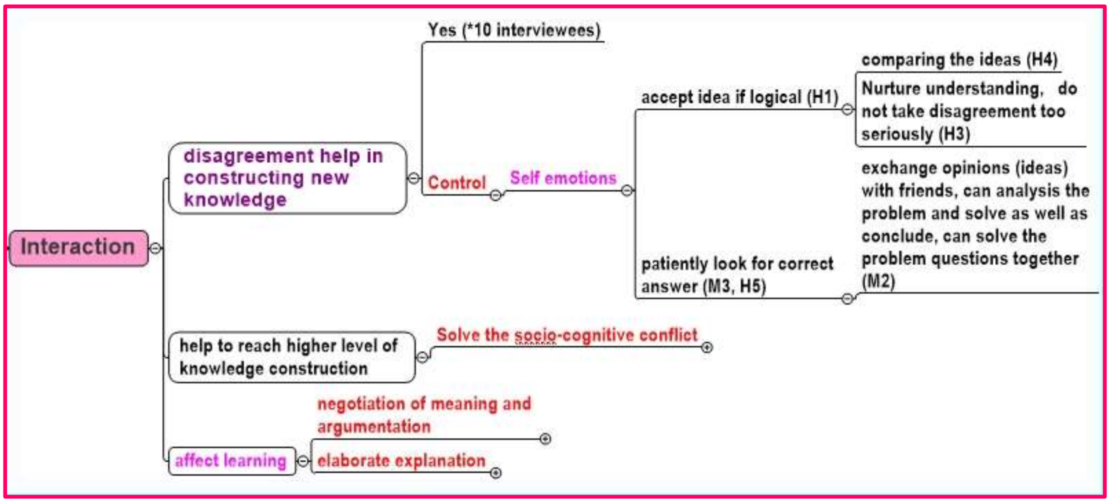


Figure 5.27 Network diagram of interaction and control self-emotion (MM4, HM1 and HM5) [Note: H=HM, M=MM]

All the interviewees shared the same idea, that is, that disagreement helped them in constructing new knowledge, as shown in Figure 5.27. However, they needed to have self-control of their emotions when facing disagreement. If they remained logical, they were able to accept other teammates' ideas when they were explained in detail. In the meantime, effective interaction helped the engineering students to reach a higher level of KC in the online SCL environment supported by IS.

The answer is based on an interviewee's perception:

HM5: "If I made a mistake, I found out what was wrong. So, I would look for the correct answer in the problem-solving questions with my members. I also found more information and contradictory statements. This could make me gain a higher level of new knowledge. When members and I found more information, we shared and compared the ideas via the Facebook discussions. This also made a higher level of KC possible. Therefore, I could get new and good information. At the same time, I could give a good explanation of the topic if, for example, Miss Tan posted, 'How about the application of 5 equations of linear motion for Team 6 members?"

On the other hand, the engineering students continued to discover and explore the knowledge in order to reach a higher level of KC. In contrast, they faced social-cognitive conflict, which affected their ability to continue the task. However, they did not give up easily, and they continued to debate with their team members until consensus was reached, as shown in Figure 5.28.

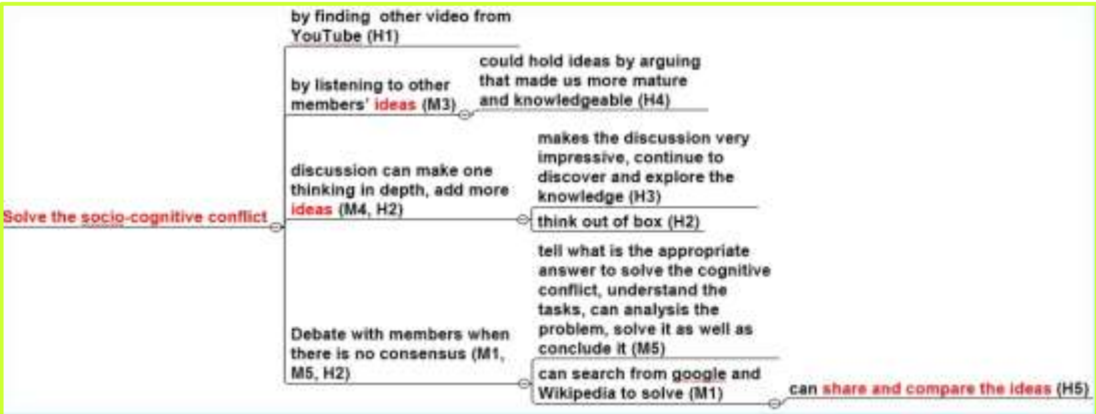


Figure 5.28 Network diagram of resolving socio-cognitive conflict (9 interviewees except MM2) [Note: H=HM, M=MM]

A typical interviewee's perception is as follows:

MM5: "Yes. When I was faced with disagreement with my peers, I debated with them and told them what I thought was correct. I also searched for videos from YouTube to find the appropriate answer. For example, I debated with MM2 regarding the distance and displacement. I said that displacement was a scalar quantity. But, MM2 said it was a vector quantity. We started arguing. This will help me to remember which one is right or wrong. At the same time, I could resolve the conflict by searching YouTube. I played the role of moderator. I controlled them when there was a disagreement on the negotiation of meaning. I called Miss Tan when we could not resolve our argument. I can reach higher level of knowledge when I accept new ideas and understand the tasks. This makes me realize that conflicts that happen can be fun, and they help you identify where the fault is. From the conflict, I knew how to analyze and solve the problem questions in the Task 2 experiment of linear motion. At the same time, I could do the conclusion of this experiment."

The findings on negotiation of meaning and argumentation led students to know more about how to read and interpret the graphs, as claimed by interviewees MM1, MM2, MM4, MM5, HM2, HM3 and HM5 and as illustrated in Figure 5.29. The findings show that the engineering students were able to become more analytical because they needed to give more elaborate explanations to support other team members' points of view. They negotiated positively about the meaning of the differences in the displacement versus time or velocity versus time graphs and the negotiations help them understand and analyse better the ill-structured questions. This helped them reach a higher level of KC.

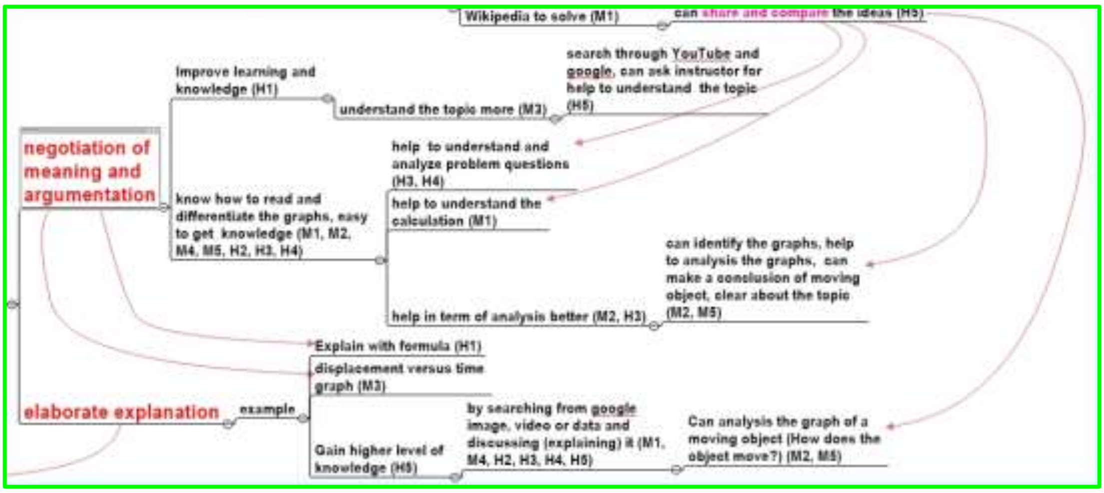


Figure 5.29 Network diagram of negotiation and argumentation of meaning (interviewees MM1, MM2, MM4, MM5, HM2, HM3 and HM5)
[Note: H=HM, M=MM]

One interviewee expressed the following idea:

MM4: "Formerly, I did not know how to read the graphs. After the Facebook discussions, I could save the data in my smart phone. Whenever I want, I can refer to the graphs via the smart phone. The knowledge that I gained is buried deep in my mind. I won't forget the knowledge. We kept on searching on YouTube. For example, in 2c, Miss Tan asked us to give more examples for instantaneous velocity and discuss it."

In general comments, interviewees MM4, HM3 and HM4 expressed the ideas that online interaction in the SCL environment supported by IS can result in effective learning, as illustrated in Figure 5.30. This helped the students to gain new knowledge at any time in their daily learning activities. Simultaneously, it also helped them reach a higher level of KC when they were satisfied with the quality of interaction and prompt and rich feedback.

HM3: "Throughout the whole SCL environment via Facebook, I have learnt a lot about linear motion. I need to learn more. Without collaborative learning, I just get the information from the lecturer, and I learn. That is it. Collaborative learning involves two-way communication. The lecturer will ask you, and you will answer. Meanwhile, you can also ask the lecturer. That is how you can get a higher level of new knowledge. I can use the new knowledge to solve problems. When we construct something with the correct measurements, we need to take precautionary steps, which the lecturer often mentions in the class. Online learning increases collaboration in two ways. I can gain new knowledge every time. I can immediately apply the new knowledge in everyday life. When there are uncertainties, I can ask my teammates. They will respond to me immediately. With the use of emoticons, I enjoy the task that I am doing. It connects me with my friends through learning collaboratively. And also, Miss Tan is committed to teaching and guiding us even though it is late at night."

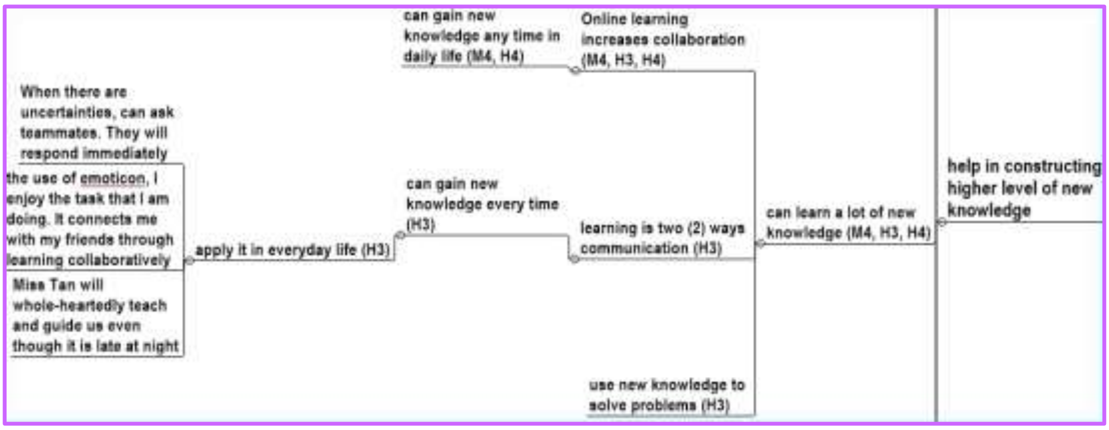


Figure 5.30 A part of network diagram of general comments (interviewees MM4, HM3 and HM4) [Note: H=HM, M=MM]

Analysis 3 on Immediacy characteristic: extract of themes of different types of discussion and rapid exchange info

Two core categories (major themes) were developed from different types of discussions and rapid exchange info from the immediacy characteristic, as illustrated in Figure 5.31.

There were different types of discussion, namely, synchronous (real time) discussion and asynchronous (delay time) discussion, as presented in Figure 5.32. The results show that five interviewees (MM1, MM3, MM4, HM1 and HM2) preferred real time discussion, while the other five interviewees preferred AOD. The real time discussion students claimed it was easy for them to focus when facing the instructor, who may give them more ideas to think about. Getting a rapid response from the instructor, which is related to the rapid exchange info theme, is an encouragement to ask questions, as student HM2 stated. Thus, the immediacy characteristic assisted the engineering students to achieve a higher level of knowledge construction.

Engineering students' typical responses were as follows:

HM2: "I like to do the real time discussion in the class because I can ask Miss Tan on the spot. She explains to me and encourages me. She also replies to me promptly and accurately. So, I can improve my knowledge construction."

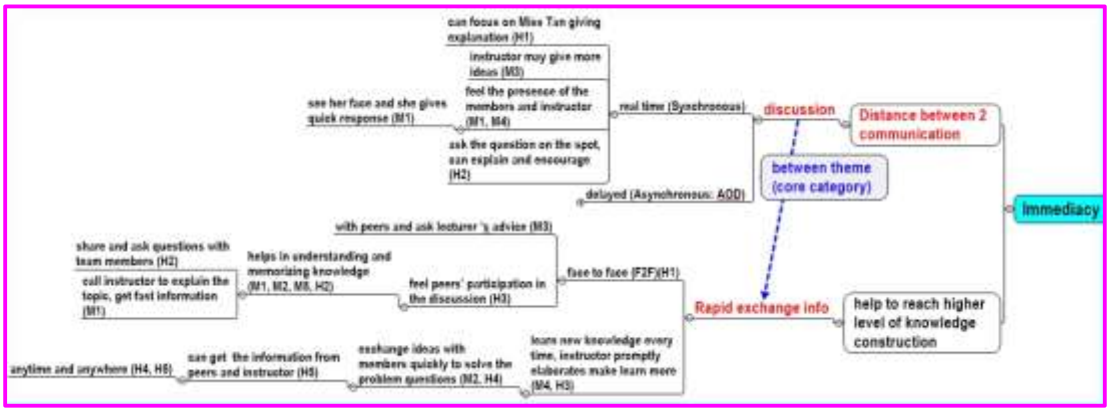


Figure 5.31 Network diagram of immediacy (themes of discussion and rapid exchange info) [Note: H=HM, M=MM]

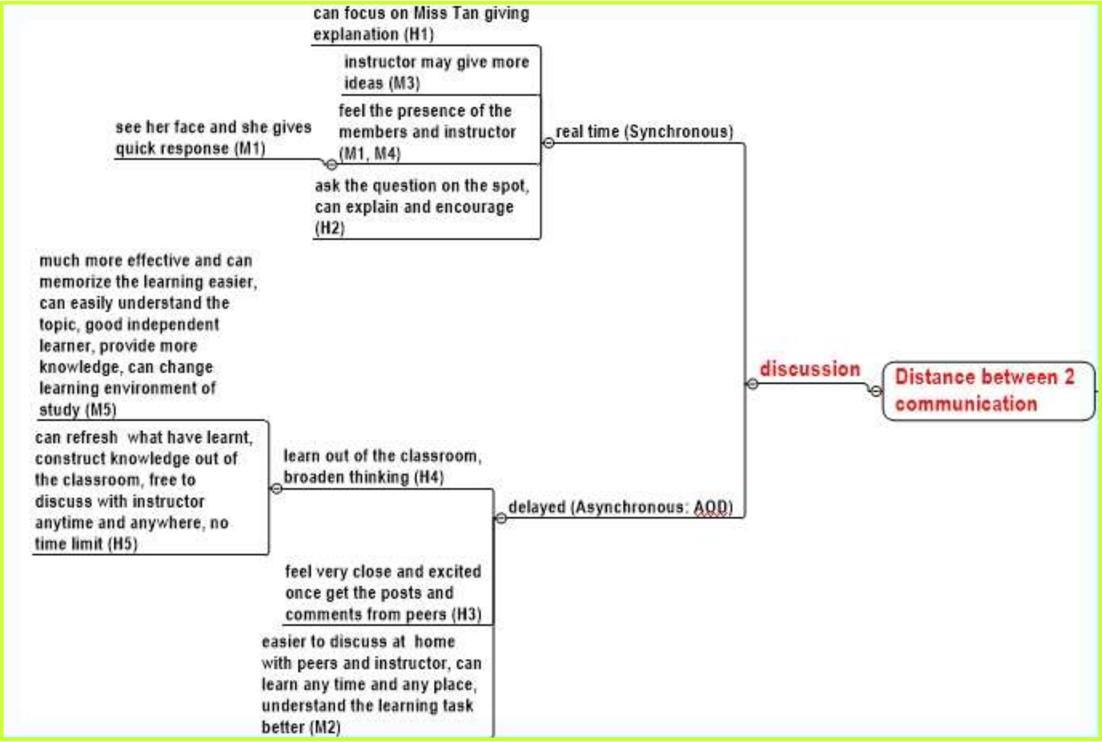


Figure 5.32 Network diagram of different types of discussion (synchronous: MM1, MM3, MM4, HM1, HM2 and asynchronous: MM2, MM5, HM3, HM4, HM10) [Note: H=HM, M=MM]

The detailed results of the rapid exchange info are given in Figure 5.33. All ten interviewees had the same perspective, that is, that the immediacy characteristic in the SCL environment would help them reach a higher level of KC. Two interviewees, HM4 and HM5, expressed the same opinion, that is, that KC can be done out of the classroom. It means that informal learning can be held anytime, anywhere, and in any place. Simultaneously, they discussed and exchanged information and ideas with their peers promptly to solve the ill-structured problems or questions, which enabled them to reach a higher level of KC via the rapid exchange of information in the online SCL environment.

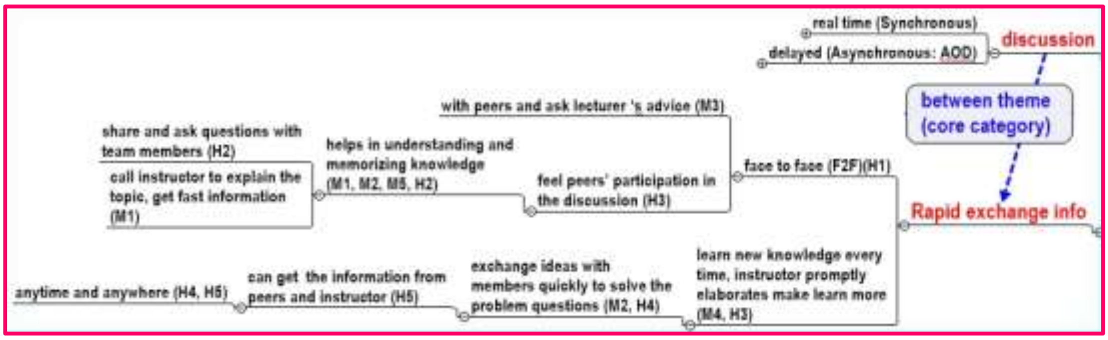


Figure 5.33 Network diagram of rapid exchange info (ten interviewees) [Note: H=HM, M=MM]

One interviewee expressed the following opinion:

HM5: “Although my members and I were on holiday celebrating Malaysia Independence Day, I still could discuss with team members anytime to get information. For example, Miss Tan posted, ‘Team 6 members, please think about how the linear motion can be applied in plumbing work of the civil engineering field.’ So, I can construct higher level of knowledge. I can discuss with them anytime and anywhere in the Facebook discussions.”

Analysis 4 on Intimacy characteristic: extract on something real in feeling close theme

Figure 5.34, a picture quotation, demonstrates the interviewees’ perception of an informal and pleasing type of discussion on Facebook. It helped the engineering students to reach a higher level of KC. The interviewees felt close to each other using emoticons to express social-emotional experiences during the Facebook discussions. With the use of emoticons, the engineering students enjoyed carrying out the learner or learning generated content (LGC) task. They felt there was no barrier between the instructor and the students and they could seek the instructor’s ideas and suggestions anytime to help them reach a higher level of KC.

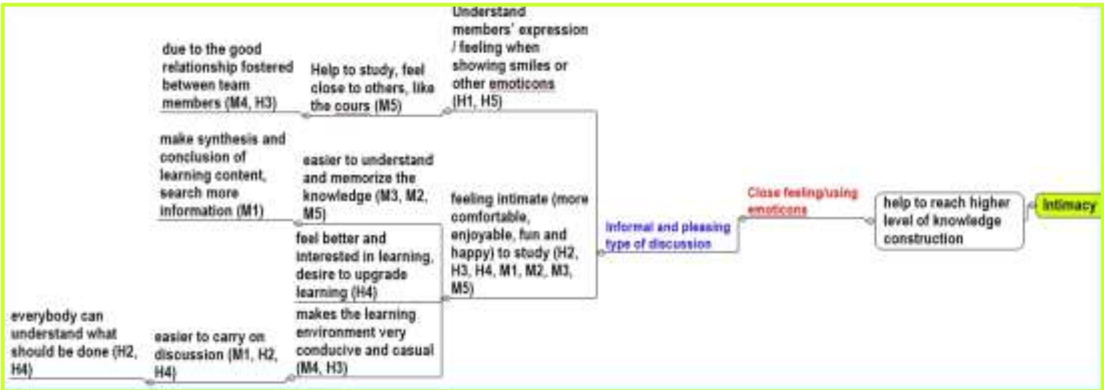


Figure 5.34 Network diagram of intimacy (interviewees MM1, MM2, MM3, MM5, HM2, HM3 and HM4) [Note: H=HM, M=MM]

The following is a typical interviewee’s report:

HM3: “It makes the learning environment very conducive and casual. You get to connect better with teammates and the instructor. We can foster good relationships with others. For example, in all of the episodes in the learning activities, Miss Tan always uses emoticons to make us feel comfortable and happy. At the same time, it provides me with a higher level of knowledge. She is very good and kind. Some people feel shy talking with others face to face. But, via the Facebook discussions, I can ask her any question when I have any doubt. I feel close to her when using emoticons. I feel happy with my learning and with my lecturer. I don't feel any tension (stress and pressure) about studying. I feel tension when studying in the classroom, and it is not good."

The overall results of research question three are shown clearly in Appendix R. The researcher constructed a holistic network representation of the data findings and analysis of how the SCL characteristics helped the engineering students reach a higher level of KC. Moreover, the overview of the outline network is directly supported by the views of other interviewees. Overall, Table 5.24 shows the summary of themes for research question three.

Table 5.24 : Summary of themes for C3I characteristic of SCL environment

Analysis	Characteristic of social collaborative learning (SCL) environment	List of themes
1	**Condition (C)**	• Acquiring new knowledge • Collaboration context • Group composition
2	**Interaction (I)**	• Control self-emotion Resolve socio-cognitive conflict • Negotiation of meaning and argumentation
3	**Immediacy (I)**	• Different types of discussion • Rapid exchange info
4	**Intimacy (I)**	• Something real in close feeling

5.6 Results on Constructing a Knowledge Construction Model with Instructional Scaffolding in an Online SCL Environment among Engineering Students

Interestingly, the researcher's proposed IS model is made up of four (4) impact factors, which are illustrated in Figure 5.35, the Instructional Scaffolding Strategy (ISS) Model, based on the results from research questions 1 and 2.

The first impact factor is engineering students' cognitive pre-engagement. This is used to engage and enhance engineering students' KC. Effective pre-engagement can have a positive impact on the students. In other words, such an ISS affects engineering students cognitively to construct their own knowledge whether the interaction is between the instructor and students or student to student.

The second impact factor is motivation, whether intrinsic or extrinsic. This has come into the engineering students' affective domain regarding KC. Students have different perceptions and perspectives. In addition, positive motivation could build up the engineering students' confidence in order to solve the complex ill-structured questions in their learning process. These ISS are probably the most widely applied in daily use today. This element of IS crucially affects engineering students' KC.

The third impact factor is the ease of the learning process regarding KC. In other words, the instructor provides flexibility and viability to explain and guide engineering students to become more independent on their learning itinerary. Surprisingly, the findings indicate that such scaffolds, which provide a variety of support and give feedback, are a hybrid between and within IS elements. This means the researcher provides a variety of support that intersects (interconnects) with the giving feedback (reflection) criterion. Hence, this may produce an effective ISS to strengthen engineering students' KC and to help engineering students reach a higher level of KC.

The last impact factor is encouragement and praise. This factor affects engineering students' determination (persistency/persevere) in the cognitive domain (categories) whereas the comfort and engagement factor affects the affective domain. The researcher should be moderate in giving praise to engineering students regarding KC. All these factors make engineering students work harder to complete the challenging tasks. Furthermore, the researcher provides these elements of ISS to motivate the students so they do not become frustrated, but will take the risk to carry out the tasks to succeed in learning to achieve KC.

Finally, the results of these analyses are summarized as the core category (major theme or construct). The way IS cognitively steers engineering students' KC is shown in Figure 5.35.

Then, the results from research questions 1 and 2 are hybridised with the results from research question 3 in order to produce a knowledge construction model (KCM) for engineering students. Figure 5.36 illustrates the overview of a holism KCM, which comprises eight essential elements of the ISS hybrid with C3I (condition, interaction, immediacy and intimacy) in an online SCL environment in order to cognitively enhance and steers engineering students' KC to reach a higher level.

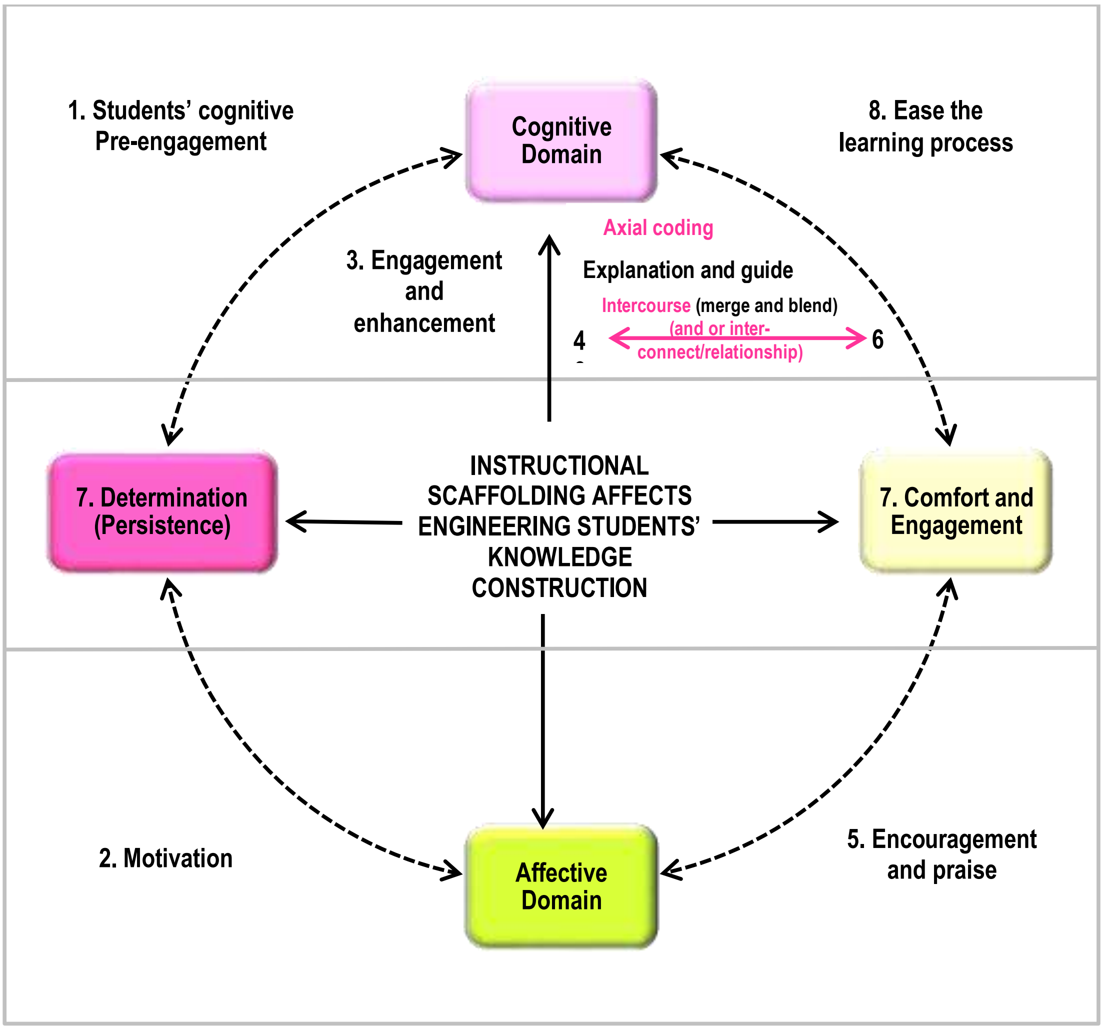


Figure 5.35 Instructional Scaffolding Strategy Model (construct core category of eight essential elements of instructional scaffolding)

From the findings of research question three, it can be seen that the condition characteristic directly affected the students' cognitive pre-engagement and motivation. Pre-engagement helped engineering students in exchanging their point of views (ideas) during the Facebook discussions. The motivation characteristic motivated them to share whatever knowledge they had. Thus, these two elements of instructional scaffolding strategy (ISS) can cognitively steers engineering students' knowledge construction in online social collaborative learning (SCL).

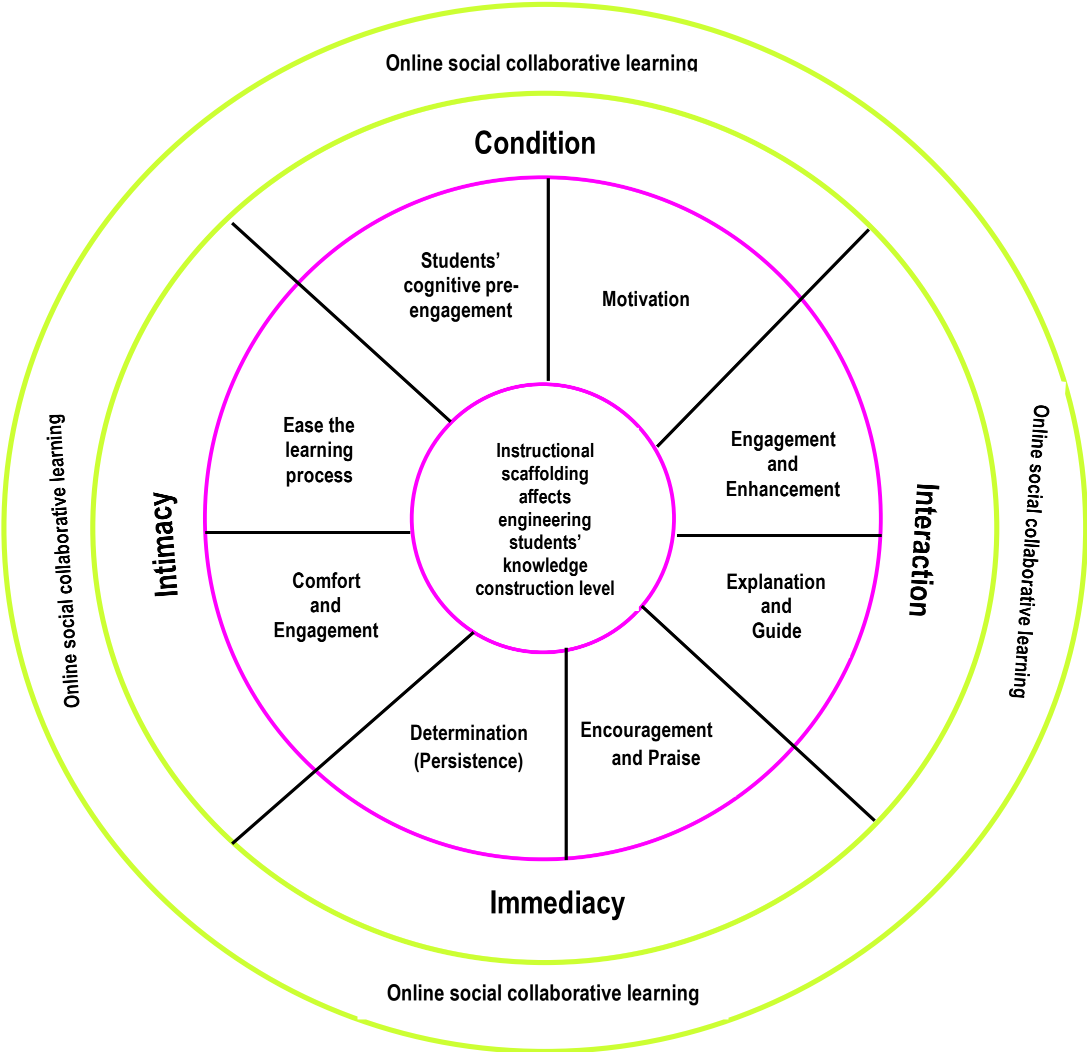


Figure 5.36 Holism knowledge construction model (C3I) guided with instructional scaffolding strategy (ISS) in online social collaborative learning environment

Simultaneously, the interaction characteristic affects student active engagement and enhancement as well as explanation and guidance. These two elements of ISS increased the discourse and interactivity between the instructor and the students when providing a variety of support and giving feedback via the Facebook discussions to cognitively steer the engineering students' KC in online SCL.

On the other hand, there are two concepts in social presence, namely, immediacy and intimacy. The immediacy characteristic affects determination (persistence) as well as the ISS elements of encouragement and praise. The instructor needed to provide the engineering students with guidance to enable them to reflect promptly and with persistency during the asynchronous online discussion (AOD) via the Facebook platform in the SCL environment.

Meanwhile, the intimacy characteristic directly brings comfort and engagement, which may have facilitated the engineering students' learning process. They felt something real in the close feeling they got when emoticons or emoji were used when conducting the learning or LGC task via the Facebook discussions in the online SCL environment. These elements of the ISS cognitively steered engineering students' KC as well as help them reach a higher level of knowledge construction.

Interestingly, based on Figure 5.36, SCL characteristics such as condition, interaction, immediacy, and intimacy, support and reinforce different hierarchies of knowledge construction (KC), instructional scaffolding (IS), and thinking skills, as shown in Figures 5.37 and 5.38. These characteristics also have different impacts on instructional scaffolding strategy (ISS) regarding knowledge construction level (KCL) and thinking skills (TS).

The correlation is different IS carried out different impact on KCL and TS. For instance, in order to nurture engineering students' creative thinking skill, the instructor should utilize metacognitive scaffolding to produce metacognitive knowledge for the students (see Figure 5.37). The online SCL environment directly affect hierarchies of knowledge construction (KC), instructional scaffolding (IS) and thinking skills (LOT and HOT).

Simultaneously, SCL characteristics have bring impact on IS on students' KCL and thinking skills. Figure 5.38 illustrated that elements of condition, interaction, immediacy and intimacy (C3I) directly influence the instructor how to use appropriate IS when conducting AOD in online SCL. For instance, strategic scaffolding interrelate with procedural scaffolding in terms of cultivate engineering students' argumentative KC. In other words, students should be able to understand how to analysis the problem solving questions through step by step when instructor embedded strategic scaffolding to them. Hence, they can debate their ideas in systematically.

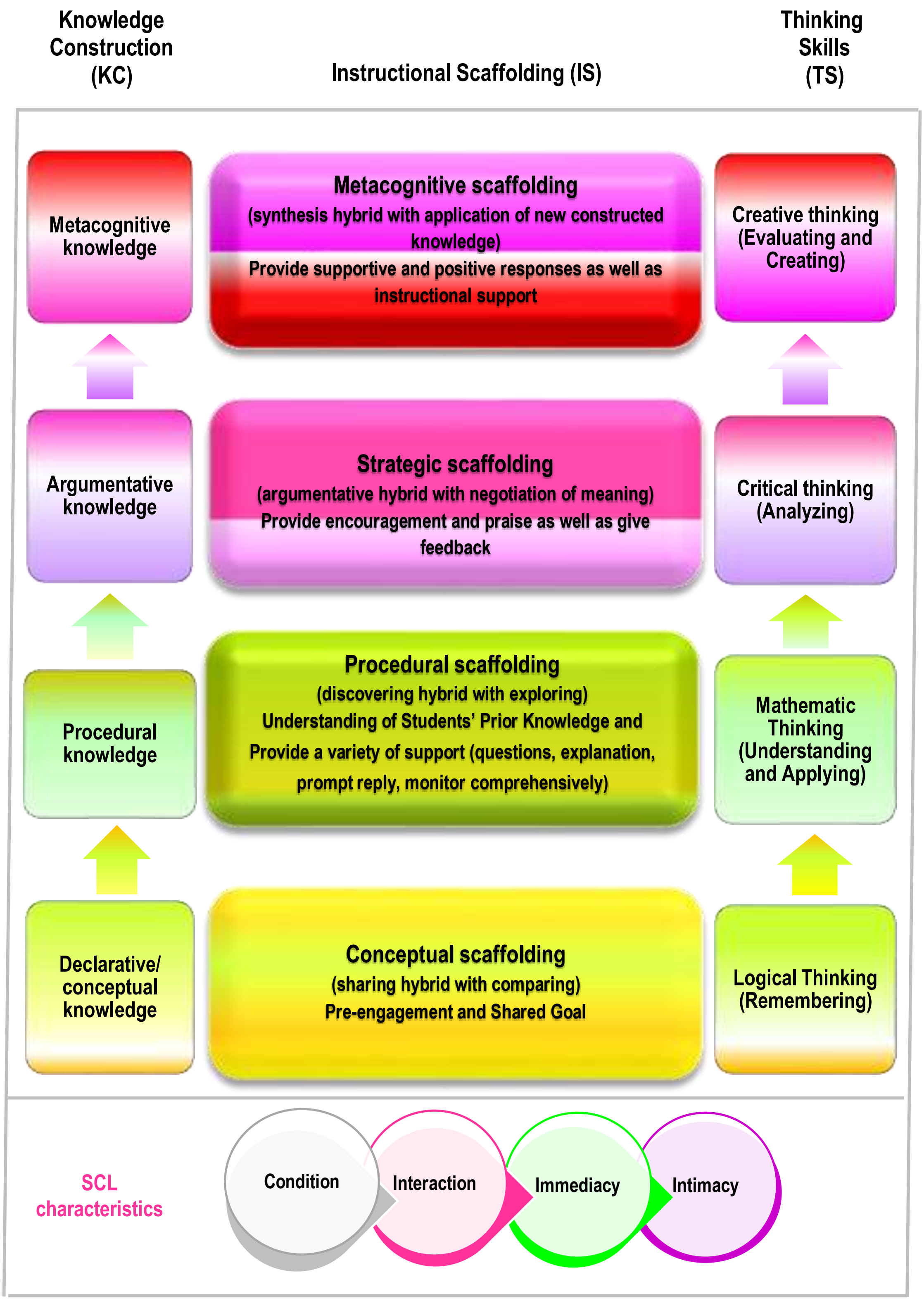


Figure 5.37 Online social collaborative learning (SCL) characteristics versus hierarchies of knowledge construction (KC), instructional scaffolding (IS) and thinking skills (LOT and HOT)

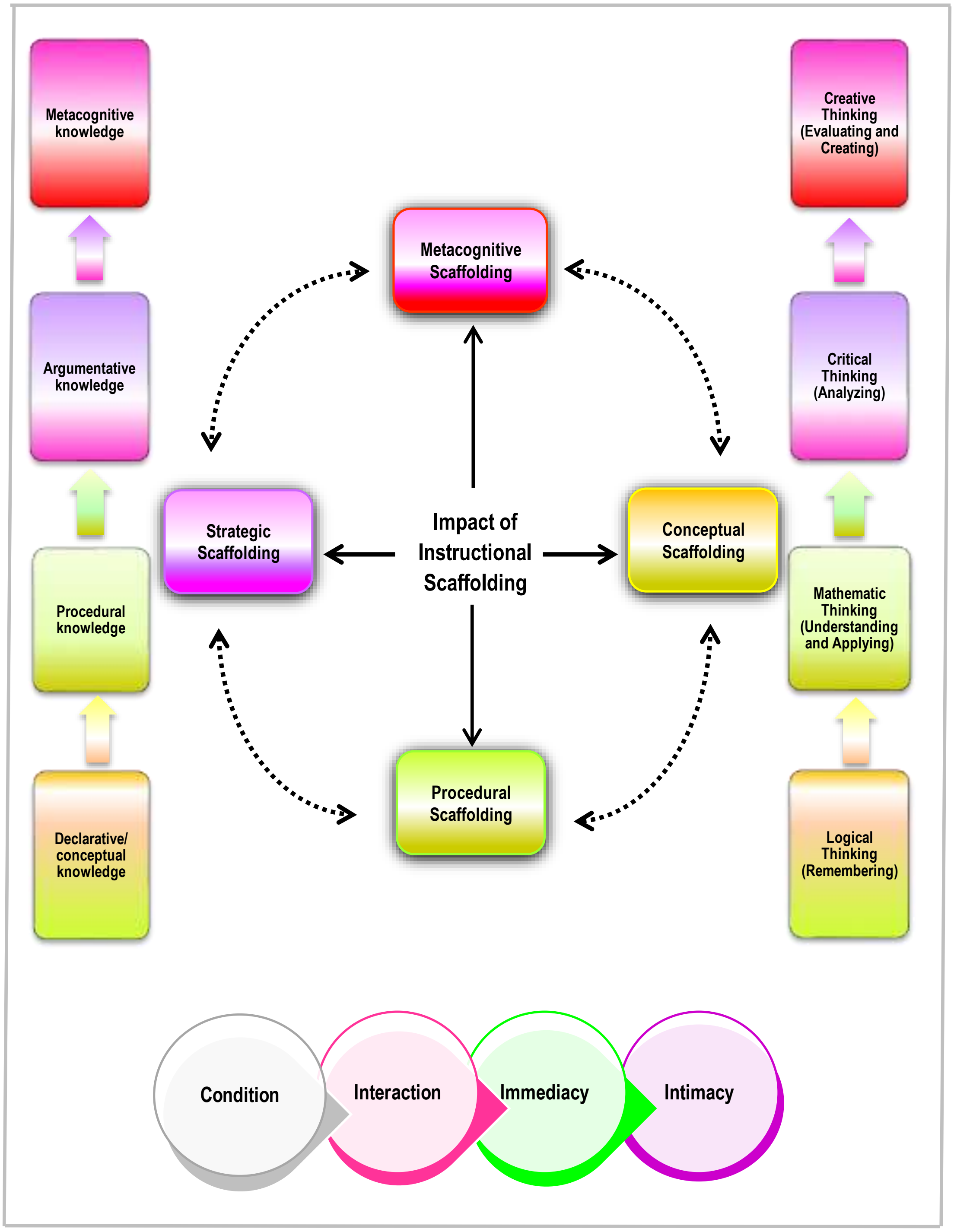


Figure 5.38 Condition, interaction, immediacy and intimacy (C3I) correlation with instructional scaffolding, knowledge construction level (KCL) and thinking skills (LOT and HOT)

5.7 Summary

The main aim of this chapter is to analyze the data collection and findings on how IS in an online SCL environment cognitively steers engineering students' KC as well as helping them reach a higher level of KC. The findings are 8 essential of IS's characteristics, only 3 of them are necessary in this study. There are pre-engagement, the provision of a variety of support mechanism and providing the students with supportive and positive responses that cognitively steer engineering students' knowledge construction and lead them to achieve a higher level of knowledge construction. On the other hand, immediacy and intimacy are enhanced by positive feedback from instructor and/or peers even though not directly affect the students' academic performance. Nevertheless, they can nurture engineering students' active engagement in the learning process particularly online learning in SCL environment.

CHAPTER 6

DISCUSSION, CONCLUSIONS AND RECOMMENDATION

6.1 Introduction

First, the researcher discusses the outcomes of instructional scaffolding (IS) that have been identified when conducting Facebook discussions as asynchronous online discussions (AOD) in an SCL environment on engineering students' achievement in tests. Subsequently, the results of the engineering students' knowledge construction levels (KCLs) will be discussed. Second, the researcher discusses the eight essential elements of IS on how the IS cognitively steered engineering students' knowledge construction (KC) embedded in the metacognitive learning activity. Third, the researcher further discusses the criteria of an online SCL environment supported by IS in order to assist engineering students to improve and reach a higher level of KC. Finally, a knowledge construction model (KCM) is developed based on IS elements, the criteria of the SCL environment, and level of KC, which is related to the hierarchies of thinking (Bloom's Revised Taxonomy).

6.2 Discussion on the Impact of IS in an Online SCL Environment on the Engineering Students' Achievement in the Tests and KCL

The first research question focuses on whether IS in an SCL environment applied to the context of engineering students has a positive impact upon their achievement in tests and their knowledge construction levels (KCL). The discussion comprises of two components: the impact on (a) achievement in tests and (b) KCL.

6.2.1 Discussion on the Impact on Achievement in Tests

The data findings show that the engineering students gained an improvement of 10.93 marks for the experimental class and 8.68 marks for the control class in the achievement test, whether in conventional CL or using the SCL approach. The analysis shows the different learning environment had a different impact on the outcomes, such as each level of KC notably to engineering students in TVET.

The researcher compared the two classes, both of which performed well. However, the results of the experimental class were better than those of the control class due to the students being more active and reflective during the Facebook discussions in the SCL environment. This finding is similar to that of Du and Wagner (2007), which revealed that online learning affects instructor-student and peer to peer interaction and has an impact on academic performance when compared to the offline (traditional) learning approach, as well as promoting and enhancing students' online collaborative learning, as such a learning environment encourages peer involvement. These factors, then, have a positive impact on engineering students' achievement in tests.

It can be shown that elements of IS play an important role in improving engineering students' KC when the instructor (researcher) delivers the lesson via a Facebook platform in an SCL environment. For instance, the IS elements such as providing “assist statements” in AOD through Facebook discussions may encourage engineering students to carry on the discussions, be more willing to learn, and be responsible for their studies. This corresponds to the view expressed by Luca and Mcmahon (2002) that providing scaffolding for students helps them bridge the gap between existing skills and potential skills.

There is evidence of this from the engineering students’ feedback.

MM4: “I felt excited to learn because it helped me to understand the linear motion and non-linear motion topic better. For example, Miss Tan said, “You are not clear on this; let me elaborate more on distance and displacement.” Miss Tan’s detailed explanation via Facebook after this statement helped me to understand more about the topic. This helped me in my knowledge construction.”

HM2: “I could improve my knowledge in learning. Lecturer Miss Tan helps us when we have weaknesses. Miss Tan helped us when we did not know how to carry out the discussions on the topic via Facebook. Miss Tan explained more about the distance and displacement topic in my group discussions. I understood more about the topic after Miss Tan’s explanation. This meant I could carry out the tasks.”

The researcher provided a variety of supports to assist the engineering students to continue the discussions even though they had lost direction and were facing problems in terms of constructing their knowledge, as seen in Figure 6.1. This affected their achievement in the test as it helped them control their frustration during their learning itinerary. The findings support the claim by Hogan and Pressley (1997) that it is important to understand students’ prior knowledge by actively diagnosing the needs of the learner.

The researcher demonstrated the characteristic of C3I (condition, interaction, immediacy and intimacy) during the Facebook discussions in order to support and help engineering students to be successful in the learning task, such as LGC (learner or learning generated content) projects and engaging them in quality online discussions. This is similar to Gao, Wang and Sun (2009), who stated that AODs help students be more collaborative and take responsibility for the learning process when the instructor provides opportunities for students to actively negotiate meanings. Moreover, the

Facebook discussions allowed the engineering students to feel free to learn from time to time and without any time constraints for sharing and comparing learning of the linear motion topic. The instructor (researcher) provided time for them to reflect on the learning content. This might increases the SCL, which would have a positive impact on improve engineering students' achievement in tests.

Simultaneously, the engineering students were engaged in a learning experience that challenged them to construct their knowledge together via discussions on Facebook. The instructor posted a question to them on a Facebook platform so as to lead quality discussions in the SCL environment. This might influence the achievement in tests when they persist in giving quality feedback to peers and when the instructor provided a variety of support, such as giving more explanations and guiding them when they generated the learning content. This supports the idea of Gao, Wang and Sun (2009), who revealed that students' active participation in online learning helps in the construction of knowledge, and instructor's explicit guidelines may have a positive impact on students so that work collaboratively with their peers in a more fluid, more responsive and more intimate way to create new knowledge.

Pre-engagement could engage engineering students' active participation in discussions, connect with their prior knowledge, help them respond to the learning content, and encourage meaningful learning. This will affect their achievement in tests when they continue to construct new knowledge. These findings support Butler and Cartier's (2004) claim that promoting a successful task can effectively engage students in the learning. Furthermore, a structured learning environment, such as SCL, may promote quality discussions when engineering students are actively discovering and exploring the learning topic. In this study, the instructor led them to improve their achievement in the test due to the high quality AOD via the Facebook platform.

Furthermore, the instructor obtained a better understanding of the students' prior knowledge by actively diagnosing their needs and continually engaging them in the quality discussions via discovering and exploring the factors of construction of procedural knowledge. They learned about understanding and applying the right learning to the field of engineering works.

Figure 6.1 Some examples of providing a variety of support elements posted on the Facebook discussions (Team 4)

Having a shared goal can motivate and stimulate engineering students to become passionate to keep on sharing and comparing the learning content with their peers via AOD. Active engagement in an SCL environment may develop engineering students' ideas at the individual level. This commits them to learn in collaboration. This study is similar to that of Goodyear and Zenios (2007), who stated that learning through discussions helps students gain the collaborative construction of knowledge. Consequently, the engineering students had different ideas and different ways of understanding and applying the new knowledge in the engineering field. They therefore improved their achievement in the test by increasing their knowledge with IS support in an SCL environment.

The new finding is the students' cognitive pre-engagement can imperative to influence the students' active participate the metacognitive learning activity due to construct their new knowledge in online SCL environment. Simultaneously, they able to enhance their soft skills such as team spirit, communication, negotiation, social ability and leadership via Facebook discussions.

6.2.2 Discussion on the Impact on Knowledge Construction Levels

The findings in Table 5.11 (comparison of percentage of respondents who achieved well in the test) show that when comparing the achievements in the test given in Table 5.8 (engineering students' expected achievement in the test), the engineering students in the experimental group performed better than did the control group for each level of KC overall. In particular, there is a significant increase in the percentage of the evaluating and creating (under metacognitive knowledge) levels of Bloom's revised taxonomy. However, the obvious findings to emerge from this study of engineering students' knowledge construction levels is that the control group performed slightly better at analysing than did the experimental group. There is a 4.97 percent difference for respondents in the control group, who performed better than the experimental group in the test. This means that the percentage of engineering students' achievement in the test under the analysing category (dimension) in the control group shows that they performed slightly better than the experimental group. It could be that there was a shortage of analysis activity for the engineering students when the researcher conducted the learning activity via the Facebook discussions in the SCL environment. Thus, the researcher should be careful when designing and planning the analysis part before executing the learning activity via AOD in the SCL environment supported by IS to increase engineering students' KC, notably in TVET. This means that learning should have more analysis activities in order to foster the engineering students' KC. Students can be analytical by giving more elaborate explanations of the negotiation of meaning and argumentation on the learning content to achieve KC.

The present investigation has compared four (4) different levels of KC in accordance with the levels of Bloom's revised taxonomy (see Table 5.6 for the marks obtained in each level of Bloom's Revised Taxonomy). This study has shown that compared to a traditional collaborative learning (CL) environment, an social collaborative learning (SCL) environment with IS support leads to a higher level of KC. Engineering students developed meaningful interaction with their peers to improve KC. They felt satisfaction and interest in the learner or LGC task during AOD via Facebook in an SCL environment. The instructor (researcher) scaffolded and supported the engineering students' KC to integrate the elements of pre-engagement, intimacy, and immediate feedback. These findings are similar to those of Mackey and Freyberg (2010), who claimed intimacy and immediacy may improve students' learning experiences and enjoyment of the learning process. The results are also similar to those of Reio and Crim (2013), who revealed that these two concepts of social presence lead and motivate students to have more interaction in an online learning environment.

The researcher invited the engineering students to reflect on their experiences by asking critical questions that are related to learner or LGC tasks, which are generally more supportive and that facilitate engineering students' KCL and engagement with the process of learning. In other words, the instructor required the engineering students to provide detailed explanations when they constructed and acquired new knowledge via Facebook in the SCL environment. This helped to foster the engineering students' fast and rich feedback as well as increase their satisfaction with constructing knowledge.

In terms of constructing the argumentative knowledge of the group of engineering students who participated actively in the Facebook discussions supported by online IS in an SCL environment, the data show that students do not easily achieve such a level of KC as listed in Table 5.11 (comparison of percentages of respondents who achieved well in the test). This corresponds to Pifarre and Cobos' (2009) claim that students construct their knowledge through different learning activities.

Hence, the researcher should integrate more instructional scaffolding (IS) in the process of knowledge construction (KC) particularly for engineering students to gain argumentative or metacognitive knowledge so that students would be more willing to learn and be responsible for their studies towards KC. For instance, making engineering students share the learning content via Facebook discussions means they can interact with the instructor and their peers to reflect upon their ideas. In addition, engineering students can demonstrate divergence of thinking when implementing the metacognitive learning activities towards KC. This is in line with Dillenbourg *et al.*'s (1996) characteristics of CL.

However, in comparison with Figure 5.6 (combination of results in percentage of KCL), it can be seen that respondents in the control and the experimental groups achieved a higher level of KC whether in the CL or the SCL environment. Both learning environments had a positive impact on the engineering students' KC, enabling them to reach a higher level of KC. In other words, the engineering students improved their scores (marks) with a pass rate of 86.11% for argumentative KC and 64.00% for metacognitive KC for the experimental group. On the other hand, the engineering students in the control group had a pass rate of 84.21% for argumentative KC and 13.16% for metacognitive KC. The rest of the KCL, such as declarative knowledge and procedural knowledge, also showed that the respondents improved their achievement in the test.

Similarly, Tables 5.13 and 5.14 (summary of number of engineering students' passes in each level of KC between the experimental group and the control group) indicate that the difference between students in the experimental and the control groups was 18 in metacognitive KCL even though it was not easy to achieve higher levels of KC in this task, as indicated by the pass rates in this KCL. In fact, the instructor designed and planned the SCL environment with IS support that showed a higher level of KC when compared to conventional CL. On the other hand, the number of engineering students that showed they had achieved this in the test had increased when compared with other levels of KC, such as declarative knowledge, procedural knowledge, and argumentative knowledge.

It seems that the results clearly indicate that the engineering students in the experimental group significantly improved their achievement in the test when compared to the control group. This means that the SCL environment supported by an IS approach is much better than conventional CL environment approach to enhance engineering students' KCL.

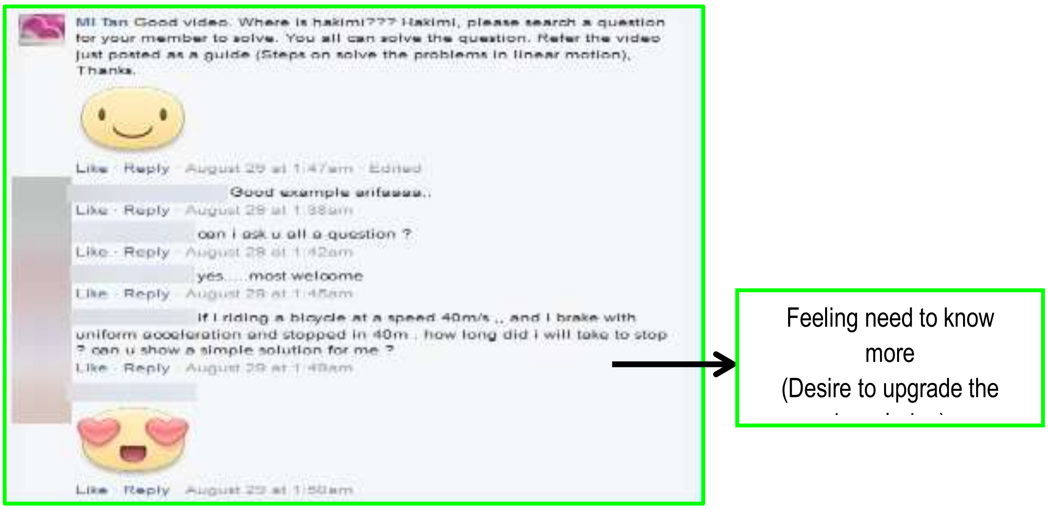
The researcher saw that such a learning approach would have a great impact on engineering students' KCL particularly argumentative and metacognitive knowledge. They constructed knowledge via Facebook discussions supported by IS in the SCL environment supplied by the instructor (researcher). This means that engineering students can learn and construct knowledge through social and collaborative learning supported by IS when they actively participate in posting statements or comments on the Facebook discussions in terms of the acquisition of new knowledge, such as argumentative or metacognitive knowledge, as shown in Figure 6.2. They claimed that learning, discovering, and exploring something new, and experiencing something wonderful became part of their meaningful social daily activities (see Figure 5.33 network diagram of acquiring new knowledge).

These results are in line with Tu and Corry's ideas (2001); they stated that an 'online learning community is people who learn through group activity. People learn together in an online environment'. The instructors provided them with opportunities to take up roles and be actively involved through AOD in the SCL environment supported by IS. How human apply appropriate information to KC is more important than simply obtaining information. In other words, the engineering students could construct knowledge supported by IS in the SCL environment provided by the instructor in order to reach a higher level of KC through social interaction. Similar to Yeo’s (2013) findings, the engineering students were able to learn better if they interacted regularly in an online learning environment. The following is a typical reply from an interviewee:

MM4: “I can take my time to find the video when the instructor gives me positive responses. I can have interactions, and find and share the video with other members via Facebook.”

The SCL environment can improve engineering students have a higher level of KC when compared with conventional CL. In other words, the engineering students can reach a higher level of KC, such as argumentative or metacognitive knowledge, through an SCL environment. This can link to the IS support that gives engineering students more opportunities to construct and create more meaningful and positive learning experiences. Interestingly, CL was better able to enrich and enhance the engineering students’ declarative and procedural KC.

The correlation is social presence (immediacy and intimacy) has bring positive interaction in team if the students interact regularly during they discuss the learning content in online SCL environment. Furthermore, the students feel desire to upgrade their new knowledge if they feedback promptly in order to solve the problem solving questions via AOD. This makes them excited to gain new knowledge.



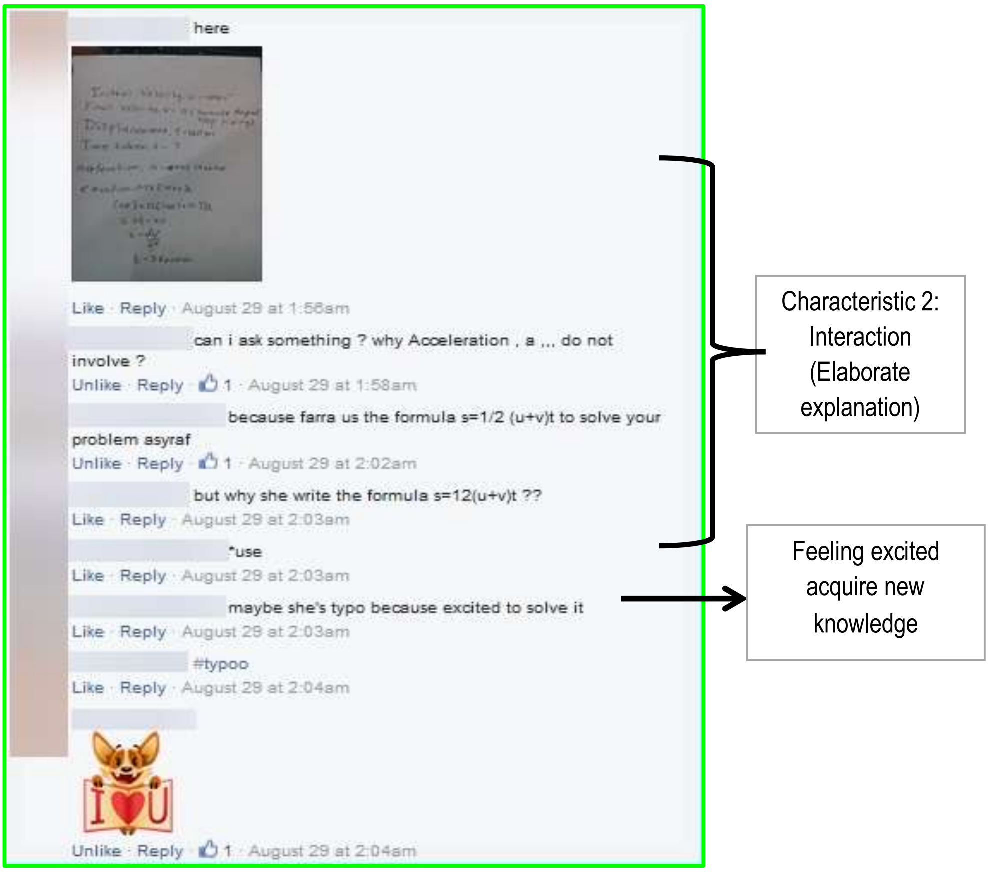


Figure 6.2 The elaborate explanation posted on the Facebook discussions (Team 6)

The study reveals that declarative knowledge affects procedural KC. Meanwhile, argumentative knowledge affects metacognitive KC, too. Moreover, the level of KC interrelates with each type of knowledge.

The relationships of thinking (achievement in test), the impact of KCL, and IS via Facebook discussions, can be seen in Figure 6.3.

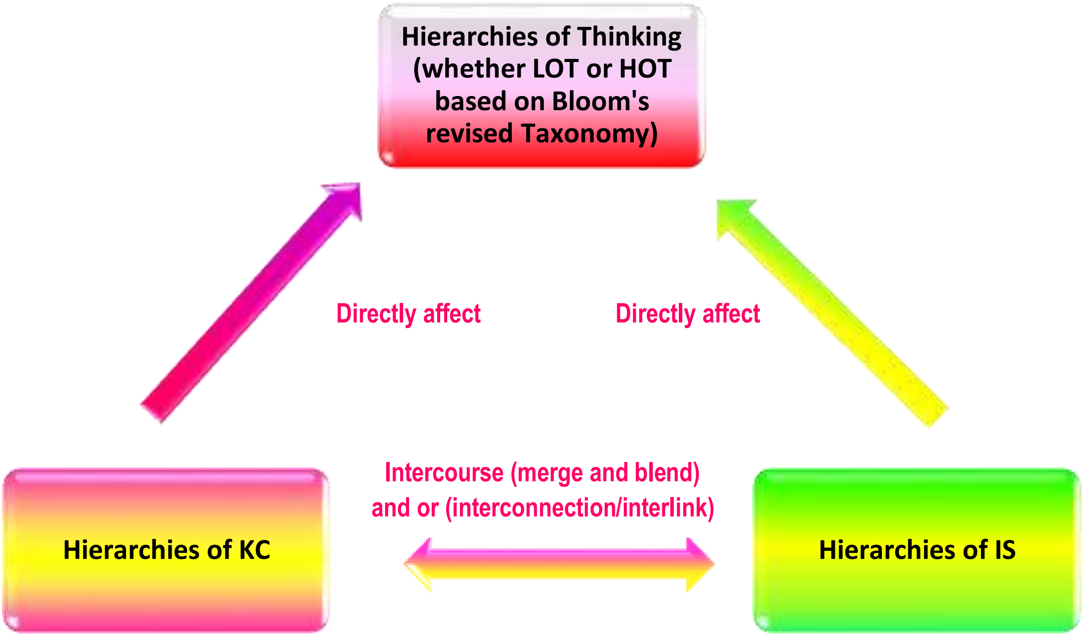


Figure 6.3 The hierarchies of KC, IS, and thinking

Table 5.16 (Summary of posting scripts based on Gunawardena, Lowe and Anderson, 1997) shows a summary of the posting scripts in the LGC task. The total comments of each level of KC can be summarised as follows:

- Students' posting scripts, statements, or comments are related to metacognitive knowledge when interacting with declarative and procedural knowledge. There are two main knowledge elements of metacognitive knowledge.
- The total number of posting scripts increased significantly from the total declarative knowledge scripts (350 comments) up to the total argumentative knowledge (788 comments) and metacognitive knowledge (756 comments) scripts. This means that the engineering students constructed the declarative knowledge through sharing and comparing opinions in their learning itinerary. Meanwhile, they also constructed argumentative knowledge via analysing the learning content by negotiating meanings. Subsequently, the engineering students constructed metacognitive knowledge by synthesising new constructed knowledge for application in the engineering field. This study has found that an SCL environment supported by IS given by an instructor might help and support engineering students to construct and

create their knowledge up to the argumentative and metacognitive levels. This is because an SCL environment comprises elements of condition, interaction, immediacy, and intimacy and so enables them to achieve them in the learning itinerary. Next, the researcher utilised the ill-structured problem analysis and questions of Task 2 to reboot the engineering students' metacognitive knowledge in order to assist and lead them to reach a higher level of KC (see Table 5.18).

Social interaction in an SCL environment affects students' KC. Pifarre and Cobos (2009) claimed that the "social dimension of learning interaction is needed to achieve the cognitive goals of collaborative learning." This point is supported by the findings of Reio and Crim (2013) and Tu and Corry (2001). It means that metacognitive learning activities suported by IS in an SCL environment can help to promote deeper learning (the process of KC). For instance, the engineering students who intended to complete their learning tasks through sharing and comparing knowledge and by discovering and exploring the new constructed knowledge, debated and argued (interaction) critically with their peers regarding the learning content, and were able to elaborate more on others' points of view and synthesise the learning topic. This led the engineering students to think and refine their learning better in the process of KC, as can be seen from the engineering students' feedback, which substantiates this finding.

HM2: "My members can work together with sharing and comparing learning about linear motion and non-linear motion. Miss Tan stated that we should think how we could apply distance and displacement knowledge in the civil engineering field. It helped me to understand better the topic we were learning. Participating in a learning activity can make me remember what I have learnt. I can think outside the box. I achieve a higher level of knowledge."

The importance of IS in an SCL environment demands closer attention with respect to defining the eight essential elements of IS characteristics to guide engineering students' KCLs. For instance, pre-engagement of elements of IS can trigger the engineering students' interest and willingness to construct their new knowledge. Subsequently, the students had to complete the learning or LGC task via

Facebook discussions (refer to Figure 6.4), and the feedback from the interviews substantiated this.

MM1: "It motivated me to explore the problem and plan how to solve the problem. I know the solving skills and understand what the discussion topic is in knowledge construction."

As outlined in the literature review, Ibrahimi and Essaaidi's (2012) ideas are similar to Sharma and Hannafin's (2007) opinion that students find inspiration, motivation, and improvement in the learning process through online learning. In addition, the instructor's feedback may help engineering students in understanding their progress in KC when appropriate IS is used in an SCL environment.

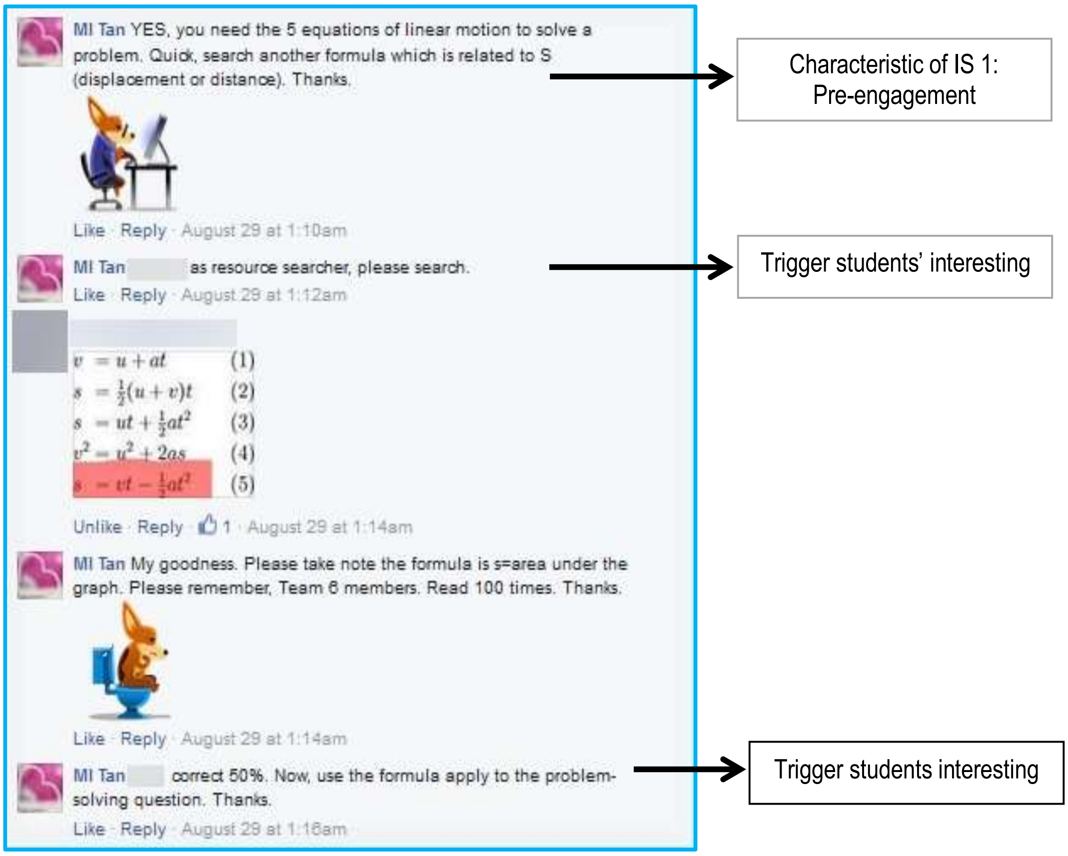


Figure 6.4 Examples of pre-engagement element posted on the Facebook discussions (Team 6)

Simultaneously, the findings show Team 5 members scored 594, the highest posted scripts in the LGC learning task. Besides, they also scored 158, the highest number of emoticons via the Facebook discussions. The results reveal that they felt intimacy and a willingness to complete the learning tasks. Interestingly, the score for argumentative knowledge is 212.60, the highest percentage in this learning activity for overall Facebook discussions supported by IS in an SCL environment. These findings have demonstrated Team 5 members' active engagement and involvement in the Facebook discussions in an SCL environment with IS support. The data show 10.48 percentage of declarative knowledge, 13.50 percentage of procedural knowledge, 29.84 percentage of argumentative knowledge and 46.18 percentage of metacognitive knowledge for each level of KC (see Table 5.17 summary of posting scripts in percentage based on Gunawardena, Lowe and Anderson, 1997). One of the more significant findings to emerge from this study is that the intimacy and immediacy characteristics of an SCL environment play a crucial role in encouraging engineering students to have more interaction and reflection in arguing about argumentative or negotiating meaning on the linear motion topic and synthesizing the new knowledge in the engineering field through AOD and success in completing the LGC task and the ill-structured question task. This result corresponds with Reio and Crim (2013), who revealed that intimacy and immediacy as a concept of social presence may foster students' satisfaction in the learning process and the learning outcomes. This is similar to Mackey and Freyberg (2010), who stated that social presence may affect students' satisfaction as a sense of feeling of increasing their knowledge acquisition. Finally, explicit construction of metacognitive knowledge can be seen in learning activity Task 2 in order to achieve the highest level of KC among engineering students at TVET.

Hence, several solutions are summarised in Table 6.1 to foster engineering students' KC. As can be seen in this table, negotiation of meaning or argumentation of strategies can foster engineering students' KC, such as argumentative knowledge. They become more analytical when analysing the ill structured problems and questions to get the right answers. Besides, the engineering students drew the conclusion on the learning content via the Facebook discussions supported by IS in an SCL environment. The researcher concluded that elements of IS helped the engineering students to construct metacognitive knowledge when they synthesized and reflected the learning content of the linear motion topic. Subsequently, they became more critical in AOD when they had to face the divergent viewpoints of other peers. Moreover, they had to elaborate upon their explanation of their point of views in order to reach a consensus.

Table 6.1 : Overview of various IS versus KCL

Instructional scaffolding (IS)	**Knowledge construction level (KCL)**	**Strategy (Method) of network instructional scaffolding**	**Bloom's Revised Taxonomy**
Conceptual Scaffolding	Declarative/ Conceptual knowledge	Sharing (An example: How does a car move on the highway?) Comparing (An example: How does velocity affect the acceleration of the car?)	Remember
Procedural Scaffolding	Procedural knowledge	Discovering (An example: How about search from YouTube or search engine?) Exploring (to get agreement) (An example: Let's find out more resources related to instantaneous velocity and average velocity)	Understand and Apply
Strategic Scaffolding	Argumentative knowledge (the researcher's philosophy assumption)	Negotiation of meaning (Social negotiation) (An example: How to discuss the differences of displacement versus time graphs?)	Analyse
Metacognitive Scaffolding	Metacognitive knowledge (self-awareness, self-reflection on feedback, self-regulatory competencies and meta-competency)	Synthesis (summary and conclusion) (An example: How do we combine all the learning contents and diagrams of displacement versus time graphs?) Application of new constructed knowledge (An example: How do we apply new knowledge in the engineering field works?)	Evaluate and Create

6.3 Discussion on how IS in an Online SCL environment Cognitively Steers Engineering Students towards Knowledge Construction

In order to investigate the process of how instructional scaffolding (IS) can help or promote or steer (strengthen) engineering students' towards knowledge construction (KC), there are two approaches. A qualitative approach was used for the eight essential elements of IS in an SCL environment for engineering students' KC. The following is a brief description of certain results and the ranking of the important elements of IS.

6.3.1 Discussion of Eight Essential Elements of Instructional Scaffolding Affecting Engineering Students' Knowledge Construction

To investigate the impact factors had on instructional scaffolding (IS) for engineering students' knowledge construction (KC), the criteria of IS were analysed. When analysing these elements using data from the ten (10) interviewees, the researcher focused on details of how IS can affect the engineering students' KC during the metacognitive learning activities via Facebook discussions in an SCL environment. The results show that the underlying elements of IS have a positive impact on engineering students' KC.

There are a number of different elements of IS as given below:

i. Pre-engagement

Pre-engagement is the priority element of IS to cognitively steer engineering students' KC. This is an essential stage, as the engineering students participated actively in AOD via the Facebook platform. The researcher utilized guidelines A and G (Refer to Appendices A and L) as a pre-engagement for the students to discuss the learning content so as to lead them to complete the learning or LGC task.

The results (see Figure 5.10: a picture quotation) show each interviewee had different ideas about how the pre-engagement element of IS affects KC, such as understanding what to do in the next steps. The interviewees pointed out that pre-engagement brought the participants the benefits of knowing the learning process as they understood their role and responsibility. These are the reasons why the researcher assigned roles, groups, and tasks (see Figure 6.5) for them before conducting the metacognitive learning activities. The aim was to make the students more responsible during the learning. Hence, the learning activities could be conducted easily and smoothly via Facebook discussions in the SCL environment.

Interestingly, pre-engagement criteria interconnected with the CL characteristic, as stated in the theoretical framework (see Figure 1.4). These are the elements of IS that encouraged them to study and motivated them to solve the ill-structured task towards KC. It is a good way of encouraging collaboration between instructor-student and peer to peer. These findings correspond with the views of Butler and Cartier (2004), who stated that the student engagement involves active and reflective self-regulation in order to succeed in the task engagement within the learning environment. The engineering students showed their pre-engagement successfully in the SCL environment, which allowed them to work together, as presented in Figure 6.6.

There following extract shows one interviewee's perspective:

HM2: "Understand the learning tasks. Learn the engineering science through collaboration with the group via Facebook. I can share my opinion with others. For example, my friends act as moderator and summarizer. When I learn from my friends, I can better understand the topic. Guideline A helps me do the LGC task easily step by step and Guideline G helps me solve the problem-solving questions. I can work together with my members."

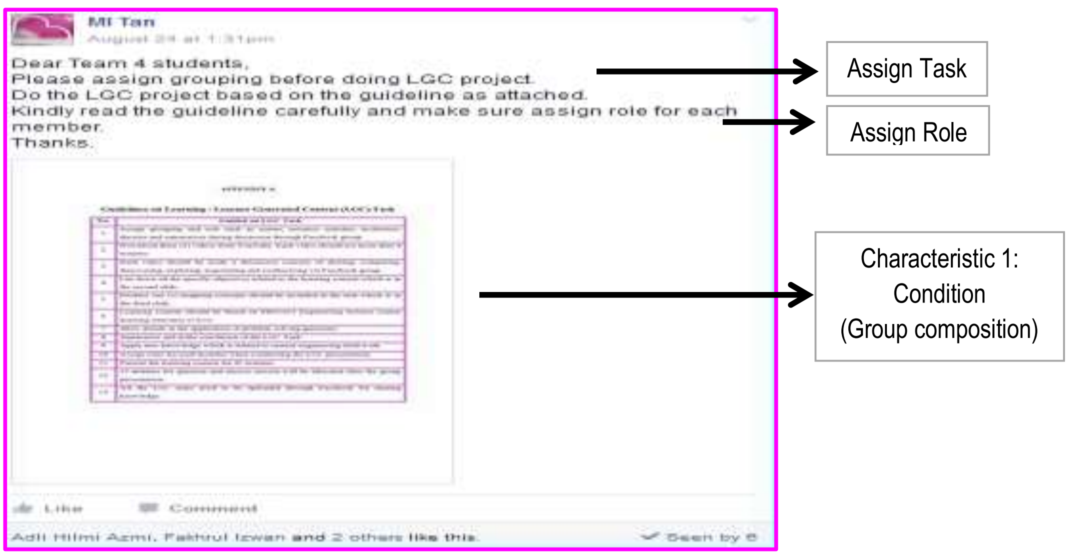


Figure 6.5 Guideline posted on the Facebook discussions (Conditions: group composition and task structure) (Announcement: Inform 6 teams)

Figure 6.6 Engineering students' successful task engagement posted on the Facebook discussions (Team 2)

Pre-engagement of the IS element also enhanced the engineering students' thinking skills when they conducted online discussions about the learning content any place or any time. These results confirm the previous studies by Ally (2004), Siraj (2005) and Siraj and Alias (2005). The researcher claimed that students can generate the knowledge moving from general to detailed knowledge, exploring the problem, planning how to solve the problem, looking for new information and sharing ideas with their peers as well as drawing conclusions from the learning task. These affect engineering students' construction of knowledge.

Surprisingly, the results reveal that "pre-engagement" is the most important element of IS. It accounts for 197 out 288 marks and 68.40 percent of the overall percentage.

As outlined in the literature review, Hannafin, Land and Oliver's (1999) ideas are similar to those of Jonassen *et al.* (1999), who stated that learning environments provide students with certain amounts of information and help them engage in learning activities, as well as guiding them in the learning process through scaffolding.

The following is a typical response from an interviewee:

M4 (most important): "Guideline A helped me understand how to do the task, and Guideline G helped me to solve the problem-solving questions. I could work together with other teammates. It helped me to finish the tasks."

ii. Share goal

The most challenging part of KC for the engineering students was that team members cannot work together at the same time. As outlined in the literature review, DeWitt, Siraj and Alias (2014) claimed that collaborative KC is rarely implemented even though such learning can enhance and enrich the learning experience for the students. The researcher found that the engineering students felt confused about solving the problems or ill-structured questions when they did not know and understand the right formula to use in a new topic. In addition, they also found it difficult to find more ideas or points for sharing with their peers and to stimulate other peers to conduct the AOD via Facebook in the SCL environment.

The findings in Figure 5.11 (a part of the network diagram of the shared goal) show the views of four interviewees, namely M2, M3, M4 and M5, who had the same view, specifically, that they had to keep on trying to find the best solution in the learning tasks given by the instructor. This motivated them towards KC. These results are definitely related with the collaboration context, as depicted in Figure 6.7.

HM3: "My difficulty was getting all the team members to work together at the same time in the social collaborative learning environment. I could learn all the time with my cell phone because I could access Facebook with an internet connection. When everybody was involved in the online discussions, I enjoyed asking questions, and my peers replied to me promptly. I can use my laptop to access online anywhere and anytime in learning."

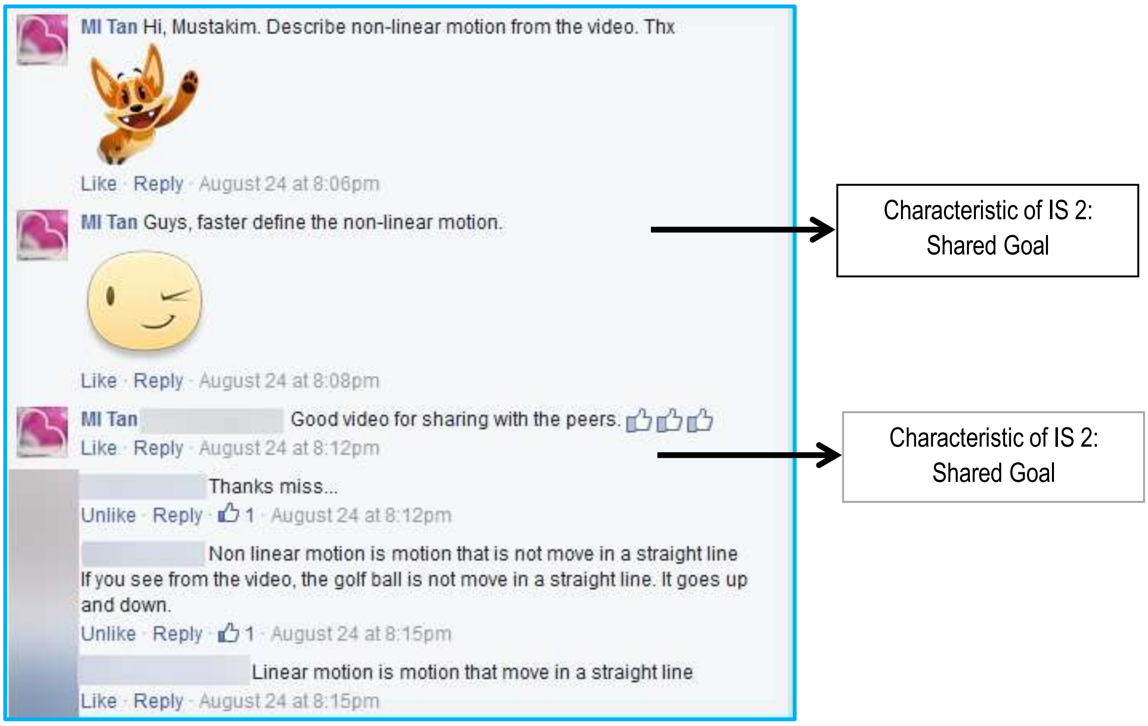


Figure 6.7 An example of collaboration context posted on the Facebook discussions (Team 2)

However, the challenge is to motivate engineering students to keep on trying to find the solution either using the library, Google, or search engines and to share the knowledge with their peers. This way, they will have good collaboration in the Facebook discussions with their team members and the instructor. They also exchange ideas with team members via online discussions. As Dillenbourg *et al.* (1995) stated, “mutual engagement” is needed for students to play their roles and share their new ideas. This makes them better thinkers when sharing their opinions.

iii. Understanding students’ prior knowledge

YouTube engaged and enhanced the engineering students’ prior knowledge via Facebook discussions in the SCL environment. The researcher had a great deal of information to share and compare, discover and explore with others via YouTube. The engineering students could visualize the learning content and understand the new knowledge better by the animation of videos that could attract the engineering students’ attention towards KC. The students found it easy to memorize the learning topic.

Activate engineering students' prior knowledge by utilizing examples from YouTube video. Simultaneously, the instructor (researcher) actively diagnosed the students' needs and whether they could share and compare the learning content with their peers. The popularity of utilizing YouTube or other media sharing tools, such as Google or search engines, could help to upgrade the engineering students' prior knowledge. Their perceptions of its use were positive. For instance, five interviewees (MM2, MM4, MM5, HM1 and HM2) said that the YouTube videos made it easier for them to understand the learning content, as illustrated in Figure 5.12. These learning tools provided a successful integration of technology in the engineering classroom. Figure 6.8 shows how the characteristic of IS of understanding students' prior knowledge affected the engineering students' KC in the SCL environment. The instructor could understand better the engineering students' background, existing knowledge, and learning experience so as to integrate them with IS in the learning activities via Facebook discussions. They were able to get more useful information from the YouTube videos and the instructor made them give further explanations in an easier way and with more clarity as well as cognitively steering them towards KC.

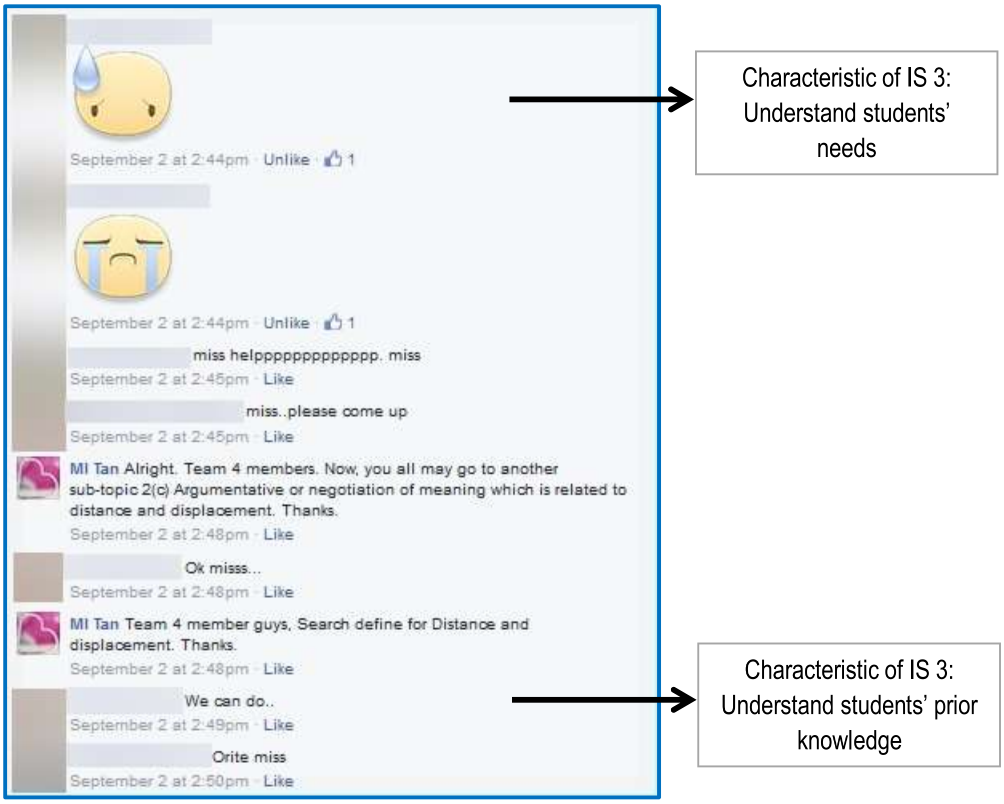


Figure 6.8 Examples of understanding students' prior knowledge posted on the Facebook discussions (Team 4)

The following is typical of the engineering students' responses:

HM1: "The video on YouTube showed a good example that helped me and the other members to understand the topic more easily. For example, in the discussions, Miss Tan explained how to get the video. Then, I replayed the video again and again to understand more about the topic."

This finding corresponds with Bligh's (2000) claim that teamwork can increase memory, reduce mistakes, and motivate students. The research findings show the engineering students' desire to construct knowledge when they were curious about the topic of the study so as to get a correct answer.

iv. Provide a variety of support (questions, explanation, monitor comprehensively)

The engineering students felt it was good, happy, fun, and joyous to construct their knowledge when an instructor provides a variety of support, such as "ask questions, give more explanations, and monitor their learning process comprehensively via Facebook discussions." These are the IS elements that support them to be more independent in constructing knowledge. In addition, it is the second most important element of IS based on the findings regarding the interviewees' perspective.

Nine of the interviewees, that is, all except HM3, claimed that the statement "assist" in AOD could help them to explain in detail about the learning content, and they found it easier to remember and understand what had been learnt as well as to carry out the tasks. These elements may cognitively steer engineering students towards KC. On the other hand, interviewee HM3 stated that he felt confident when the instructor provided the "assist statement". This motivated him to study. As can be seen in Figure 6.9, providing a variety of support helps cognitively steer engineering students' KC.

One interviewee had a typical opinion:

MM3: "I feel it's very important because a human needs support. For example, Miss Tan always supported me to continue the discussions with other group members in KC. This is the beginning of a discussion after watching a video. I can upgrade my knowledge."

Figure 6.9 An example of providing a variety of the support element posted on the Facebook discussions (Team 2)

The researcher viewed the "assist" statements as an element of IS that helps to improve the engineering students' KC. For instance, they were able to have further discussions with peers once they had mastered the declarative knowledge, they knew how to use the appropriate formula to solve the ill-structured problems or questions, and they became problem solvers. Subsequently, it was easier for them to remember the learning content and carry out the tasks properly. This is similar to Lombardi's (2007) point that clearly, the role of IS is to support teamwork, online learning, resource sharing, and KC. Simultaneously, they also knew how to use the appropriate formula to solve the ill-structured problems or questions and by solving the problem questions, they were able construct knowledge. This helped the engineering students to have further discussions once they had mastered the declarative knowledge. These are the IS criteria in the SCL environment that cognitively steered the engineering students' towards KC.

The results of providing a variety of support have been obtained through the ranking as second importance of IS. There are 189 marks, which corresponds to 65.63 percent. The following is one interviewee's response:

MM2 (2nd. important): “I think it could help my learning process to run smoothly and helped us to share ideas about the topic. I could do the tasks step by step. Then, I could increase my knowledge when Miss Tan supported me in online learning. Made me understand better, and I carried out the tasks such as the LGC project and the problem-solving questions in experiment 2 linear motion (Task 2).

v. Provide encouragement and praise

Giving complimentary statements is one of the IS elements that enhanced the engineering students’ KC. The researcher holds the view that encouragement can engage them to stay on to continue discussing the learning content via Facebook. The findings showed that providing encouragement and praise may motivate engineering students to learn more, and provide them with the inspiration to learn and a desire not to give up in their process of learning. Consequently, they found it exciting to learn and became responsible in their studies to cognitively strengthen their KC in the SCL environment. Figure 6.10 shows the encouragement and praise the researcher provided to assist the engineering students to stay on to discuss the learning content. They felt excited and were not easily frustrated to construct knowledge in the learning itinerary.

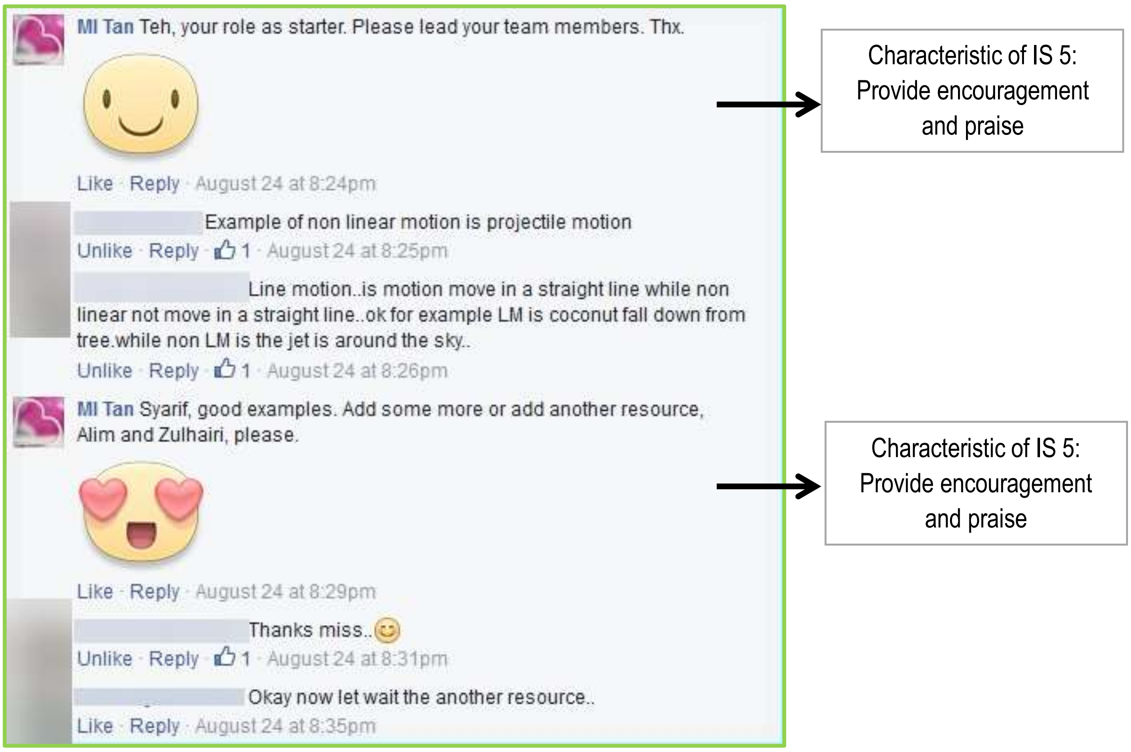


Figure 6.10 Some examples of providing encouragement and praise posted on the Facebook discussions (Team 2)

The following is typical of the engineering students' feedback:

HM3: "This motivated me to study more. For example, Miss Tan praised us by saying, 'Well done' in the Episode 2c learning activity. I got motivated to study harder because of her compliment. Everyone felt happy when receiving the praise. I would not give up easily when Miss Tan needed me do a good job."

By contrast, 'provide encouragement and praise' represents the least important ranking IS to the heuristics that help engineering students to acquire new KC. The majority of the engineering students revealed that praise could cause them to fail in constructing the knowledge. They did not need the praise while they were enjoying the process of learning. One engineering student's feedback was as follows:

HM3 (least important): "I cannot take too much praise from the instructor. She should say that I'm not good enough. Then, I would work more. I became lazy about learning, having been made too comfortable by her praise. Need to reserve some praise. But, still can provide some encouragement for students."

vi. Give feedback

The researcher gave prompt feedback to the engineering students when conducting the Facebook discussions in the SCL environment so as to support and lead them to complete the learning or LGC task. They frequently received feedback from the instructor in the metacognitive learning activities. The researcher found out the views of ten interviewees about which types of the instructor's feedback helped them most in KC as the feedback guided them to find the right information, enabled them to give explanations in an easier way with greater clarity, led them in the right direction, and linked them with the convergent ideas (thinking) from different perspectives via the online discussions supported by IS. In other words, the researcher monitored engineering students' progress comprehensively, so she could cognitively steer them towards KC in the SCL environment. Several examples of the feedback given to the engineering students are shown in Figure 6.11.

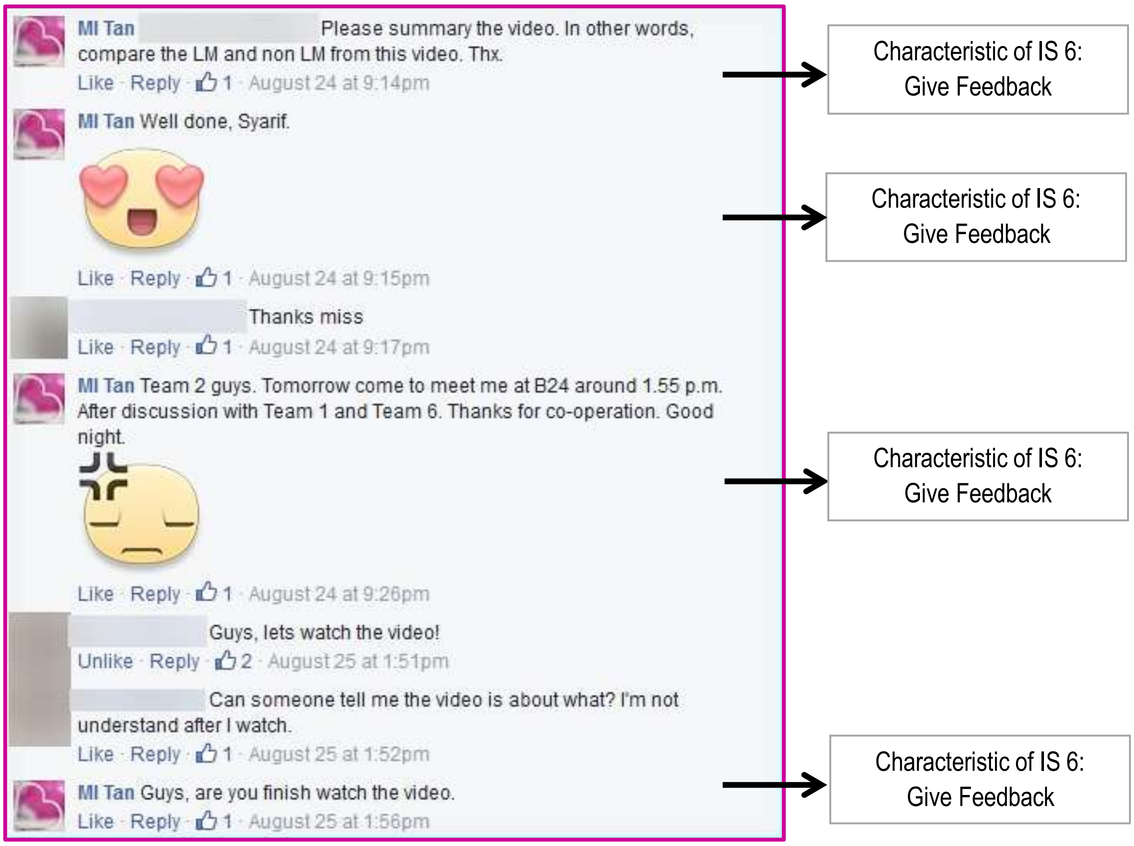


Figure 6.11 Several examples of giving feedback to engineering students posted on the Facebook discussions (Team 2)

The following is a reply from an engineering student:

MM2: “Yes. The instructor guided me to do the right things and corrected me if I did it wrong. She helped me understand better the key points and to know what I was studying. That is why I revised at home every day. By sharing and comparing, discovering and exploring the learning content, I knew my progress in knowledge construction. I liked the feedback; e.g., Miss Tan asked us to watch the video and understand the content, as well as describe the video. It helped me understand the topic better after watching the video. As a result, I increased my knowledge.”

vii. Provide supportive and positive responses

The results of the researcher providing supportive and positive responses are the third most important element of IS. Figure 5.16 (a network diagram of providing supportive and positive responses) depicts those kinds of responses that made engineering students feel happy, comfortable, and glad to study. They did not feel stressful about learning towards KC according to the opinions offered by the ten interviewees. These findings are in line with the findings by Dias and Diniz (2014) that students achieve a better learning performance when they have higher levels of satisfaction in the learning itinerary.

The researcher claimed that the engineering students took time to search for the correct videos through YouTube so as to share knowledge with their peers. In the meantime, they also had further interaction about the learning content and learned, via the learning activities, to be patient. Surprisingly, this is related to the characteristic of interaction. For further details, refer to Figure 6.12: providing supportive and positive responses.

The following is a typical interviewee's response:

HM3: "It made studying online more comfortable and enjoyable when Miss Tan asked us to be patient and to take our time to complete the task. I tried to find out the most accurate answer for my teammates. For example, I would take my time to verify the instantaneous velocity and average velocity since there are a lot of definitions in Google search and YouTube. Support and positive responses are important, as they lead students to complete the LGC project and achieve a higher level of knowledge."

Moreover, this was ranked the third most important element of IS. The students felt happy and encouraged to learn more about the new topic towards KC. One engineering student's response was as follows:

MM1 (3rd important): "Although I did not understand the topic, I could still carry out the tasks when Miss Tan gave me positive responses. I could continue the discussions with members and Miss Tan's support. This upgraded my knowledge. For example, Miss Tan asked me to read the summary of the topic. I could understand after that."

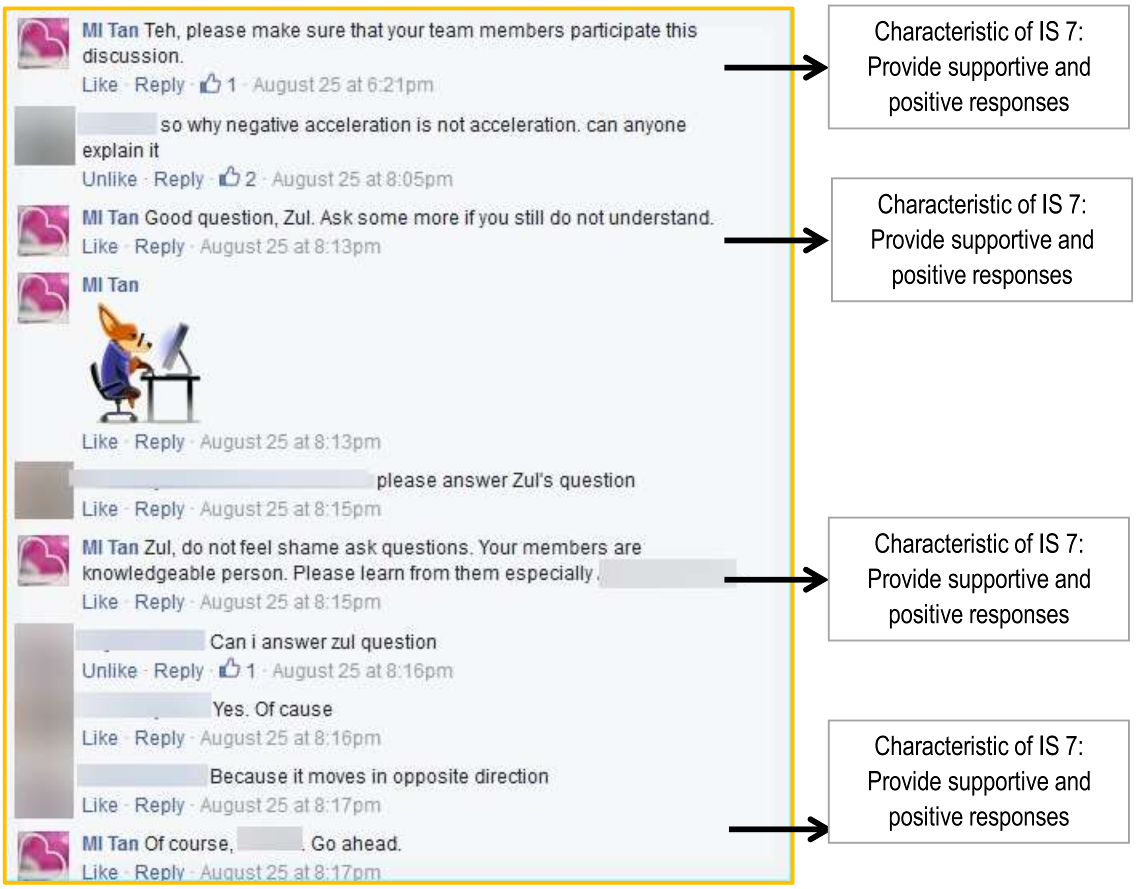


Figure 6.12 Examples of providing supportive and positive responses to an engineering student posted on the Facebook discussions (Team 2)

viii. Provide instructional support

From the data findings, all the interviewees agreed the researcher had provided appropriate clues or hints that helped them do the analysis in the ill-structured problems or questions. They performed better to solve the questions properly. This means that this element of IS can cognitively steer engineering students in an SCL environment towards KC. For instance, providing clues or hints makes the tasks easier. Comprehensive monitoring lets them save a lot of time in searching for videos and other resources and, if possible, helps them to have further discussions after watching the video again and asking their peers or the instructor to elaborate more upon the learning content. Surprisingly, the data findings were linked with the social present characteristics, such as intimacy, in which the engineering students felt excited to construct knowledge even though they were facing difficulties in their learning itinerary, as shown in Figure 6.13.

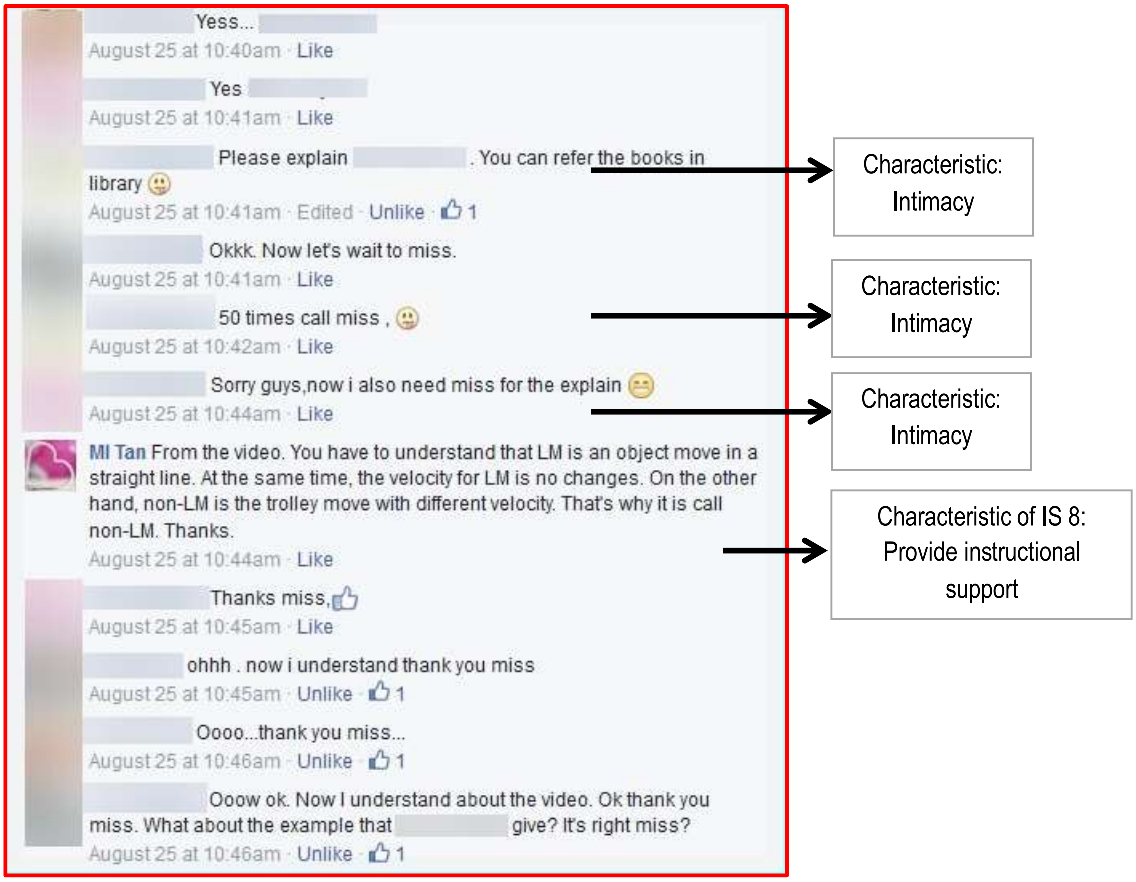


Figure 6.13 Examples of providing instructional support to an engineering student posted on the Facebook discussions (Team 6)

The following extract is an answer from an interviewee and gives to evidence to substantiate the ‘provide instructional support’ of elements of IS.

HM2: “She gave me an instruction to find a video and other resources to solve the problem questions. I could perform better in KC after watching the video again and asking group members or getting instructor Miss Tan’s explanation. I could study and share ideas after watching the YouTube video.”

6.4 Discussion on how the Online SCL Environment Guided with Instructional Scaffolding Support Engineering Students to Reach a Higher Level of Knowledge Construction

Several characteristics need to be considered when discussing research question three: conditions, interactions, and immediacy and intimacy (C3I). When discussing the ten (10) interviewees' perception and perspectives of the characteristics C3I, the researcher examined how the SCL criteria supported by IS were able to reboot the engineering students to reach a higher level of KC. The results showed there are several components of SCL characteristics, and these will be discussed in the following sub-topics.

6.4.1 Discussion on how the Condition Characteristic of the Online SCL Environment Support Engineering Students to Reach a Higher Level of KC

The findings in Figures 5.24 (network diagram of condition criteria and group composition), 5.25 (network diagram of acquire new knowledge), and 5.26 (network diagram of collaboration context) were useful to the researcher. There are various components in the condition characteristic, namely, acquiring new knowledge, collaboration context, and group composition.

As can be seen in Figure 5.24, all the interviewees held the same point of view, specifically, that the condition characteristic of the SCL environment could enhance engineering students' learning and satisfaction in terms of acquiring new knowledge.

Evidence from the interviewees' replies substantiated this view.

HM4: "My interest was aroused because I could share and compare my ideas with my friends."

Working together with a good degree of collaboration helped the students to explore more about their learning. Two interviewees (HM4 and MM4) claimed that via the Facebook discussions, they could gain a higher level of KC, apply the knowledge, and compare and explore ideas to get more information. In the meantime, they analysed the problem-solving questions to find the correct solution. Such learning activities improved their memory and helped them understand the topic better in order to reach a higher level of KC, as illustrated in Figure 6.14.

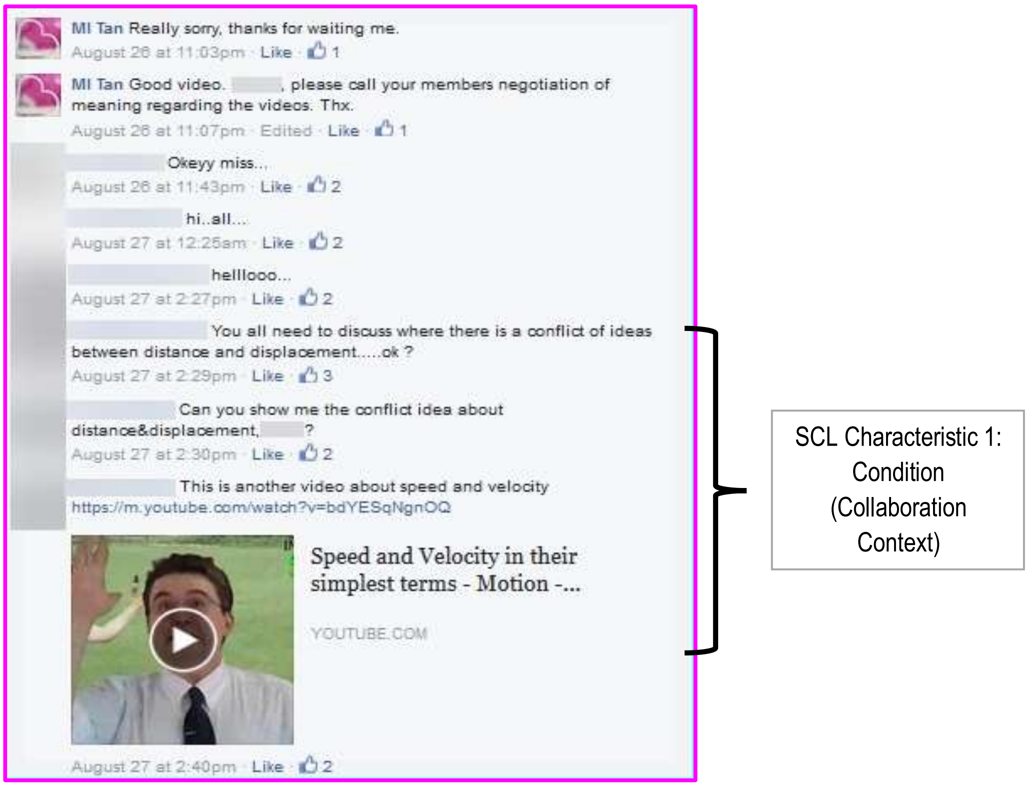


Figure 6.14 Collaboration context posted on the Facebook discussions (Team 3)

One interviewee had the following opinion:

MM4: "I gained knowledge through the Facebook discussions. For example, in learning activity 2d (synthesis and application of new knowledge in the civil engineering field), Miss Tan stated that we should think about how to apply linear motion knowledge in the civil engineering field. Because we compared our ideas, we improved our knowledge and got more information."

Appropriate group size affected the quality of the engineering students' discussions of the learning content via the Facebook platform in the SCL environment. They felt that this setting would help them reach a higher level of KC when the discussions were orderly and were led by members who performed their roles efficiently and gave good explanations in the discussions. Appropriate group size would be conducive to interactivity (type of tasks and size of group) for engineering students who could give more explanations to the members in an easier way, as shown in Figure 6.15. This finding is in line with that of Strijbos, Martens and Jochems (2004), who revealed that group size influenced the interaction, such as feedback from peers, exchanging points of view, and discussions. This means that group composition, such as gender distribution, prior knowledge, and size of group, would affect the quality of interaction via the Facebook discussions in an SCL environment.

MM4's opinion was as follows:

MM4: "Yes. My role was as a starter. I started the discussions and led the other members to perform their role. I had a good topic. Miss Tan always gave us freedom to choose our role. Our team members also explained to me well during the discussions via Facebook. This enabled me to reach a higher level of knowledge when I taught them. From being ignorant about the learning content, I became clear about the topic."

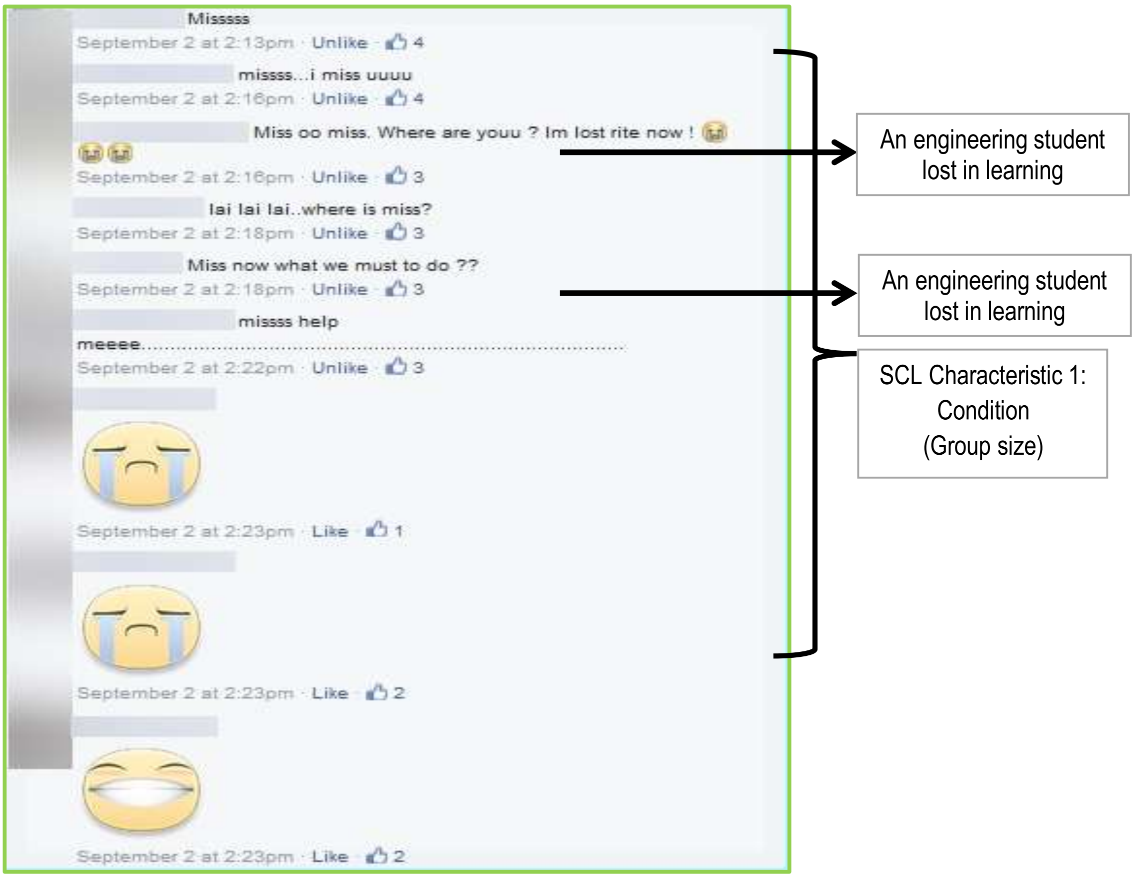


Figure 6.15 Examples of giving more explanations posted on the Facebook discussions (Team 3)

6.4.2 Discussion on how the Interaction Characteristic of an Online Social Collaborative Learning (SCL) Environment Support Engineering Students to Reach a Higher Level of KC

In order to help engineering students reach a higher level of KC, the researcher needs to integrate several elements of interaction for them when implementing metacognitive activities in AOD via the Facebook platform. In the meantime, the researcher describes how engineering students can achieve a higher level of KC supported by IS in an SCL environment.

Interactions may further be classified into several themes which are related to the stated learning conditions:

i. Control

The engineering students could exchange ideas when discussing the learning or LGC task with peers via Facebook in the SCL environment. The researcher provided a variety of support in order to control their emotions and help them not to feel frustrated in the process of KC, as shown in Figure 6.16.

Figure 6.16 An example of providing a variety of support posted on the Facebook discussions (Team 3)

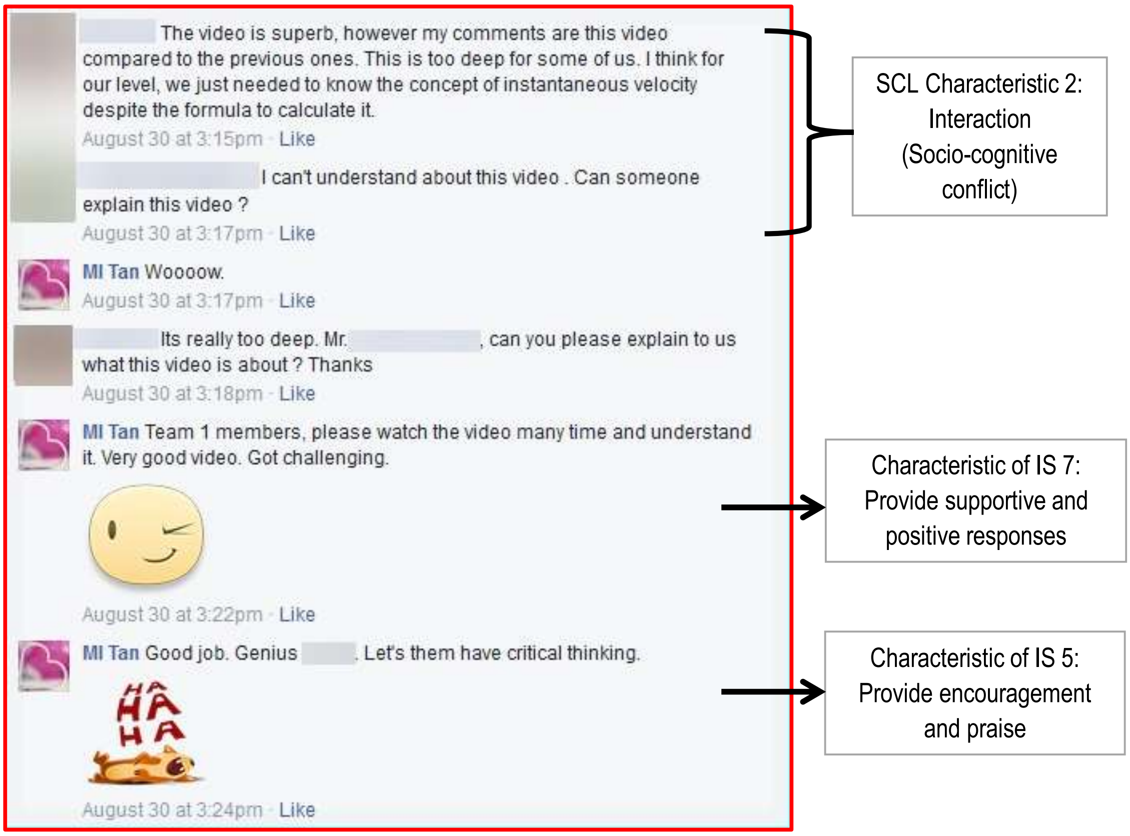
When the engineering students were faced with contradictory statements from their peers, the researcher supported them to reach a higher level of KC through the interaction characteristic supported by IS elements. A typical interviewee's reply was as follows:

HM3: "Yes. I needed to control myself in an argument when we were faced with disagreement in the discussions. It nurtured understanding. We should not take things too seriously."

The findings reinforced Strijbos, Martens and Jochems's (2004) claim that the interaction characteristic is affected by group composition and the type of tasks. The engineering students kept on exchanging or creating ideas when they interacted within the SCL environment guided by the IS elements supplied by the researcher.

ii. Socio-cognitive conflict

The engineering students debated with their teammates when they were faced with conflicting ideas while discussing the learning or LGC task in the SCL environment. This helped them to reach a higher level of KC by finding other videos from YouTube, listening to other members' ideas, and discussing with their peers, as shown in Figure 6.17.



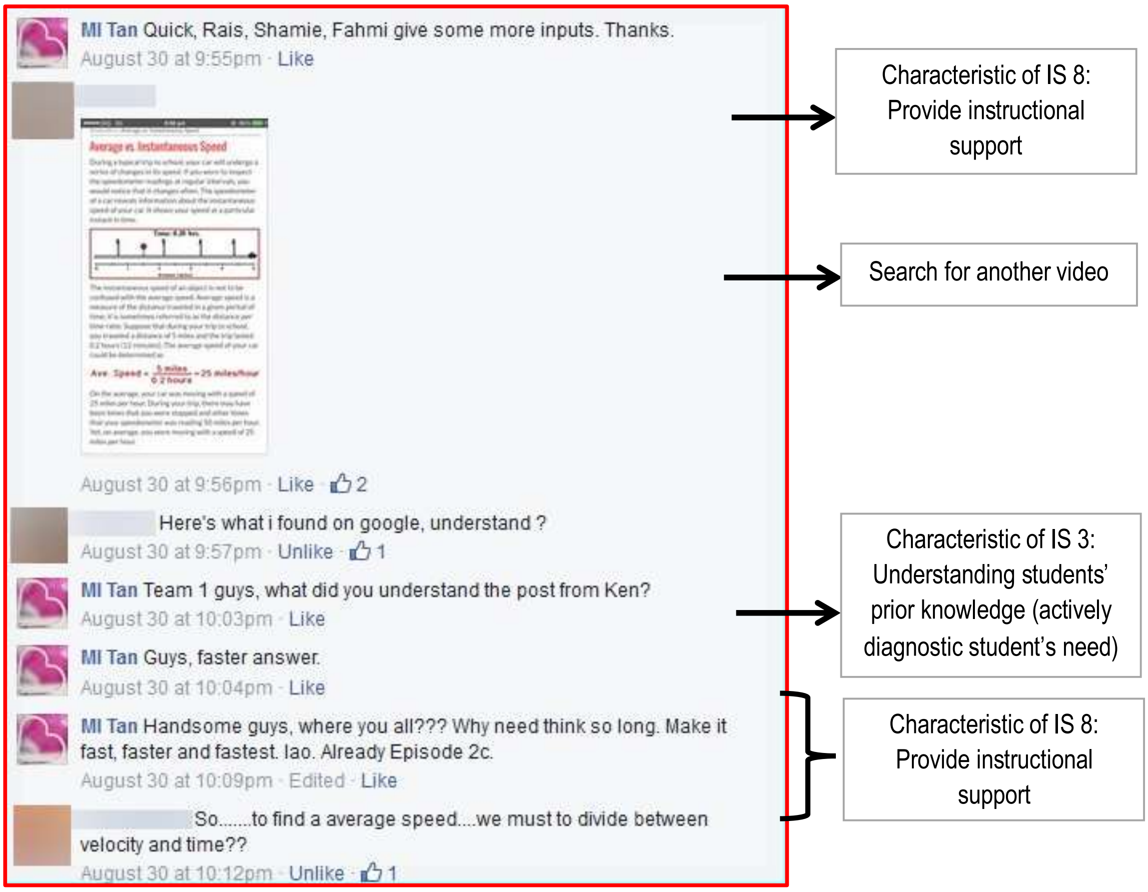


Figure 6.17 Examples of discussions with peers to solve socio-cognitive conflict posted on the Facebook platform (Team 1)

One of the engineering students, namely, MM2, pointed out that exchanging an idea can help solve the socio-cognitive conflict by the negotiation of meaning from a theorist or an instructor. The following is typical of the interviewees' answers:

MM2: "I could debate with others. So, I could exchange opinions (ideas) with friends in the Facebook discussions (online learning). I could stop them if they argued about the learning task, such as negotiation of the meaning of distance and displacement. At the same time, I could call upon a theorist to solve this conflict. Meanwhile, I could change my opinion based on the learning given by the instructor and knew what was correct and incorrect. So, from the cognitive conflict, I could analyze the problem and solve it Then, I concluded the discussions. This helped me reach a higher level of KC. We solved the problem questions together."

This statement corresponds with the ideas of Pena-Shaff and Nicholls (2004), who claimed that students' interaction can promote meaningful and collaborative learning as well as enhancing the process of KC. In other words, the quality of interaction, such as discussion about the learning or LGC task could engage and encourage the engineering students to reach a higher level of KC in the SCL environment.

iii. Factors that affect learning: negotiation and argumentation of meaning as well as elaborate explanation via quality of interaction

The data findings show that negotiation of meaning or argumentation of multiple opinions during the interaction between peers and with the instructor via the Facebook discussions may help engineering students to reach a higher level of KC in an SCL environment. As can be seen in Figure 6.17, the researcher provided a variety of IS to engage and scaffold engineering students in order to encourage them to move on in the process of KC. They integrated and generalized the linear motion terminology, such as distance and displacement, instantaneous velocity and average velocity, and speed and velocity, and accepted the argumentation or negotiation of meaning through the quality of interaction with their teammates. They recapitulated (restated) the main points of an argument on the linear motion topic. They also had to draw conclusions regarding the learning content.

For instance, student HM5 shared and compared ideas with students HM3 and HM4 in order to help them understand and analyze the problem questions. MM1 was also helped to understand the calculation better. They could identify and analyze the five types of displacement versus time graphs through peers giving more examples and elaborating in detail. This affected their process of learning in terms of leading engineering students to reach a higher level of KC in an SCL environment.

The following is typical of the interviewees' reports:

HM3: "Formerly, I did not know how to differentiate the graphs between displacement versus time and velocity versus time. I felt confused. We kept on searching for information patiently with my team members. After the Facebook discussions, I knew how to differentiate them. I could save the data in my smart phone. Whenever I wanted, I could refer to the graphs via my i-Phone. Argumentation over the graphs definitely helped me understand and analyze the graphs much better. For example, Miss Tan told us to debate about instantaneous velocity and average velocity.

For example, s= total displacement of the graph. The knowledge that I gained is buried deep in my mind. I will not forget the knowledge. For example, in 2c, Miss Tan asked us to give more examples of instantaneous velocity and discuss them. The problem question made me search for more data to solve it. Before solving the problems, I had to know the differences of the graphs and how they related to each other. If not, I might have got stuck in solving the problem questions. Besides, I could gain a higher level of knowledge."

This is similar to the views of Pena-Shaff and Nicholls (2004), who claimed that interaction needs active participation in the social and discourse process in which there are different perspectives, an exchange of opinions, and negotiation of meaning for learners to gain new knowledge.

In general comments on interaction with the instructor and peers (scaffolder) (see Figure 5.30), the interviewees (MM4, HM3 and HM4) found that the SCL environment could help them to construct a higher level of new knowledge at any time although they were not physically together. This means that this was not a real time discussion. Meanwhile, interviewee HM3 claimed that online learning can increase collaboration with peers when discussing the LGC task via the SCL environment. Apart from that, he utilized new knowledge to solve problems.

The following response is typical of interviewees' opinions:

MM3: "I think this way of studying is good. We improve our thinking skills and language (communication) skills. We can interact with other team members and with our lecturer Miss Tan. It is easier to learn online (internet) because we can search for the points (ideas) and information in a faster way."

6.4.3 Discussion on how the Immediacy Characteristic of an Online SCL Environment Supports Engineering Students to Reach a Higher Level of Knowledge Construction

There are two themes, namely, different types of discussion and rapid exchange of information in the immediacy characteristic of an SCL environment. When the engineering students carried out a learning or LGC task, they gave explanations via either synchronous or asynchronous interaction. The researcher provided prompt feedback and a variety of ISS to help the engineering students to reach a higher level of KC. Meanwhile, the researcher also encouraged them to participate actively in the Facebook discussions in the SCL environment. Figure 6.18 gives an example of prompt feedback from the instructor and peers.

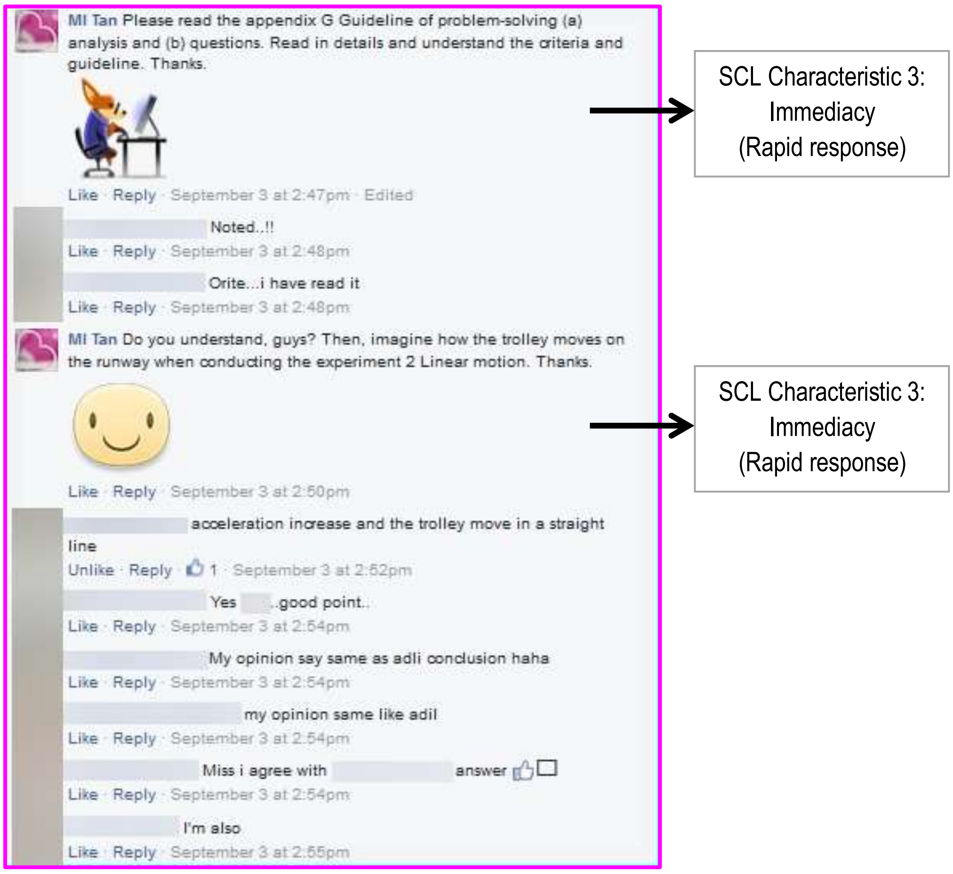


Figure 6.18 Examples of prompt responses from the instructor and rapid exchange info between peers posted on the Facebook discussions (Task 2: Analysis and Problem solving questions)

Interestingly, the ten interviewees were split evenly about the types of discussions they preferred. Some preferred AOD because they could learn outside of the engineering classroom and broaden their thinking and views, and while they were at home, they found it easier to discuss problems with their peers and the instructor at any time and in any place. This could help them reach a higher level of KC, which is in line with the opinion expressed by the following interviewee:

MM2: “AOD. I prefer online study because it is easier for me: I can sit at home and discuss with my peers and instructor. No need go to the class and just login in to my Facebook account. Then, I can learn any time and at any place. I understand the learning task better by playing the role.”

Surprisingly, an overview of the findings of the study shows that distance between two communications, whether real time discussions or delayed discussions, influenced the interaction of engineering students’ detailed explanations when they implemented the LGC task or solved the ill-structured problems or questions task via Facebook discussions. All the interviewees had the same view, that is, that rapid exchange of information can really help them reach a higher level of KC when the instructor promptly elaborates upon the statement, which makes them learn more. This finding is substantiated by evidence from the following reply from an interviewee:

HM3: “Rapid exchange of information can make me feel my peers’ participation in the discussions. Then, I learn new knowledge every time. For example, in 2c, Miss Tan explained promptly to us about instantaneous velocity and average velocity when we asked her. I could repeatedly read the comments via Facebook, and the quick feedback made me learn more. So, I could get a higher level of KC.”

6.4.4 Discussion on how the Intimacy Characteristic of the Online SCL Environment Support Engineering Students to Reach a Higher Level of Knowledge Construction

The intimacy characteristic helped make engineering students feel close to each other when using emoticons and emoji during their AOD via Facebook in the SCL environment. Surprisingly, they maintained their desire to gain new knowledge and new experience when executing learning or LGC tasks or solving the ill-structured problem or question tasks. This may support and help engineering students reach a higher level of KC. The engineering students felt happy when compliments or praise were given to them during the process of KC. This made them committed in their learning itinerary towards KC.

Informal and enjoyable discussions may have helped the engineering students reach a higher level of KC, as shown in Figure 6.19. They were able build up self-discipline, confidence, and a desire to learn in order to upgrade their knowledge, such as argumentative knowledge or metacognitive knowledge. During this time, the engineering students experienced joyful interaction between peers without tense or emotional arguments when conducting Facebook discussions through sharing and comparing, discovering and exploring, and analysis and synthesis of the ideas to get the consensus on the learning content. Interaction efficiency guided by IS helped engineering students increase a feeling of intimacy (more enjoyable, fun, and happy) to learn towards achieving KC. They felt open discussions with the instructor and peers could help them gain a higher level of KC with greater efficiency and more satisfaction.

The intimacy characteristic of the SCL environment made it easier for the engineering students to understand and memorize the knowledge. They were also willing to learn and desirous of upgrading the learning environment to be conducive for discussion in the Facebook platform. A typical interviewee's opinion on the intimacy characteristic was as follows:

MM5: "It helped me because I enjoyed it without having any stress from my study. There's fun, so I liked the course. It's easier for me to understand and memorize the knowledge. Miss Tan always posted the emoticons during our Facebook discussions. Emoticons make us feel close to others emotionally. It can encourage and motivate me to study with fun. For example, smiles and other emoticons can make me understand that I need to work hard and understand the topic more."

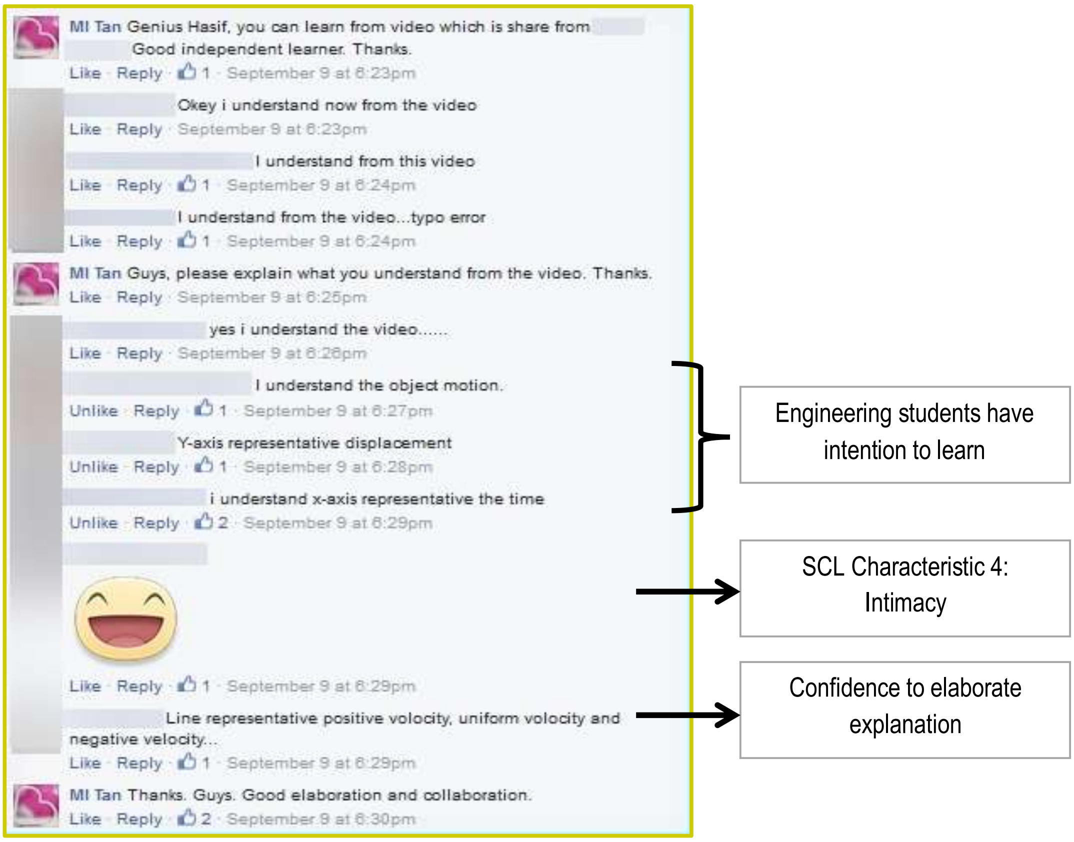


Figure 6.19 Several examples of the intimacy characteristic posted on the Facebook discussions (Task 2: Analysis and Problem solving questions)

6.5 Discussion on Knowledge Construction Model (KCM) in an Online SCL Environment Integrated with Instructional Scaffolding that Enhances Engineering Students' Knowledge Construction Level

The social or online learning needs to be implemented and applied among engineering students to support and guide them to become more competent in KC. In other words, the instructor should be able to set up an appropriate learning environment, such as SCL supported by an IS strategy, to assist and support engineering students to be more engaged and active in constructing new knowledge.

Moreover, Figure 5.36 (holism KC model) shows that the condition characteristic directly affects students' cognitive pre-engagement and motivation. From the results of this study, the researcher noticed that pre-engagement is the vital element of IS to enhance engineering students' KC. It can be said that the shared goal is a type of motivation in the IS strategy for engineering students' KC. Goal achievement and relationship with peers are noted for motivation in or out of the engineering classroom.

Simultaneously, the interaction characteristic directly affects the factors of engagement and enhancement as well as explanation and guide. The researcher should treat engineering students equally when executing the Facebook discussions in an SCL environment. The quality or type of discourse (whether synchronous or asynchronous communication) can be more conducive to the engineering students' KC and achievement of learning outcomes than can the quantity or amount of engagement and enhancement. In other words, quality of interaction, such as explanation and guide of learning content between the instructor and the engineering students as well as peer to peer, would lead to them reaching a higher level of KC. It is important for them to obtain good collaboration and to complete the learning tasks.

In addition, critical discourse, such as analysis, may support argumentative KC via students sharing their opinions and persuading their peers in terms of negotiation of meaning. This corresponds with findings by Schwarz *et al.* (2004), who claimed that critical discourse could lead to effective KC. Meanwhile, reflective discourse such as synthesis would help lead engineering students to draw conclusions from the learning content.

Consequently, the immediacy characteristic directly affects determination (persistence), and encouragement and praise. Prompt responses from the instructor or facilitator would help engineering students in KC. They would be more persistent in their learning and would not give up easily when encouragement and praise are provided.

Finally, the intimacy characteristic is vital as it directly affects ‘comfort and engagement’. It makes the engineering students’ learning process easier, according to the interviewees’ perception as revealed in this study. The participants enjoyed the AOD when the instructor provided emoticons or emoji via the Facebook platform in the SCL environment (see Figure 6.19). This made them more engaged in the learning and helped them gain a higher level of KC.

Figure 5.35 (IS strategy model) shows intercourse between providing a variety of support and giving feedback. The engineering students experienced a feeling of closeness in the process of KC. Surprisingly, the findings showed that the participants that had a good quality of interaction could have a better KC experience and gain a higher level of knowledge as well as greater goal achievement. The ‘intimacy’ of the engineering students resulted in persistence and rapid feedback from their peers or the instructor. This made them willing to complete the learning tasks given by the instructor although they faced difficulties via Facebook discussions in the SCL environment. The engineering students also felt satisfied with their learning experience when the instructor (researcher) gave fast and rich feedback to them so as to enhance their KC. This may promote quality of interaction and of students’ engagement in the learning process.

Interestingly, the researcher further discusses the novel design of the ISS model (see Figure 5.35) integrated with IS elements. Impact factors 1 (students’ cognitive pre-engagement) and 3 (engagement and enhancement) led the engineering students to continue constructing their own knowledge. This means that they continued upgrading their new engineering knowledge. Impact factors 2 (motivation) and 5 (encouragement and praise) helped to support engineering students’ learning itinerary. Then, impact factors 4 and 6 (explanation and guide) assisted the engineering students to elaborate more about the learning content and to become more analytical in order to solve the ill-structured problems or question. They were able to remember and apply their newly constructed knowledge in the engineering field. This eased the learning process (impact factor 8). Lastly, impact factor 7 (persistence and comfort and engagement) can be broken up into the cognitive domain and the affective domain, both of which may affect the engineering students' KC due to the support provided by the IS strategy. The researcher provided a variety of support and positive responses for the engineering students to keep them performing well in their academic field.

This ISS can be written as the following equation:

IS Strategy = Students' cognitive pre engagement + motivation + engagement and enhancement + explanation and guide + encouragement and praise + determination (persistence) + comfort and engagement + ease in learning process

This ISS is used to measure and define scaffolding and solve the engineering students' KC problems. It also hints at the underlying factor structure of IS. The most important thing is practicing the ISS in order to steer cognitively engineering students' KC throughout AOD in an SCL environment.

The researcher concludes that IS successfully supports engineering students' KC, notably in TVET. Thus, the researcher needs to structure the learning environment to support active, reflective, and productive tasks, such as LGC and ill-structured problems and questions for the students. The IS strategy should include not only engineering students' construction of productive metacognitive knowledge, but also students' awareness and reflection on the tasks as learning activities in the SCL environment. It is encouraging to note that the results show that engineering students' KC can be influenced by how the instructor structures the learning activities to support and guide them with IS in a hybrid learning environment.

The conclusion for this discussion can be illustrated in Figure 6.20.

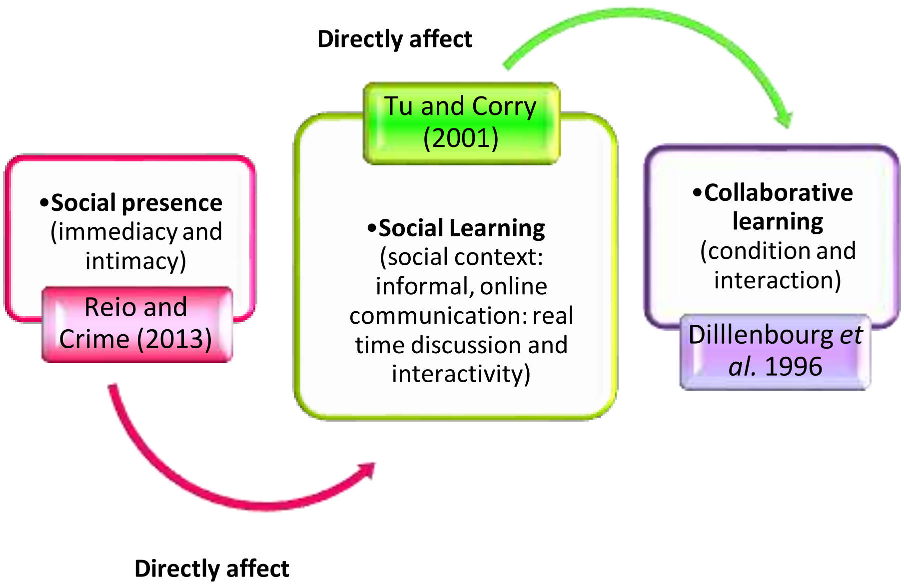


Figure 6.20 Immediacy and intimacy characteristic of online SCL affect the quality of interaction between instructor and engineering students

6.6 Conclusion

There are four conclusions in the study. This study concluded that an online SCL environment guided by IS may have a positive impact on engineering students' achievement in both tests and KCL. They were more active in cognitive engagement, reflective self-regulation, and the productive quality of asynchronous online discussions which assist the learning environment. Furthermore, IS in SCL can also take students' knowledge into a higher level and expand their prior knowledge and learning experience.

The second conclusion is "pre-engagement", "a variety of support" and "positive responses" are crucial elements for helping engineering students to construct their argumentative or metacognitive knowledge. Thus, the ISS model (see Figure 5.35) is vital to guide students' KC. The results indicate that not all the elements of IS supported and assisted the engineering students' KC. The researcher had to use sufficient appropriate scaffoldings, such as conceptual, procedural, strategic, and metacognitive scaffolding, to support the engineering students' KC, which is related to the learning activities. Thus, different types of IS would have different outcomes regarding KC, notably to engineering students in TVET.

The third conclusion is characteristics of SCL, viz., condition, interaction, immediacy and intimacy (C3I) in online learning. The two imperative of characteristics such as immediacy and intimacy are directly affected the engineering students in reaching a higher level of KC. In means that these two elements are related to the quality and satisfaction of the interactions with the instructor and with peers in an online SCL environment via Facebook discussions. The engineering students were satisfied with their learning experience when the instructor and their peers gave prompt feedback. This corresponds to the view of Reio and Crim (2013), who revealed that immediacy and intimacy could minimize learners' frustration while enhancing satisfaction and active participation in learning. Moreover, it also increases collaboration in terms of interaction and promotes a meaningful learning experience for the engineering students to reach a higher level of knowledge.

The fourth conclusion is the holism KCM in the online SCL environment, integrated with IS can enhance and nurture the engineering students' KCL. This model, which comprises C3I (condition, interaction, immediacy and intimacy), directly influenced the students' cognitive and affective domains. Moreover, it could be applied to TVET and/or engineering students' curriculum in terms of nurturing engineering students' KCL in online SCL.

Finally, the ISS combined with the SCL characteristics (C3I) is vital to help, lead, guide, facilitate, and support engineering students' KC. It can also help them to construct knowledge at a higher level. The use of IS is essential for engineering students to complete the learning tasks successfully in engineering course.

6.7 Limitations of the Research

There are several limitations in this study. The engineering students should introduce role play before conducting the asynchronous online discussions (AOD) via the Facebook platform. They need to both understand and carry out the LGC task. In addition, the participants have different demographic profiles, as they are from the departments of civil and of mechanical engineering.

Simultaneously, engineering students may face uncertainties and/or difficulties with concepts of KC in an online learning environment. Besides, some students in rural areas may face online problems, such as an unreliable internet connection or out of order data sources.

Consequently, the present study does not discuss “motivation” and “providing encouragement and praise” in the ISS model. Motivation can energize and directly affect engineering students’ behavior and feelings. It comprises intrinsic (autonomous) and extrinsic (controlled) motivation as part of the topic for discussion with the students. For instance, only two interviewees (MM2 and MM3) felt the importance of providing encouragement and praise when the instructor conducted the Facebook discussions in the SCL environment. Even though eight of the ten interviewees expressed the view that providing praise could not result in them having an improvement in KC, the researcher considers positive and supportive statements are still desirable to lead students on the right path in their learning itinerary.

Finally, this study does not look at the types of engineering students’ online interaction. In other words, can the discourse between instructor and students or peer to peer make students more adept (skillful or competent) in an online SCL learning environment supported by IS. This is subject to much argument from researchers and deserves further investigation, particularly in engineering education.

6.8 Recommendation

As well this study can move to investigate on how IS can be further scaffolding (lead) and expand the engineering students' thinking skills. In means that how to manipulate IS to construct and enhance engineering students' creative and innovative skills in the engineering curriculum if the learning setting such as Facebook hybrid with Whatsapp or Skype or WeChat in online learning.

The implementation of online SCL as a hope in techno-pedagogy (innovation in pedagogy) among online learner community, notably in engineering education field. These practices along with the ability to enhance and enrich in pedagogical innovation typically TVET. Allow this approach to be used globally in other courses in the department and in the engineering course.

As the needs of society have drastically changed to become harmonized with creation and innovation in our work and daily lives. There are constant efforts to find new ways to enhance pedagogy in terms of how to create and work together (team work) via online SCL environments integrated with IS elements. Hence, engineering education researchers have the responsibility to construct new techno-pedagogy for the engineering students in online learning.

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APPENDIX A

Guidelines on Learning / Learner Generated Content (LGC) Task

No.	Guidelines on LGC Task
1	Assign grouping and role such as starter, resource searcher, moderator, theorist and summarizer during discussion through Facebook group.
2	Download three (3) videos from YouTube. Each video should not more than 4 minutes.
3	Each video should be made a discussion consists of sharing, comparing, discovering, exploring, negotiating and synthesizing via Facebook group.
4	List down all the specific objectives related to the learning content which is in the second slide of power point presentation.
5	Produce one (1) mapping concepts should be included in the task which is in the third slide of power point presentation.
6	Learning content should be based on Engineering Science course learning outcomes (CLO).
7	Show details in the application of problem solving questions.
8	Summarize and make conclusion of the LGC Task.
9	Apply new knowledge which is related to current engineering field work.
10	Assign roles for each member when conducting the LGC presentation.
11	Present the learning content for 45 minutes.
12	15 minutes for question and answer session will be allocated after the group presentation.
13	All the LGC tasks need to be uploaded through Facebook for sharing knowledge.

APPENDIX B : MODULARIZED ENGINEERING PEDAGOGIC CURRICULUM

Modularized Engineering Pedagogic Curriculum

COURSE OUTLINE DBS1012
JUNE SESSION 2015
LECTURER: TAN MAY LING

PROGRAMME AIMS

PROGRAMME CODE	PROGRAMME AIMS
DAD	Graduates of diploma in mechanical engineering (automotive) program at Polytechnics will have knowledge, skills and attitude that will allow them to make tangible contributions and meet new technical challenges. They will possess entrepreneurial skills, practice good work ethics, be able to promote good morality and behavior, and continuously enhance their knowledge and skills. The graduates will communicate and interact responsibly and be able to contribute effectively as a team member. They will also be adaptable to new changes at the workplace
DEM	The Diploma in Mechatronic Engineering graduates in Polytechnics, Ministry of Education will have the knowledge, technical skills, community service responsibilities and attitude to adapt themselves with new technological advancement and challenges in the mechatronic engineering field.
DEP	The Diploma in Electronic Engineering (Communication) graduates in Polytechnics, Ministry of Education Malaysia will have the knowledge, technical skills, communication skills and attitude to adapt themselves with new technological advancement and challenges in the electronics communication field.
DKA	The Diploma in Civil Engineering graduates in Polytechnics, Ministry of Higher Education will have knowledge, technical skills and altitude to adapt themselves with new technological changes and challenges in Civil Engineering Fields.
DKM	Graduates of diploma in mechanical engineering program at Polytechnics will have knowledge, skills and attitude that will allow them to make tangible contributions and meet new technical challenges. They will possess entrepreneurial skills, practice good work ethics, be able to promote good morality and behavior, and continuously enhance their knowledge and skills. The graduates will communicate and interact responsibly and be able to contribute effectively as a team member. They will also be adaptable to new changes at the workplace.
DTK	The Diploma in Electronic Engineering (Computer) graduates in Polytechnics, Ministry of Education Malaysia will have the knowledge, technical skills, communication skills and attitude to adapt themselves with new technological advancement and challenges in the computer and electronics field.

COURSE & CODE	DBS1012 ENGINEERING SCIENCE
WEEKS	16
CREDIT(S)	2.0
PRE-REQUISITE(S)	TIADA
SYNOPSIS	ENGINEERING SCIENCE is an applied science with theoretical concepts and practical learning sessions that can be applied in the engineering fields. This course focuses on the Physical Quantities, Measurement, Linear Motion, Force, Work, Energy, Power, Solid, Fluid, Temperature and Heat.
COURSE LEARNING OUTCOMES	Upon completion of this course, students should be able to: CLO1 Solve the basic engineering science problems by using related concept. (C3, LD1) CLO2 Organize an appropriate experiment to prove related physic principles. (P3, LD2) CLO3 Apply related physic principles in various situations to enhance knowledge. (C3, LD1)

Week	Topic	CLO	Recommended Time Allocation (RTA) / Assessment	Development of Facilitating Tasks	Instructional Focus	Instructional stage and session	Strategies and Techniques/ Remarks
1	Weeks of registration and orientation						
2	1.0 PHYSICAL QUANTITIES AND MEASUREMENT This topic introduces physical quantities which are consisting of base and derived quantities. Physical Quantities also categorized into of scalar and vector quantities. Conversion of physical quantities also will be explained. Students will be exposed to use measurement equipment and right measurement techniques	CLO1 CLO2	04:02	Facilitating with simplest complexity-undimensional Facilitating with simple complexity	Designing of a lecture Planning of a whole lecture Knowledge of declarative/ conceptual and procedural	Develop background knowledge 1st session (2nd week)	Brainstorming Explicit and interactive explanation Stimulation of prior knowledge
3	cont. QUIZ 1 LABWORK 1				Working with LGC task Working in the laboratory	Develop background knowledge 2nd session (3rd week)	Explicit instruction and explanation
4	2.0 LINEAR MOTION This topic explains about linear motion which includes displacement, velocity, and acceleration. The methods of problem-solving of linear motion using formulas and graphs will be shown. Students will be exposed to identify displacement, velocity and acceleration.	CLO2 CLO3	08:03	Facilitating with increased complexity	Working with LGC task Knowledge of declarative/ conceptual and procedural	Presentation of LGC 3rd session (4th week)	Online Interaction (Fahy, 2000) Online Instructional Scaffolding in Online Social collaborative learning (SCL) environment via Facebook discussion group. Asynchronous online discussion (AOD) (Teo and Chai, 2011)
5	cont.				Knowledge of argumentative	4th session (5th week)	Social Feedback Group Discussion via Facebook platform
6	cont. LABWORK 2				Working in the laboratory	5th session (6th week)	Working in Group Metacognitive / Self-regulatory learning procedures

					Knowledge of self-regulatory (Meta-cognitive)		(Labwork Rubric: DBS1012 Engineering Science set by KPM) Guidance by facilitator Self-instructions explicit to encourage
7	3.0 FORCE This topic explains about forces, Newton's Second Laws and moment of forces which is applied in equilibrium. Problem-solving using resolution method to find the resultant force will be explained.	CLO1 CLO2 CLO3	06:03	Facilitating with lighter complexity	Working with LGC tasks	Collaborative practice $6^{nd} - 15^{th}$ sessions (7^{th} until 16^{th} week)	
8	cont.						
9	cont. THEORETICAL EXERCISE 1				Designing of exercise		
10	4.0 WORK, ENERGY AND POWER This topic explains about the relationship between work, energy and power. Students will be exposed to energy changes and mechanical efficiency.	CLO1 CLO2 CLO3	04:02	Facilitating with diverse complexity	Working with LGC task	Collaborative practice	
11	cont.						
12	5.0 SOLID AND FLUID This topic explains about solid and fluid materials. Students will be exposed to density and pressure. Pascal's and Archimedes' Principles will be described.	CLO2 CLO3	06:03	Facilitating with high complexity	Working with LGC task	Collaborative practice	
13	cont. LABWORK 3				Working in the laboratory		
14	cont. THEORY TEST 1				Designing of test		
15	6.0 TEMPERATURE AND HEAT This topic describes temperature and heat. Students will be exposed to the process of heat transfer. They will be able to solve problems related to heat quantity and specific heat capacity. LABWORK 4	CLO2 CLO3	04:02	Facilitating with highest complexity	Working with LGC task Working in the laboratory	Collaborative practice	
16	cont. THEORETICAL EXERCISE 2				Designing of exercise		

APPENDIX C : PRE TEST FOR DBS1012 ENGINEERING SCIENCE

APPENDIX C

CONTINUOUS ASSESSMENT

MATHEMATICS, SCIENCE AND COMPUTER DEPARTMENT
POLYTECHNIC UNGKU OMAR

JMSK
Jabatan Matematik Sains dan Komputer

JUNE 2015 SESSION

DBS1012-ENGINEERING SCIENCE

Theory Test (Set A)

/ 25

Name : ....

ID No. : .... Class : ....

Lecturer's Name: ....

Instruction ***: Answer all questions. (CLO 1 and CLO 3)***

Duration ***: 1 hour***

Question 1 (Remembering)

Define and state the S.I. units of the terms below:

Deceleration (2m)

____

____

Question 2 (Understanding)

(a) Convert the unit from 30 m/s to km/hour. (3m)

(b) Give two examples of linear motion. (2m)

Linear Motion	
	(1m)
	(1m)

Question 3 (Applying)

Solve the velocity of the car if it has moved 100 m South in 5 s. Then, it moves 250 m West in 10 s. (5m)

Questione 4 (Analyzing)

State the differences (distinguish) between speed and velocity (3m)

Speed	Velocity

Questione 5 (Evaluating)

Explain the two roads represent distance and displacement based on the Figure 5.1 as shown. (4m)

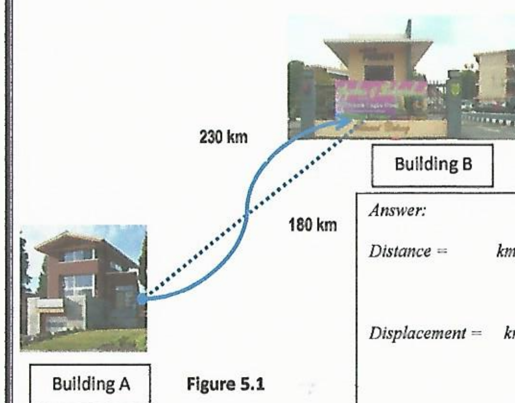


Figure 5.1

Answer:

Distance = *km,* [2m]

Displacement = *km,* [2m]

APPENDIX D : POST TEST FOR DBS1012 ENGINEERING SCIENCE

APPENDIX D

CONTINUOUS ASSESSMENT

MATHEMATICS, SCIENCE AND COMPUTER DEPARTMENT
POLYTECHNIC UNGKU OMAR

JMSK Jabatan Matematik Sains dan Komputer

DBS1012-ENGINEERING SCIENCE
Theory Test (Set B)

/ 25

Name : ....

ID No. : .... Class : ....

Lecturer's Name: ....

Instruction ***: Answer all questions. (CLO 1 and CLO 3)***
Duration ***: 1 hour***

Question 1(Remembering)

Define and state the S.I. units of the terms below:

Acceleration (2m)

____

____

Question 2 (Understanding)

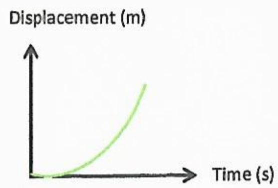
(a) Convert the unit from 30 km/hour to m/s. (3m)

(b) Give two examples of non-linear motion. (2m)

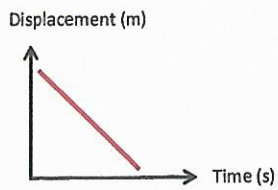
Non-linear Motion	
	(1m)
	(1m)

Questione 6 (Creating)

Relate to motion of the graphs as shown in Figure 6.1. Explain the graphs. (6m)

a)


Answer:	
Velocity =	*(1m)*
	(1m)
	(1m)

b)


Answer:	
Velocity =	*(1m)*
	(1m)
	(1m)

Prepared By:
....
(TAN MAY LING)

Approved By:
....
ZULIANA BINTI ABDUL MUTALIB
Ketua Kursus Sains
Jabatan Matematik, Sains & Komputer
Politeknik Ungku Omar
Ipoh, Perak Darul Ridzuan

Question 3 (Applying)

Solve the velocity of the car if it has moved 200 m North in 5 s. Then, it moves 250 m West in 10 s. (5m)

Question 4 (Analyzing)

State the differences (distinguish) between Distance and displacement. (3m)

Distance	Displacement

Question 5 (Evaluating)

Interpret the two roads represent distance and displacement based on the Figure 5.1 as shown (4m)

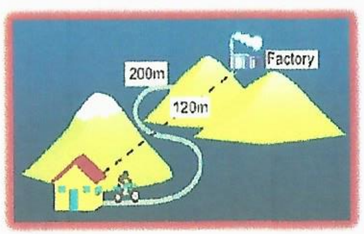


Figure 5.1

Answer:

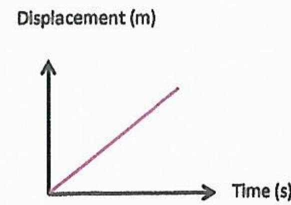
Distance = *m*
(2m)

Displacement = *m,*
(2m)

Question 6 (Creating)

Relate to motion of the graphs as shown in Figure 6.1. Explain the graphs. (6m)

a)



Answer:
Velocity = *(1m)*

(1m)

(1m)

b)

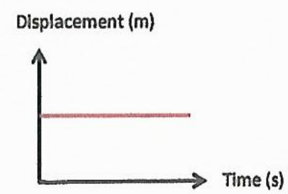


Figure 6.1

Answer:
Velocity = *(1m)*

(1m)

(1m)

Prepared By:

(TAN MAY LING)

Approved By:

ZULIANA BINTI ABDUL MUTALIB
Ketua Kursus Sains
Jabatan Matematik, Sains & Komputer
Politeknik Ungku Omar
Ipoh, Perak Darul Ridzuan

APPENDIX E

CONTINUOUS ASSESSMENT

MATHEMATICS, SCIENCE AND COMPUTER DEPARTMENT
POLYTECHNIC UNGKU OMAR

DBS1012-ENGINEERING SCIENCE

Theory Test (Pre Test) ANSWER SCHEME

25

Question 1 (Remembering)

Define and state the S.I. units of the terms below:

Deceleration (2m)

The object is decreasing the velocity when it is moves. **[1m]**
Unit= **m/s^2** **[1m]**

Question 2 (Understanding)

a) Convert the unit from 30 m/s to km/hour. (3m)

1km=1000 m, 1 hour = 3600 s **[1m]**

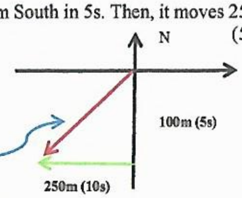
$\frac{30\ m}{1\ s} \times \frac{1\ km}{1000\ m} \times \frac{3600\ s}{1\ hour}$ = **108 km/hour** **[2m]**

b) Give to (2) examples of linear motion. (2m)

Linear Motion	
A passenger on a moving escalator	**[1m]**
An athlete running at 100 m	**[1m]**

Question 3 (Applying)

Solve the velocity of the car if it has moved 100 m South in 5s. Then, it moves 250 m West in 10s. (5m)



Magnitude or displacement = $\sqrt{(Fy)^2 + (Fx)^2}$

$= \sqrt{(100)^2 + (250)^2}$

=269.258 m [2m]

Total time = 5 s + 10 s = 15 s [1m]

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Velocity = $\frac{\text{displacement}}{\text{time}}$ [1m]

$= \frac{269.258\ m}{15\ s}$

= 17.951 m/s [1m]

Questione 4 (Analyzing)

State the differences (distinguish) between

Speed and velocity (3m)

Speed	Velocity
Scalar quantity Rate of change in distance [1.5m]	Vector quantity Rate of change in displacement [1.5m]

Questione 5 (Evaluating)

Explain the two roads represent distance and displacement based on the Figure 5.1 as shown. (4m)

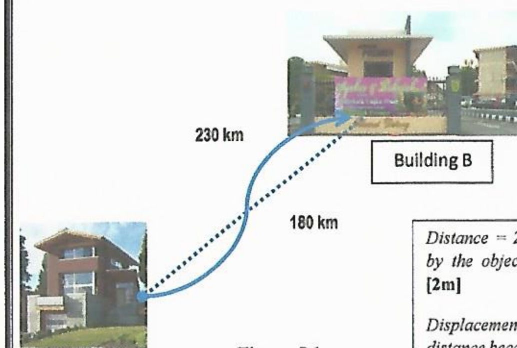


Figure 5.1

Distance = 230 km, total length travel by the object. It has magnitude only.
[2m]

Displacement = 180 km, shorter distance because it stated the magnitude and direction.
[2m]

APPENDIX F

CONTINUOUS ASSESSMENT

MATHEMATICS, SCIENCE AND COMPUTER DEPARTMENT
POLYTECHNIC UNGKU OMAR

JMSK

DBS1012-ENGINEERING SCIENCE

Theory Test (Post Test) ANSWER SCHEME

25

Question 1 (Remembering)

Define and state the S.I. units of acceleration. (2m)

Define as rate of velocity change by an object. **[1m]**
Unit= ***m/s²***. **[1m]**

Question 2 (Understanding)

a) Convert the unit from 30 km/hour to m/s. (3m)

1km=1000 m, 1 hour = 3600 s **[1m]**

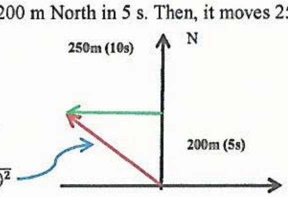
$\frac{30\ km}{1\ hour} \times \frac{1000\ m}{1\ km} \times \frac{1\ hour}{3600\ s} = 8.3333$ m/s **[2m]**

b) Give to (2) examples of non-linear motion. (2m)

Non-linear Motion	
A spinning top	**[1m]**
The earth orbiting the sun	**[1m]**

Question 3 (Applying)

Solve the velocity of the car if it has moved 200 m North in 5 s. Then, it moves 250 m West in 10 s.
(5m)



Magnitude or displacement $= \sqrt{(Fy)^2 + (Fx)^2}$

$= \sqrt{(200)^2 + (250)^2}$

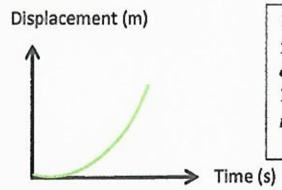
$= 320.16$ m **[2m]**

Total time = 5 s + 10 s = 15 s **[1m]**

Questione 6 (Creating)

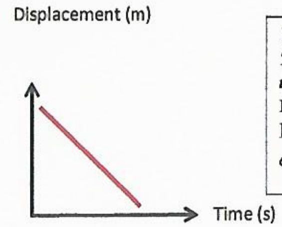
Relate to motion of the graphs as shown in Figure 6.1. Explain the graphs. (6m)

a)



Velocity = increasing. **[1m]**
The graph is curve, shows that the gradient is not constant. **[1m]**
The gradient increase over time, indicates that the velocity increases over time. **[1m]**

b)



Velocity = decreasing and uniform **[1m]**
The graph is non-horizontal straight line. Hence, the gradient is not equal to zero. **[1m]**
For straight line, the gradient is constant.
Hence, the velocity of moving object *decreases over time.* **[1m]**

Figure 6.1

Prepared By:
(TAN MAY LING)

Approved By:
ZULIANA BINTI ABDUL MUTALIB
Ketua Kursus Sains
Jabatan Matematik, Sains & Komputer
Politeknik Ungku Omar
Ipoh, Perak Darul Ridzuan

$$\text{Velocity} = \frac{\text{displacement}}{\text{time}}$$ **[1m]**

$$= \frac{320.16\ \text{m}}{15\ \text{s}}$$

$$= 21.30\ \text{m/s}$$ **[1m]**

Question 4 (Analyzing)

State the differences (distinguish) between distance and displacement. (3m)

Distance	Displacement
Scalar quantity. Total route taken from one place into another place. Has magnitude only **[1.5m]**	Vector quantity. Distance along with direction. Have magnitude and direction. **[1.5m]**

Questione 5 (Evaluating)

Interpret the two roads represent distance and displacement based on the Figure 5.1 as shown (4m)

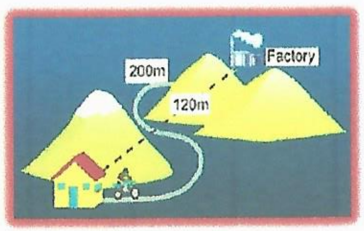


Figure 5.1

Distance = 200 m, total length travel by the object. It has magnitude only. **[2m]**

Displacement = 120 m, shorter distance because it stated the magnitude and direction. **[2m]**

Questione 6 (Creating)

Relate to motion of the graphs as shown in figure 6.1. Explain the graphs. (6 m)

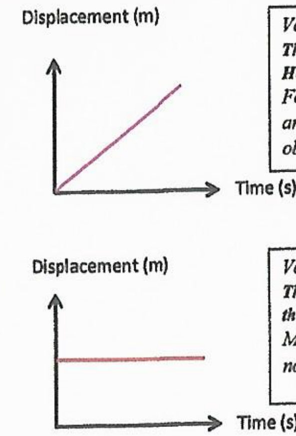


Figure 6.1

a) *Velocity = uniform and increase.* **[1m]**
The graph is a non-horizontal straight line. Hence, the gradient is NOT equal to 0. **[1m]**
For a straight line, the gradient is constant and positive. Hence the velocity of the moving object is uniform. **[1m]**

b) *Velocity = 0.* **[1m]**
The graph is a horizontal straight line. Hence, the gradient is 0. **[1m]**
Means that object is stationary (at rest, does not move). **[1m]**

Prepared By:

(TAN MAY LING)

Approved By:

ZULIANA BINTI ABDUL MUTALIB
Ketua Kursus Sains
Jabatan Matematik, Sains & Komputer
Politeknik Ungku Omar
Ipoh, Perak Darul Ridzuan

APPENDIX G

(a) Level of knowledge construction in Pre and Post Test based on Bloom's Revised Taxonomy of cognitive domain

(a) Marks Allocation

Cognitive Domain	Level of Knowledge Construction	Question	Part I				Part II				Total
			1a	2a	2b	3	4	5	6a	6b	8
Low	Declarative	Remembering									2
	Procedural	Understanding									5
		Applying									5
High	Argumentative	Analyzing									3
	Metacognitive	Evaluating									4
		Creating									6
Total Marks											25

(b) Examples of Question in Pre Test

Cognitive Domain	Level of Knowledge Construction	Question	Examples
Low	Declarative	Remembering	Define and state the SI units of the deceleration.
	Procedural	Understanding	Convert the unit from 30 m/s to km/hour. Give two (2) examples of linear motion.
		Applying	Solve the velocity of the car if it has moved 100 m South in 5 s. Then, 250 m West in 10 s.
High	Argumentative	Analyzing	State the differences (distinguish) between: speed and velocity
	Metacognitive	Evaluating	Explain the two roads represent distance and displacement based on the Figure 5.1 as shown.
		Creating	Relate to motion of the graphs as shown in Figure 6.1. Explain the graphs.

(c) Examples of Question in Post Test

Cognitive Domain	Level of Knowledge Construction	Question	Examples
Low	Declarative	Remembering	Define and state the SI units of acceleration.
	Procedural	Understanding	Convert the unit from 30 km/hour to m/s. Give two (2) examples of non-linear motion.
		Applying	Solve the velocity of the car if it has moved 200 m North in 5 s. Then, 250 m West in 10 s.
High	Argumentative	Analyzing	State the differences (distinguish) between: distance and displacement
	Metacognitive	Evaluating	Interpret the two roads represent distance and displacement based on the figure shown.
		Creating	Relate to motion of the graphs as shown in Figure 6.1. Explain the graphs.

APPENDIX H

PROCESS AND PROCEDURE TO CONDUCT STRUCTURE INTERVIEW

Step1: Sensitizing concept

- Look at communication process such as gender differences in the ways male and female engineering students posting questions and interactions.
- Establish good rapport with respondents. It would help researcher get close to the engineering students. They feel comfortable when researcher carries out interview sessions with them.
- Develop the tolerance for respondents in poor and unpleasant situation when carrying out the task activities during the implementation of instructional scaffolding.
- Engineering students participate in activities lasting at least 2 hours. They are prohibited from taking any notes.
- Design those activities that fit in instructional scaffolding to be implemented for engineering students' knowledge construction in online SCL environment.

Step 2: Interview the phenomena

- Interview the physical surroundings setting such as SCL environment.
- Interview closely the process of interaction that occurs in the knowledge construction between peer to peer. For instance: who talks to whom, how the peer makes decisions, who give suggestions or opinions. It may be impossible to find out whether engineering students' achieve higher level of knowledge construction.
- Look for the different or unusual events that occur. For instance, to structure asynchronous online discussion (AOD) groups via Facebook platform on engineering students' level of knowledge construction in online SCL environment.

Step 3: Write down interviews

- Record details in field notes for those activities that need instructional scaffolding for engineering students' knowledge construction and level of knowledge construction.
- Record information as detailed as possible regarding how instructional scaffolding is to be used in engineering students' knowledge construction.
- Describe what respondents are doing in details and what else needs to be interviewed.
- Tools for interview such as tape recorders, video cameras or field note. These tools can assist researcher to describe what she sees.

Step 4: Look for patterns across interview

- Draw an outline map to figure out details in interview.
- Researcher needs to review persistently what she is looking for and whether researcher is seeing it similar with the actual situation presented at field work.
- Researcher also needs to look at the paradigms of interaction and to understand what is actually going on for respondents.

Step 5: Use inductive method to draw generalizations

- Reflect and elaborate the process of interaction in the field note.
- Do not talk to anyone after interviewing to avoid the data collected from being unreliable and invalid.

APPENDIX I : VALIDATION ON PRE AND POST TEST

Validation By Expert

Hereby I certify and validate that the **Pre-Test and Post-Test** questions produced by Tan May Ling from the Department of Mathematics, Science and Computer, Politeknik Ungku Omar are suitable for Engineering Science course. Both test questions have been checked and the general comments are as follows:

General Comments:

PRE - TEST DAN POST - TEST INI ADALAH BERSESUAIAN DENGAN ENGINEERING SCIENCE COURSE

Signature :

Name : ZULIANA BINTI ABDUL MUTALIB

Experience in teaching: (……7…..) years.

Qualification:

BACHELOR IN SCIENCE (PHYSIC)

Name and address of Institution/University:

POLITEKNIK UNGKU OMAR
JALAN RAJA MUSA MAHADI
31400 IPOH, PERAK.

Institution stamp: ZULIANA BINTI ABDUL MUTALIB
Ketua Kursus Sains
Jabatan Matematik, Sains & Komputer
Politeknik Ungku Omar
Ipoh, Perak Darul Ridzuan

Date: 18/6/2015

APPENDIX J : VALIDATION UPON ONLINE COLLABORATIVE LEARNING ASSIGNMENT

Validation by Expert

Hereby I certify and validate that the **Learning Activities in Facebook Discussion** produced by Tan May Ling from the Department of Mathematics, Science and Computer, Politeknik Ungku Omar are suitable for Engineering Science course. Both learning activities (Learning or Learner Generated Content and Ill-structure Problem Solving Analysis and Questions) have been checked and the general comments are as follows:

General Comments:

Secara keseluruhan sistem pembelajaran yang dibangunkan berjaya meningkatkan minat untuk pelajar belajar dan menambah kemahiran berkomunikasi di media sosial.

Signature ______________________

Name : SAIFUL BAHARIN BIN HAIRUDDIN

Experience in teaching: (…9…..) years.

Qualification:

B Sc (Hons) Information Technology (UiTM)

Name and address of Institution/University:

Institution stamp:

Date: 19/10/2015

SAIFUL BAHARIN BIN HAIRUDDIN
Pegawai Pendidikan Pengajian Tinggi
Jabatan Teknologi Maklumat Dan Komunikasi
Politeknik Ungku Omar
31400 Ipoh, Perak.

APPENDIX K

The Steps of Conducting Content Analysis

(Source: Adapted from http:http://libweb.surrey.ac.uk/library/skills/Introduction)

Step	Guidelines for Conducting Content Analysis
1	Read through the transcript and look for the relevant information.
2	Find the gist and write into the probing words (keyword) column.
3	List out the different types of information found.
4	Read through the list and categorize them into items according to what it is about and sort out the relationships too.
5	Identify the major categories (or core theme) or minor categories (or sub-theme) after comparing them.
6	Repeat the same processes from step one to step five if there are more than one transcript.
7	Collect all the core categories once all the transcripts have been completed.
8	Review the core categories in order to make sure the information is in the correct categories.
9	Review all the categories again and see whether some of the core categories can be merged or need to be sub-categorized.
10	Review the original transcript to ensure all the information has been categorized.

APPENDIX L

Learning Activity for Task 2

No.	Guidelines On Learning Activity
1	Solve the problems (a) Analysis and (b) Questions based on guidelines to address problem solving skills,
2	Each team needs to download at least one (1) video from YouTube related to problem solving question (Graph: Displacement versus Time).
3	Each team member can post at least one (1) discussion.
4	A discussion raising further question about velocity, gradient and movement of the trolley (an object).
5	Total displacement of the trolley = 0.935 m (at site).
6	Submission of asynchronous online discussion (AOD) for each Team: Final writing through Facebook.
7	A several questions: a) How does a trolley move on the runway? b) How does velocity affect the acceleration of the trolley (Compare Graph 1 and Graph 2)? c) How about search from YouTube related to Graph: Displacement versus Time? d) Let's find out more from any other resources related to linear motion. e) How do you all discuss the differences of Displacement versus Time? f) How do you all combine all the learning contents and diagrams of Displacement versus Time? g) How do you all apply this new knowledge in the Civil engineering field?

APPENDIX M : EVALUATE AND COMMENTS FROM SECOND MARKER ON POST TEST

Evaluate and Comments From Second Maker

UNIT PENILAIAN DAN PEPERIKSAAN
POLITEKNIK UNGKU OMAR

(Pindaan 2013)
KALI KE: __________

BORANG PENYELARASAN PEMERIKSAAN SKRIP JAWAPAN CALON

KOD KURSUS	DBS1012
NAMA KURSUS	Engineering Science

JABATAN*	JKA/JKE/JKM/JKP/JP/JTMK/JMSK/JPA
PROGRAM	DKA
SEKSYEN	1B

Bil	ID Pelajar	No Siri Skrip Jawapan	MARKAH ASAL (markah dari pemeriksa skrip jawapan)	MARKAH PENYEMAKAN (markah dari pemeriksa kedua)	Perbezaan Markah	Markah Penyelarasan (jika perlu*)	Catitan
			JUMLAH (A)	JUMLAH (B)	JUMLAH (A-B)	JUMLAH	
1	S1		12	12	0		
2	S2		14	14	0		
3	S3		14	14	0		
4	S4		12	12	0		
5	S5		16	16	0		
6	S6		17	17	0		
7	S7		18	18	0		
8	S8		16	16	0		
9	S9		10	10	0		
10	S10		19	19	0		
11	S11		15	15	0		
12	S12		15	15	0		
13	S13		16.5	16.5	0		
14	S14		14.5	14.5	0		
15	S15		16	16	0		
16	S16		14	14	0		
17	S17		23.75	23.75	0		
18	S18		14	14	0		

UNIT PENILAIAN DAN PEPERIKSAAN
POLITEKNIK UNGKU OMAR

(Pindaan 2013)
KALI KE: __________

BORANG PENYELARASAN PEMERIKSAAN SKRIP JAWAPAN CALON

KOD KURSUS	DBS1012
NAMA KURSUS	Engineering Science

JABATAN*	JKA/JKE/JKM/JKP/JP/JTMK/JMSK/JPA
PROGRAM	DKA
SEKSYEN	1B

Bil	ID Pelajar	No Siri Skrip Jawapan	MARKAH ASAL (markah dari pemeriksa skrip jawapan)	MARKAH PENYEMAKAN (markah dari pemeriksa kedua)	Perbezaan Markah	Markah Penyelarasan (jika perlu*)	Catitan
			JUMLAH (A)	JUMLAH (B)	JUMLAH (A-B)	JUMLAH	
19	S19		17.5	17.5	0		
20	S20		12	12	0		
21	S21		14	14	0		
22	S22		8.5	8.5	0		
23	S23		14	14	0		
24	S24		9.5	9.5	0		
25	S25		7	7	0		
26	S26		20	20	0		
27	S27		13	13	0		
28	S28		8	8	0		
29	S29		13	13	0		
30	S30		11	11	0		
31	S31		15.5	15.5	0		
32	S32		9	9	0		
33	S33		10	10	0		
34	S34		18	18	0		
35	S35		20	20	0		
36	S36		8.5	8.5	0		

ULASAN:
Tiada perbezaan markah bagi semua skrip jawapan calon.

(Diisi oleh Pemeriksaan Kedua)

	NAMA	TANDATANGAN	TARIKH
Pemeriksa Kedua	Zulhikmi Bin Zali @ Mat Tahir		4 Nov. 2015

POLITEKNIK UNGKU OMAR
Jabatan Matematik, Sains dan Komputer
IPOH

APPENDIX N : NUMBER OF ENGINEERING STUDENTS' PASSES IN EACH LEVEL OF KNOWLEDGE CONSTRUCTION (CONTROL GROUP)

Respondent	Declarative		Procedural		Argumentative		Metacognitive	
(Student, S)	Pre Test Score	Post Test Score	Pre Test Score	Post Test Score	Pre Test Score	Post Test Score	Pre Test Score	Post Test Score
S1	0	0	0	3	0	1.5 (pass)	0	2
S2	0	0	0	4	0	3 (pass)	0	2
S3	0	1 (pass)	0	5 (pass)	0	3 (pass)	3	4
S4	1 (pass)	2 (pass)	0	5 (pass)	0	1.5 (pass)	0	2
S5	0	1 (pass)	0	2.5	0	0	0	2
S6	0	1 (pass)	0	2	0	3 (pass)	2.5	3
S7	1 (pass)	2 (pass)	0	5 (pass)	0	3 (pass)	0	2
S8	0	1 (pass)	0	5 (pass)	1	1	3.5	2
S9	2 (pass)	2 (pass)	2	7 (pass)	1	3 (pass)	3.5	3
S10	0	2 (pass)	0	5 (pass)	0	2.5 (pass)	0	2
S11	0	1 (pass)	0	5 (pass)	0	3 (pass)	0	3
S12	0	0	0	5 (pass)	0	3 (pass)	0	2
S13	2 (pass)	2 (pass)	0	5 (pass)	0	0.5	4	2
S14	0	1 (pass)	0	2	0	3 (pass)	0	4
S15	0	1 (pass)	0	3	0	1	0	3
S16	0	2 (pass)	0	5 (pass)	0	2 (pass)	3.5	2
S17	0	1 (pass)	0	4	0	3 (pass)	2	6 (pass)
S18	2 (pass)	2 (pass)	2	2	0	3 (pass)	2	2
S19	0	1 (pass)	0	5 (pass)	0	2.5 (pass)	0	3
S20	0	2 (pass)	0	5 (pass)	0	3 (pass)	2	2
S21	1 (pass)	2 (pass)	0	5 (pass)	0	3 (pass)	3.5	2
S22	1 (pass)	2 (pass)	0	5 (pass)	0	3 (pass)	1.5	5
S23	0	2 (pass)	0	5 (pass)	0	3 (pass)	2	4
S24	0	2 (pass)	0	5 (pass)	0	3 (pass)	1.5	5 (pass)
S25	1 (pass)	2 (pass)	0	5 (pass)	2 (pass)	3 (pass)	0	6 (pass)
S26	2 (pass)	2 (pass)	3	5 (pass)	1.5 (pass)	2.5 (pass)	3	2
S27	0	1 (pass)	0	1	0	0	0	2
S28	1 (pass)	2 (pass)	0	5 (pass)	0	3 (pass)	0	3
S29	2 (pass)	1 (pass)	0	5 (pass)	1	1	1	2
S30	1 (pass)	2 (pass)	0	5 (pass)	0	3 (pass)	1	6 (pass)
S31	1 (pass)	2 (pass)	0	5 (pass)	0	2 (pass)	2.5	2
S32	0	2 (pass)	0	5 (pass)	0	3 (pass)	1.5	2
S33	2 (pass)	1 (pass)	0	3	1.5 (pass)	3 (pass)	3.5	5 (pass)
S34	1 (pass)	1 (pass)	0	5 (pass)	1.5 (pass)	3 (pass)	3.5	2
S35	0	0	1	5 (pass)	0	3 (pass)	0	3
S36	1 (pass)	2 (pass)	0	7 (pass)	1	3 (pass)	3.5	4
S37	0	2 (pass)	0	2	0	2 (pass)	0	4
S38	1 (pass)	2 (pass)	0	5 (pass)	0	1.5 (pass)	2.5	3

APPENDIX O : THE OPEN-ENDED QUESTIONS TRANSCRIPT

PROTOCOL STRUCTURE INTERVIEW

RQ 2: How does instructional scaffolding in a social collaborative learning (SCL) environment cognitively steer engineering students towards knowledge construction?

Date : _________ Start : _________a.m./p.m. End : ______a.m./p.m. Duration: _______________

Name : ____________________________ ID NO : _____________________

Email address : ______________________ Contact number: _______________ Institution : PUO

Respondent : M1/M2/M3/M4/M5/H1/H2/H3/H4/H5

Elements of Instructional Scaffolding	Interview Statement	Engineering Student's Answer	Remarks (Probing words /Keywords)
1) Pre-engagement	What are the benefits when you are provided guidelines A (learning/learner generated content) and guideline G (problem-solving skills) for all the learning tasks and collaborative learning activities via Facebook discussion?		
	How does it affect your knowledge construction?		
2) Share Goal	What is the most challenging part when you are committed to learning in collaboration via Facebook discussion (SCL environment)?		
	How does it motivate you towards knowledge construction?		
3) Understanding of students' prior knowledge	How does YouTube engage and enhance your prior knowledge through asynchronous online discussion (AOD) on Facebook discussion?		
4) Provide a variety of support (questions, explanation etc.)	How do you feel about the instructional scaffolding when I provide "assist" statement in your AOD through Facebook discussion?		
	How does the statement help you in knowledge construction?		
5) Provide encouragement and praise	How do complimentary statements such as good job, well done, excellence etc. via Facebook discussion enhance your knowledge construction?		
6) Give feedback	Does instructor's feedback lead you to the knowledge construction?		
	How does instructor's feedback help you in understanding your progress in knowledge construction?		
7) Provide supportive and positive responses	How those kind of responses (such as be patient, take your time) help you in knowledge construction via Facebook discussion?		
8) Provide instructional support	Does the instructor provide appropriate clue/hints that may help you perform better in knowledge construction?		
	How does the instructional statement from instructor help you to solve the problem-solving questions?		

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

Date : ___________tart : __________a.m./p.m. End : _______a.m./p.m. Duration: _______________

Name : ____________________________ ID NO : ________________________

Email address : _______________________ Contact number: ________________ Institution : PUO

Respondent: M1/M2/M3/M4/M5/H1/H2/H3/H4/H5

Criteria	Interview Statement	Engineering Student's Answer	Remarks (Probing words /Keywords)
Condition	What is your feeling with all the learning task and social-collaborative learning activities such as working in group, sharing and comparing about linear motion and non-linear motion, discovering and exploring about uniform motion and non-uniform motion, negotiation of meaning / argumentative about distance and displacement?		Acquire new knowledge, collaboration context
	How do all these help you to reach a higher level of knowledge construction?		
	To solve task or problem given, you have to work and collaborate with your group members. Each member plays his/her own role as starter, moderator, theorists, resource searcher or summarizer. Can this setting especially when you have to work in online learning via Facebook discussion (SCL environment) help you in knowledge construction?		Group composition, group task, communication medium
	How do all these (assign role/group/task), help you to reach a higher level of knowledge construction?		
Interaction (negotiation and argumentation)	Sometimes, you have been faced disagreement with your peers in solving learning tasks given. Does it help you in constructing new knowledge?		Control
	How this conflict/disagreement helps you to reach higher level of knowledge construction?		socio-cognitive conflict
Interaction (negotiation and argumentation)	In Activity negotiation of meaning such as between distance and displacement, instantaneous velocity and average velocity, speed and velocity or five (5) types of displacement versus time graph, you need to do lots of detailed explanation and discussion with peers and also instructor. How does this kind of discussion in collaborative learning activities via Facebook affect your learning?		negotiation of meaning and argumentation
	Can you give example and elaborate more especially on how it helps you to reach higher level of knowledge construction.		elaborate explanation
immediacy	In solving learning task related with application for 5 equations of linear motion, you have a chance to do synchronous discussion (*real time discussion*) as well as asynchronous discussion (*distance between communication or delayed discussion*) with your peers in Facebook discussion. Which one do you prefer the most in helping you to construct knowledge? Why?		Distance between 2 communication
	How do these help you to reach higher level of knowledge construction?		Rapid exchange info.
intimacy	How does informal and pleasing type of discussion in Facebook help you to achieve a higher level of knowledge construction?		close feeling/using emoticons

Any general comments on how interaction with instructor and friends (Scaffolding) and the use of online social-collaborative learning via Facebook (SCL) environment help you in constructing higher level of new knowledge.

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Verified By:

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APPENDIX P : AN EXAMPLE OF INTERVIEW TRANSCRIPTS VERIFIED BY HM3 (MEMBER CHECKING)

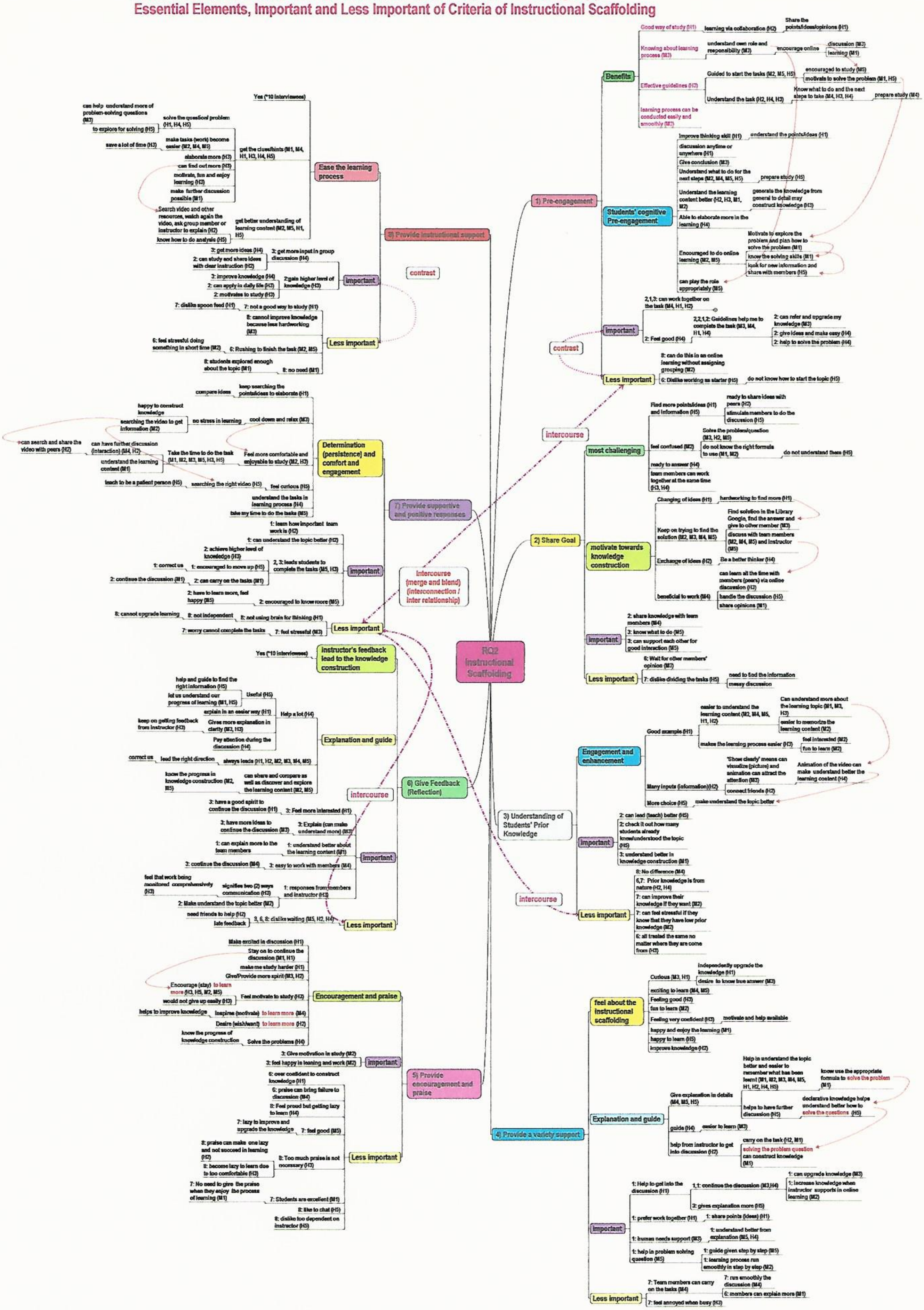
Any general comments on how interaction with instructor and friends (Scaffolding) and the use of online social-collaborative learning via Facebook (SCL) environment help you in constructing higher level of new knowledge.

Throughout the whole SCL environment via Facebook, I have learnt a lot about linear motion. I need to learn more. How?
Without collaborative learning, I just get the information from lecturer and I learn .That is it. Collaborative learning is two (2) ways communication. Lecturer will ask you and you will answer. Meanwhile, you also can ask lecturer. That is how you can get higher level of new knowledge. I can use new knowledge to solve problems. When we construct something with correct measurements, we need to take precautionary steps which lecturer often mentions in the class. Online learning increases collaboration in two (2) ways. I can gain new knowledge every time. I can straight away apply the new knowledge in everyday life. When there are uncertainties, I can ask my teammates. They will respond to me immediately.
With the use of emoticons, I enjoy the task that I am doing. It connects me with my friends through learning collaboratively. And also, Miss Tan will whole-heartedly teach and guide us even though it is late at night.

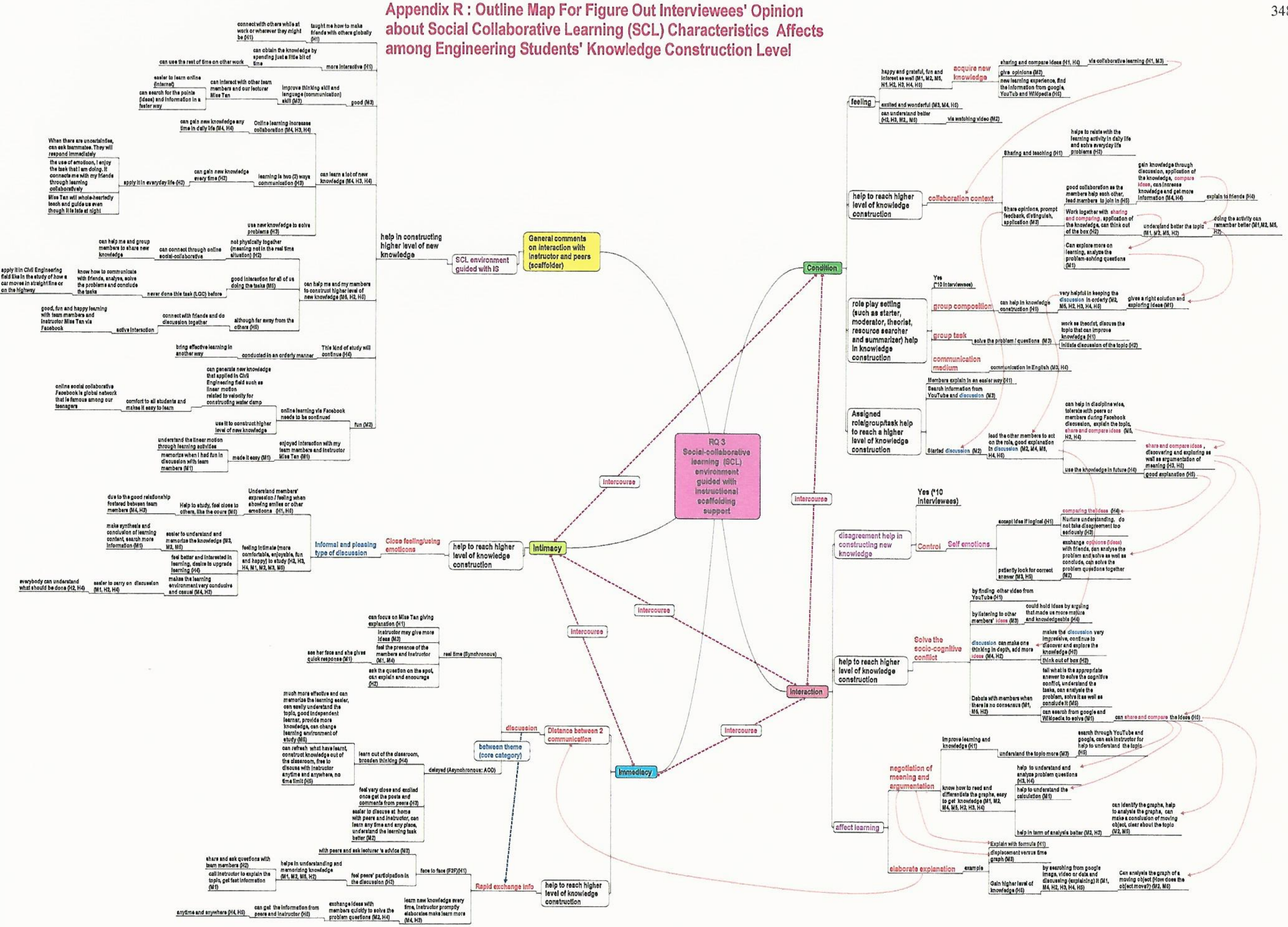
Verified By:

(Lee Yew Ken)

Appendix Q : Outline Map For Figure Out Interviewees' Opinion About Eight (8) Essential Elements, Important and Less Important of Criteria of Instructional Scaffolding



Appendix R : Outline Map For Figure Out Interviewees' Opinion about Social Collaborative Learning (SCL) Characteristics Affects among Engineering Students' Knowledge Construction Level



APPENDIX S : LAB WORK RUBRIC

MALAYSIAN POLYTECHNIC
MATHEMATICS, SCIENCE AND COMPUTER DEPARTMENT
LAB WORK RUBRIC
DBS1012 – ENGINEERING SCIENCE

A. COGNITIVE DOMAIN

No	Criteria	Excellent (4 marks)	Good (3 marks)	Satisfactory (2 marks)	Needs Improvement (1 mark)	Unsatisfactory (0 mark)
1	Procedures	Procedures are clearly described in complete and passive sentences.	Procedures are clearly described in complete and active sentences.	Procedures are stated but difficult to follow.	Procedures are partially stated and difficult to follow.	Procedures are not stated.
2	Drawings /Diagrams	Clear, accurate diagrams are included. Diagrams are labeled neatly and accurately.	Diagrams are included and are labeled.	Diagrams are included and partially labeled.	Diagrams are included but are not labeled.	Needed diagrams are missing.
3	Data	Accurate presentation of the data in tables or graphs. Graphs and/or tables are labeled and titled.	Accurate presentation of the data in tables or graphs. Graphs and/or tables are not labeled and titled.	Accurate presentation of the data in written form, but no graphs or tables is presented.	Data are shown but inaccurate.	Data are not shown.
4	Calculations	All calculations are shown and the results are correct with appropriate units.	All calculations are shown and the results are correct but without appropriate units.	All calculations are shown but not all the results are correct.	All calculations are shown but all the results are incorrect.	No calculations are shown.
5	Analysis	Explain the findings in the experiment. Able to explain experimental errors, their possible effects, and ways to reduce errors.	Explain the findings in the experiment. Able to explain experimental errors and their possible effects.	Explain very briefly about the findings in experiment. Experimental errors are mentioned.	Explain very briefly about the findings in experiment Or only experimental errors are mentioned.	No analyses are shown.
6	Questions	The given questions are answered correctly, clearly identified and stated according to the theory.	The given questions are answered correctly, clearly identified, but not stated according to the theory.	Not all the questions are answered.	All questions are answered incorrectly.	All the questions are not answered.
7	Conclusion	Conclusion included the finding from the experiment and supported the hypothesis / theory.	Conclusion included the finding from the experiment but supported with incorrect hypothesis / theory.	Conclusion included the finding from the experiment but not supported the hypothesis / theory.	Conclusion included but not related to the experiment.	No conclusion was included in the report.
8	Submission date			On the specified date.	1 to 3 days late after the due date.	More than 3 days late after the due date.

B. PSYCOMOTOR DOMAIN

No	Criteria	Excellent (4 marks)	Good (3 marks)	Satisfactory (2 marks)	Needs Improvement (1 mark)	Unsatisfactory (0 mark)
1	Ability to follow procedures	Understand and able to follow directions as stated in the lab sheet.	Understand and followed procedures but not in sequence.	Understand but moderately followed procedures.	Moderately understand and moderately followed the procedures.	Did not understand and did not follow directions.
2	Demonstrated knowledge of tools	Group members know and able to identify and to explain necessary tools to complete of the experiment.	Group members are able to identify and explain necessary tools to complete the experiment with some assistance.	Group members are able to identify but unable explain necessary tools to complete the experiment with some assistance.	Group members are unable to identify or use tools without major assistance.	Group members are not able to both identify and use tools.
3	Level of needed assistance	Group was able to complete the experiment without assistance and able to help other group.	Group was able to complete the experiment without assistance.	Group was able to complete the task with little assistance.	Group was able to complete the task with assistance.	Student was unable to complete task even with assistance.
4	Ability to work in group	Able to distribute the task between group members, cooperate well and able to achieve correct result.	Able to distribute the task between group members, partially cooperate but able to achieve correct result.	Able to distribute the task between group members, unable to cooperate but able to achieve correct result.	Able to distribute the task between group members, unable to cooperate and unable achieve correct result.	Unable to distribute task between group members, unable to cooperate and unable to get the correct result.
5	Time Management	Able to finish the experiment correctly in time given.	Able to finish the experiment partially correct in time given.	Able to finish the experiment correctly but out of time given.	Able to finish the experiment partially correct and out of time given.	Unable to finish experiment correctly in the time given.

APPENDIX T : LIST OF PUBLICATION SCOPUS JOURNAL / JOURNAL PROCEEDING AND SUBMISSION ON GOING SCOPUS JOURNAL

1.0	**RESEARCH AND PUBLICATION**
1.1	**Research Publications**
(a)	**Journal/E-Journal/Journal Proceeding/International Journal/National Journal** 1. Tan May Ling and Jamalludin Harun. (2014) The Effects of Scaffolding Strategy in Online Social Collaborative Learning Environment on Engineering Students' Knowledge Construction Level: A Literature Review. *Journal of Technical and Vocational Education Malaysia,* Version 2 (Oct.), 48-54. Penerbit PTVM. ISSN 1985-6052. 2. Tan, May Ling and Harun, J. (2014). Instructional Scaffolding in Online Collaborative Learning Environment for Knowledge Construction among Engineering Students. *ICEED 2014 - 2014 IEEE 6th Conference on Engineering Education.* 9-10 December 2014. Berjaya Times Square Hotel Kuala Lumpur, 40-45. Institute of Electrical and Electronics Engineers Inc. ISBN: 7194685. 3. May-Ling, Tan and Jamalludin Harun. (2016).The Impact of Instructional Scaffolding in Social Collaborative Learning Environment on Engineering Students' Knowledge Construction. *Proceedings of the 2016 RCEE International 6th Regional Conference on Engineering Education.* 9-10 August 2016. UTM Kuala Lumpur, 170-177. ISBN: 978-967-0194-65-3 4. May-Ling, Tan and Jamalludin Harun. (2016). Utilizing Concept Maps for Studying the Effect of Instructional Scaffolding Characteristics on Engineering Students' Achievement in Tests. *Journal of International of Advances in Soft Computing & its Applications.* (1st. Event of Virtual Presentation UTM).
(b)	**Submission on going SCOPUS journal** 5. May-Ling, Tan and Jamalludin Harun. (2016). Utilizing Concept Maps on Characteristic of Social Presence in Social Collaborative Learning Environment for Nurturing Engineering Students' Knowledge Construction Level. *Journal of Pertanika* 6. May Ling, Tan and Jamalludin Harun. (2017). Enhancing Engineering Students' Academic Achievement through Instructional Scaffolding in Online Social Collaborative Learning Environment. *Journal of Technical Education and Training,* Penerbit UTHM Press. 7. May-Ling, Tan and Jamalludin Harun. (2017). The Holism of Knowledge Construction Model in Online Social Collaborative Learning Environment for Enhancing Engineering Students' Knowledge Construction. *American Society for Engineering Education*