Methods to Study Elements of the Instructional Scaffolding Strategy Model for Enhancing Engineering Students' Knowledge Construction in an Online Social Collaborative Learning Environment

Miss May-Ling Tan, Universiti Teknologi Malaysia

Miss Tan May Ling as an Engineering Education postgraduate student in Universiti Teknologi Malaysia (UTM). Her major study in Online Learning such as social collaborative learning (SCL) integrates with web-based instructional scaffolding which is conducted to the engineering students who study in one of pioneer polytechnic namely Ungku Omar Polytechnic. They are technical engineers in the future. She has a Bachelor of Honors in Civil Engineering in 2000 and Master of Education (Technical) in 2002 from Universiti Teknologi Malaysia. Formerly, she as a Civil Engineer for 10 years working experience in private sector. She has been involved building consultancy, construction and other related to civil works like construction and manages the sewerage treatment plants. She was also a member of Board of Engineering Malaysia (BEM) since 2003. Additionally, she has teaching experience in Ungku Omar Polytechnic for 16 years. Her major subjects are Engineering Science and Computer Application. Meantime, she as a trainer and speaker for Construction Industrial Development Board (CIDB) in Malaysia.

Dr. Jamalludin Harun, Universiti Teknologi Malaysia

Jamalludin Harun is a Associate Professor of Educational Technology at the Department of Educational Science, Mathematics and Creative Multimedia, Faculty of Education, Universiti Teknologi Malaysia (UTM). He is also a research group member of Creative and Innovative Technology in Education (CITE) under Smart Digital Community research alliance. Prior to that, he was the Information Technology Manager (2004 - 2011) at Centre for Teaching and Learning, UTM. He obtained his first degree, BSc. Computer with Education (Chemistry)(Hons.) from UTM (1995), MEd. (Educational Media and Computers) from Arizona State University, USA (1998), and PhD (Educational Technology) from Universiti Teknologi Malaysia (2003). His research interests and expertise include Instructional Design and Development of Computer Based Instructions, Active Learning Environment through Technology, Social Networking Tools in Education and Argumentative Knowledge Construction through Online Learning.

Methods to study Elements of the Instructional Scaffolding Strategy Model for Enhancing Engineering Students' Knowledge Construction in an Online Social Collaborative Learning Environment

Abstract

Engineering students face low levels of knowledge construction when developing competence and expertise in the engineering field [1]. In addition, the industry is left dissatisfied by engineering students' deficiency in potential skills and low levels of academic achievement [2]. In order to assist engineering students to perform well in achievement tests, it is necessary to design instructional scaffolding during the learning process. Scaffolding students' learning via an online learning medium is quite a challenging task. There is thus considerable need for strategies to enable instructors to assist students' learning through such a medium. The instructional scaffolding strategy model can provide a foundation in identifying a mechanism that will lead to the description of successful metacognitive scaffolding approaches that can be used by instructors to help students in learning via an online medium.

This research paper describes and explains methods used in determining the instructional scaffolding strategy elements of a model to enhance engineering students' knowledge construction in an online social collaborative learning environment. The design of the instructional scaffolding strategy model is examined using qualitative methodologies. The process of enhancing students' knowledge construction is examined qualitatively using interviews, content analysis and thematic analysis. The categorization and analysis are achieved using concept mapping.

Ten participants took part in structured interview sessions to investigate instructional scaffolding elements. These comprised five interviewees who had significantly improved their scores on an achievement test, and another five who had actively participated in a metacognitive learning activity via the Facebook discussions in the online social collaborative learning environment and had also performed well in their tests. The following are the key findings from the study: (a) Instructional Scaffolding has eight elements in total, 1 - pre-engagement; 2 - shared goal; 3 - understanding of students' prior knowledge; 4 - provide a variety of support; 5 - provide encouragement and praise; 6 - give feedback; 7 - provide supportive and positive responses; and 8 - provide instructional support. (b) Elements to provide a variety of support and give feedback can interconnect, as in the 'explanation and guide' theme from the axial coding. These themes are mapped out to design an instructional scaffolding strategy model.

More effective pedagogical practices to improve engineering students' knowledge construction in online learning have been the subject of much argument from researchers and deserve further investigation. It is important to understand the design process of an instructional scaffolding strategy. Designing instructional scaffolding strategies as a platform for metacognitive scaffolding approaches can help instructors to improve engineering graduates' knowledge construction in terms of higher order thinking.

Keywords: Instructional scaffolding, knowledge construction, online learning

1.0 INTRODUCTION

There have been numerous technological changes to daily life, including traditional teaching and learning (T&L) in the classroom. Today, T&L is very different. The use of whiteboards and marker pens has been replaced by social networking and visual learning as well as online learning in a global context that can respond rapidly to the needs of the new generation of students (Gen-Z), particular engineering students, who are keen to learn through technological means. Hence, how do we construct the knowledge for them in ways that can be used by instructors to assist students in their process of learning via online media?

In this paper, the instructor focuses on the method for studying instructional scaffolding elements to support and enhance engineering students' knowledge construction in online social collaborative learning. The instructor set up a learning environment via the Facebook platform to enable students to discuss their Engineering Science topic at anytime, anywhere within the period of the lesson plan. Subsequently, the distribution of roles, learning tasks and metacognitive learning activities to promote and enhance the students' flexibility and construct knowledge through reflection and metacognition occurred through online learning. Salmon [3] revealed that the instructor has to develop relevant activities that can promote interaction and reflective thinking in the classroom in order to enhance the growth of students' subject knowledge via online learning.

2.0 BACKGROUND TO THE STUDY

This paper describes the methods used in determining elements of instructional scaffolding strategy, which will be used to enhance engineering students' knowledge construction in online learning. Streveler *et al.* [1] report that engineering students lack high levels of knowledge construction with regard to competence and expertise in the engineering field. Also, as pointed out by Felder [2], the industry is faced with inadequate potential skills and poor academic performance among engineering students.

Davenport and Prusak [4] emphasized that "…*knowledge is broad, deep and rich. 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 complex concept 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 relating to learning and salience. This means that knowledge is intangible and evolves. It also comprises 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 [4] also claimed that the transfer of knowledge comprises transmission and absorption. It is a process of knowledge construction. When the absorption of knowledge begins, so too does the knowledge construction process. However, the learner of knowledge does not necessarily know how to use this new knowledge to solve real-world problems, particularly in the engineering field.

In knowledge construction, critical thinking and logical thinking are important goals for students' learning processes. Students need to learn to explain their opinions, and also to elaborate the ways in which they carry out tasks and to solve problems in the tasks given [5], [6]. However, learning is subjective and different for each person. How can knowledge construction be adapted for online social learning environments to cater for individual students? Instructional scaffolding plays a crucial role in the online learning environment.

The Features of Instructional Scaffolding in Online Social Collaborative Learning Environments

Nowadays, transformative open learning environments are available that can be employed to enhance engineering students' knowledge construction in learning activities. Thus, instructional scaffolding should be integrated, particularly in online social collaborative learning (SCL) environments. This can stimulate students to more consistently reflect on their ideas and thoughts, and to construct a coherent and robust conceptual understanding of the knowledge construction process. This enables engineering students to experience metacognitive learning. It can also support students to tackle higher levels of thinking. Hence, the metacognitive scaffolding approach is implemented by the instructor.

Generation Z students make wide use of social media, which has become part of their daily lives. In online learning, students freely access the internet during their knowledge construction process. It is easy for them to gain, share and exchange knowledge through a social learning environment. This can lead to lack of time to focus on knowledge construction. Moreover, they also lack enhancement in learning activities. Hence, instructional scaffolding can be employed to scaffold and facilitate students' knowledge construction in such online SCL environments.

Specifically, Salmon [3] mentioned that scaffolding for online learning consists of five stages: (1) access and motivation, (2) online socialization, (3) information exchange, (4) knowledge construction and (5) development. The scaffolding pathways incorporate immediacy, intimacy and responsiveness. Instructional scaffolding in an online SCL environment is associated with collaborative learning and social learning. These approaches promote interaction between instructors and engineering students and among friends give encouragement to move forwards and work with others in teaching and learning sessions, particularly in engineering classrooms.

The information communication and technology (ICT) of this century has brought about a close human-technology relationship that makes learning environments for engineering students more effective. Thus, much more needs to be known about the features of online SCL before conducting instructional scaffolding on students' knowledge construction. It would be more challenging and more exciting to promote and enhance students' construction of knowledge.

The online learning environment, which consists of modern technology pedagogy in scaffolding approaches, includes four major elements: the course content, the coach (facilitator or instructor), the students and the technology [7], [8]. Through online social collaborative learning, students may find inspiration, motivation and improvement in their learning pathways. Moreover, it may bring about progress in engineering students' knowledge construction if the instructor uses the scaffolds in the online social collaborative learning environment.

Scaffolding in the online SCL environment is a form of web-based learning that supports students' learning activities. In other words, it comprises collaboration with social media technologies (Web 2.0) that provide instructional scaffolding through internet-based applications [9]. There are several social network sites or social media technologies, such as Skype, Facebook, Instagram, You Tube, Twitter, Whatsapp, We Chat and Line. Such learning environments provide students with information, engage and enhance their learning activities and guide them in the learning process through scaffolding [10], [11]. This is informal online learning. Moreover, this approach increases interaction between instructors and engineering students as well as peer-to-peer interaction.

Zuniga and Shahin [12] pointed out that digital technologies may transform and be integrated into our human society, and may have a positive impact on online social networks. They can be used more frequently to construct meaningful interaction in social life. For this reason, engineering students should engage in online SCL. This will enable students to stay in touch with their peers to construct their knowledge. They can gather, share and update learning resources via an online SCL environment, which will have a positive influence on all participants, as this approach can provide more ideas and opinions.

The use of scaffolding in online SCL environments may help students to accomplish tasks beyond their abilities. Instructional scaffolding is a temporary support that can be gradually faded as students cease to need it but reintroduced when necessary. There are different instruction scaffolding approaches and strategies based on the needs of particular students. In order to derive the benefits of knowledge construction, scaffolding can be provided in a collaborative manner and in a computer-supported learning environment.

Furthermore, technology-based scaffold by supporting students' interaction can enhance the learning environment [8]. This is akin to Teo and Chai's [13] ideas. Thus, instructional scaffolding is provided to facilitate and optimize engineering students' learning, since they need to continue to learn independently and without support in the engineering classroom.

The present study has selected the Facebook platform to integrate social learning with collaborative learning to actively engage and enhance engineering students' knowledge construction. This is the main benefit of manipulating Facebook to design and develop an SCL environment for instructors.

The Five Stages of Implementation Online Scaffolding for Experimental Group based on Salmon [3]

The first stage focused on 'access and motivation'. The instructor invited engineering students to take part in an online learning environment beyond physical engineering classroom learning. In the initial stage, students will be encouraged to learn through online social collaborative learning towards learner-centered practices (student-centered learning).

The second stage focused on 'online socialization', which involved e-discussions. Social interaction can encourage engineering students to feel free to work or learn together by utilizing the internet and technology facility through online learning environment. The instructor leads the students' e-discussions by given guidelines on Facebook platform. Also, the discussion focuses on the interactions that specifically enhancing students' knowledge construction. Thus, students have to become online learners, which will lead them to post their first messages. They can give 'feedback' on current and future needs for learning materials by posting and receiving messages in their learning process.

The instructor integrated the web-based instructional scaffolding throughout the e-discussions during this stage. Meanwhile, engineering students can construct knowledge through online SCL. 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.

The third stage looked at 'information exchange'. In the process stage, 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. There are six (6) topics covered include: (1) Physical Quantities and Measurement, (2) Linear Motion, (3) Force, (4) Work, Energy, and Power, (5) Solid and Fluid and (6) Heat and Temperature in Engineering Science subject. The Linear Motion topic is taught through e-discussions in the online SCL environment. The several examples present in Figures 1 to 5. They face problems of information exchange and achieve collaborative learning tasks. Based on Salmon (2004), mutual engagement occurs in this stage when participants focus on exchanging information. Meanwhile, the instructor needs to use learning material to support participants in the learning process.

Several examples of e-discussions on Facebook platform for Experimental Group

Figure 1 The instructor has assigned a task

Figure 2 Linear Motion topic would be discussed on the e-discussions

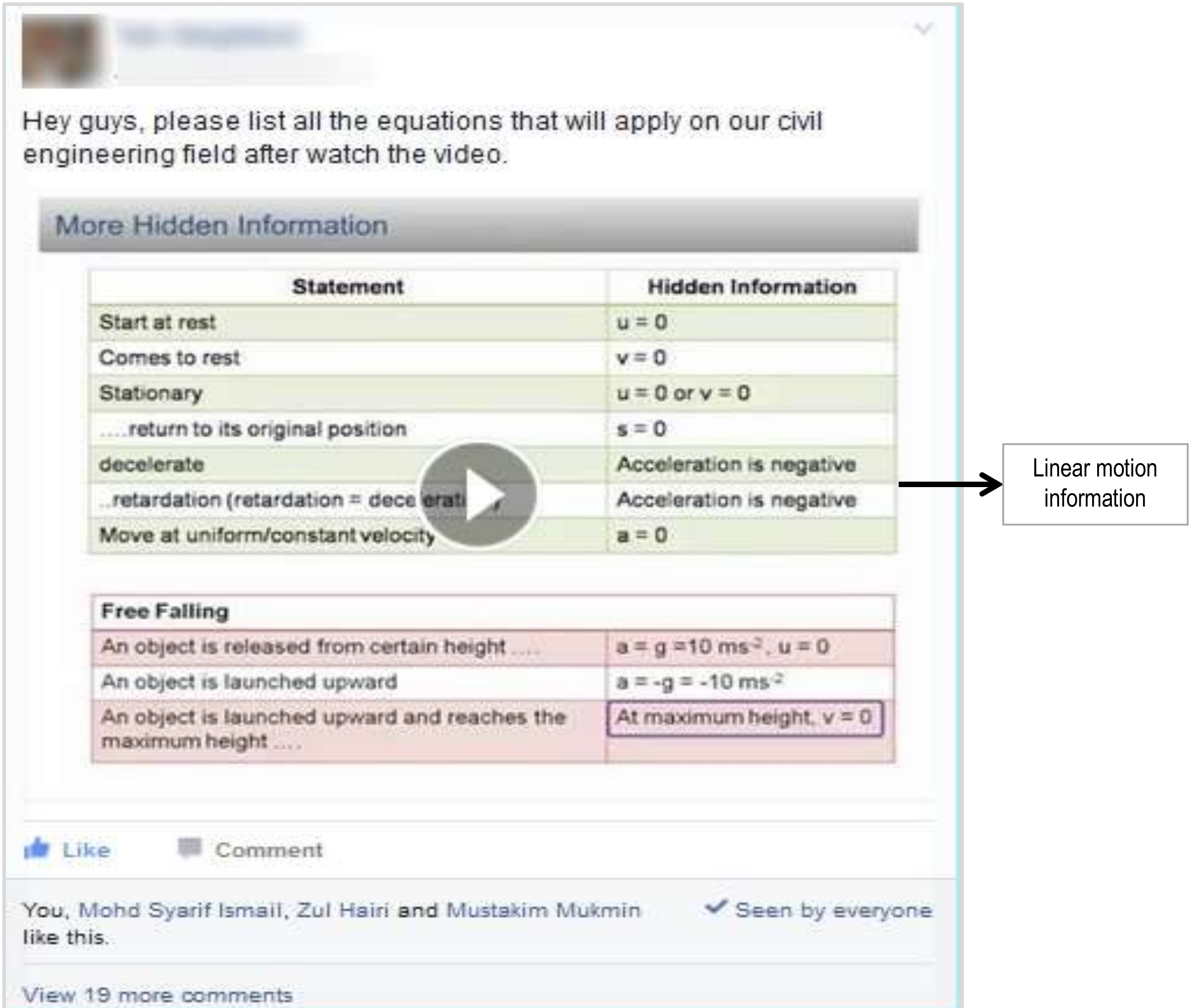


Figure 3 A student searched the information about Linear Motion topic

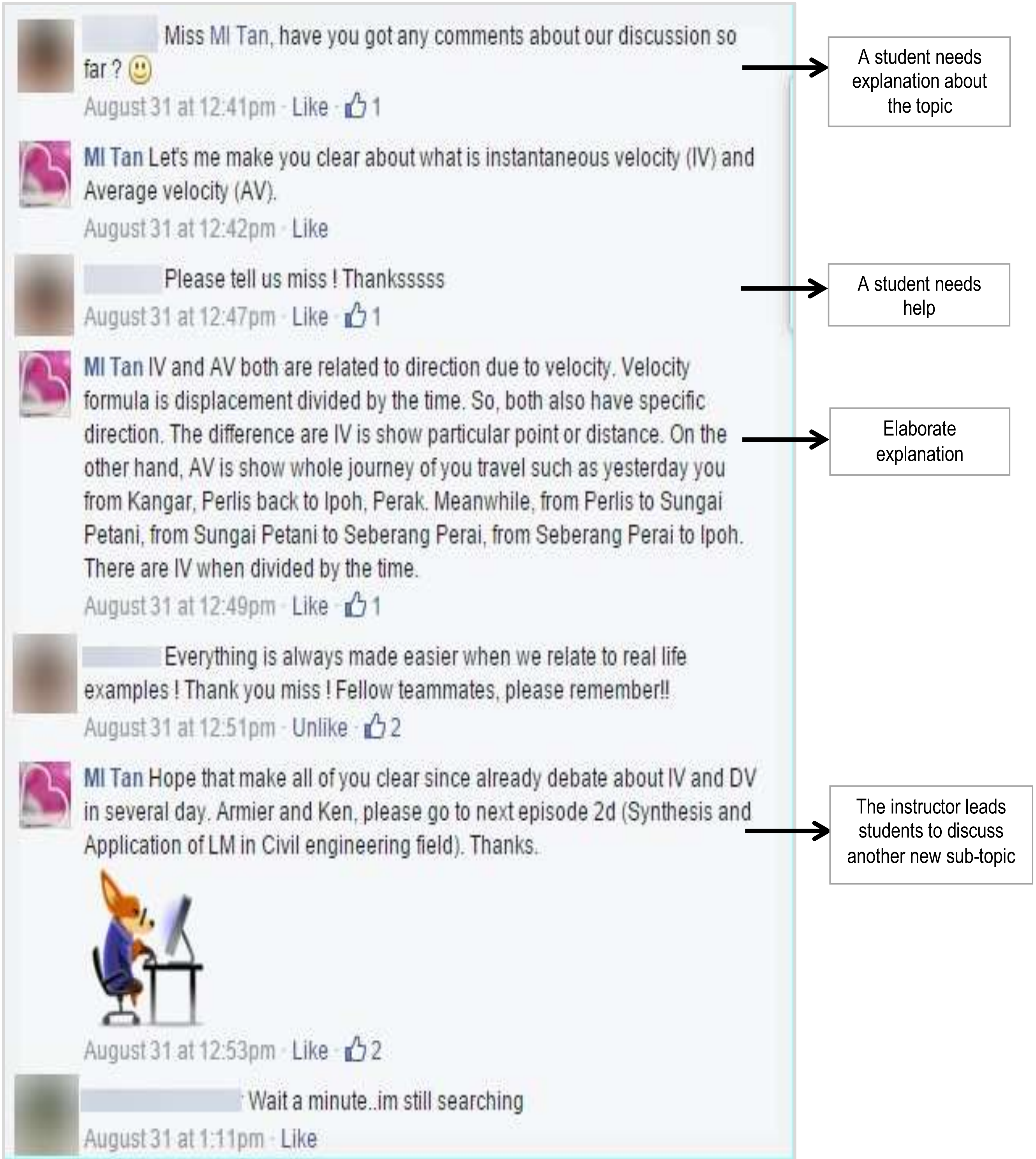


Figure 4 The elaborate explanation posted on the Facebook discussions

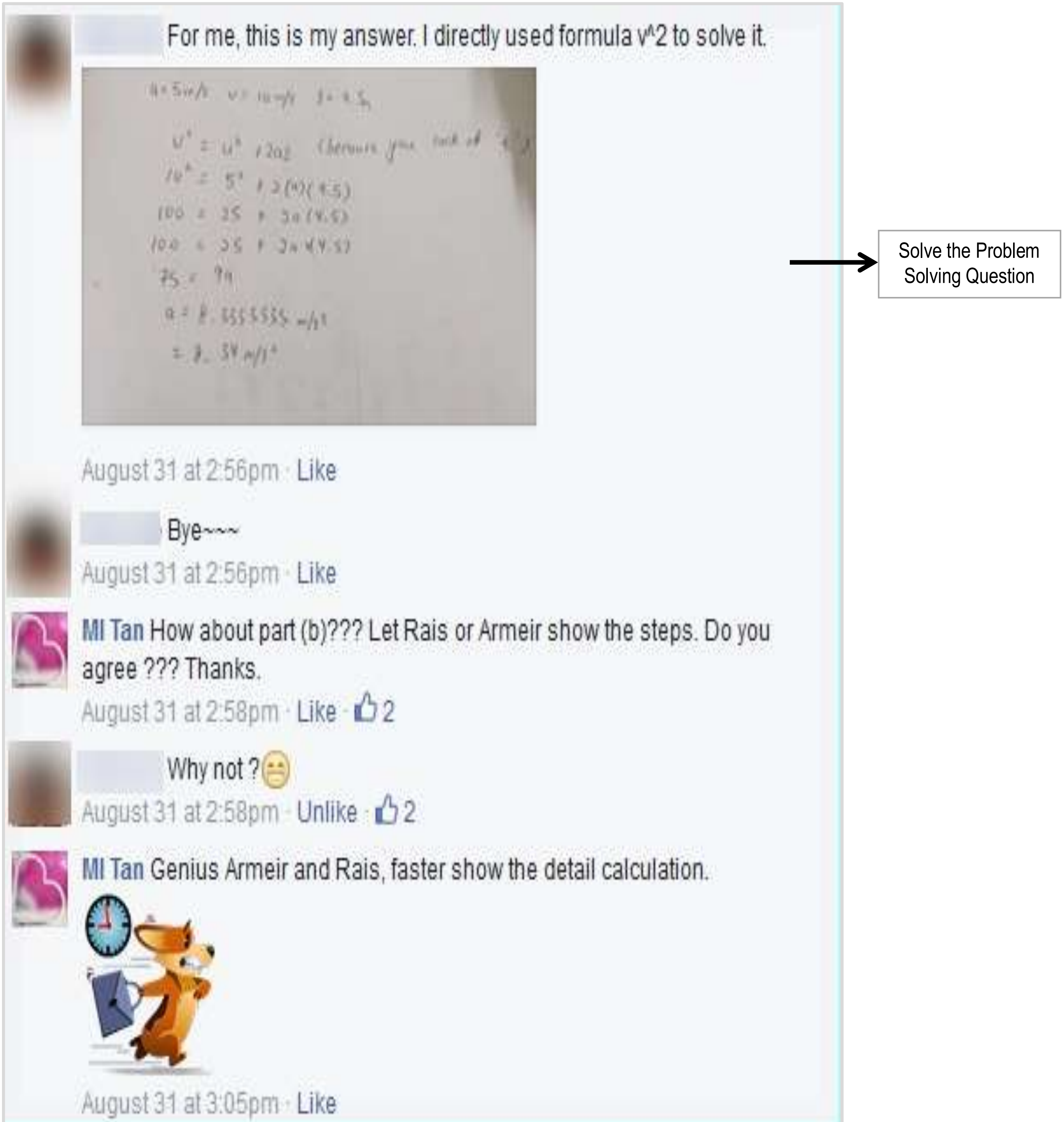
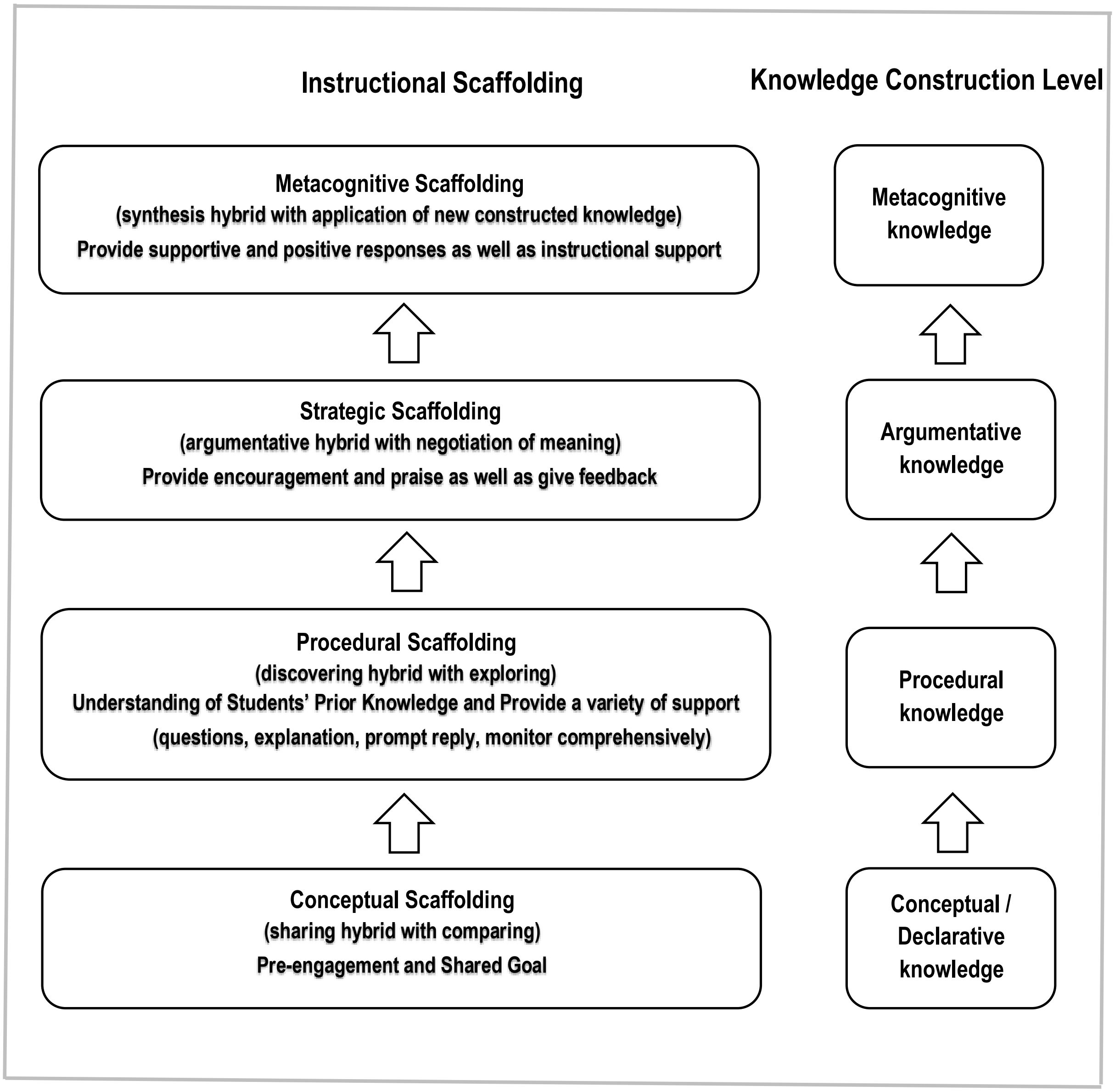


Figure 5 The students solved the problem solving question

Stage four, ‘Working out the knowledge construction’. The engineering students are able to take responsibility gradually for their learning. In addition, they can construct knowledge when there is more interaction in online social collaborative learning with their instructor or peers for e-activities and or e-discussions. According to Gunawardena, Lowe and Anderson [14], 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 [3]. Thus, the instructor provides several guides in online learning, as well as integrating instructional scaffolding elements to assist engineering students towards the completion of their learning tasks. Also, the instructor utilizes instructional scaffolding to support and guide engineering students in their process of knowledge construction, based on Hogan and Pressley’s guidelines [15].

Stage Five, ‘Working out the development.’ As a consequence, the students have confidence as online learners and able to construct knowledge on new ideas acquired through e-discussions and or e-activities about Linear Motion lesson. They would apply and integrate new knowledge into their existing knowledge and workplace, particularly in the engineering field. Hence, they enjoy learning afresh from the whole experience. Salmon [3] mentioned that developing participants to have independent critical thinking and reflection is of vital importance in this closure stage. Students deploy their new knowledge when assessed.

The schematic below illustrates the overview of how instructional scaffolding elements have been implemented towards knowledge construction in online social collaborative learning environment.



3.0 METHOD

Participants

Seventy-four engineering students from semester one of six classes of two Engineering Science courses participated in this study. They are from the Ungku Omar Polytechnic in North Malaysia.

Design

A quasi-experimental design was established with a pre- and post-test [16], [17]. Groups or classes could not be naturally created for the experiment. Thus, the instructor needed to designate two groups, which were homogeneous with respect to the learning environment: a control group, which undertook conventional collaborative learning (CCL), and an experimental group, which undertook online social collaborative learning (SCL). The study design is illustrated in Table 1.

Table 1: Quasi-Experimental Design: Pre- and post-test design

(Source: Creswell, 2014)[15]

Control Group (38 participants)	Pre-test	No Treatment (without online instructional scaffolding)	Post-test
Experimental Group (36 participants)	Pre-test	Experimental Treatment (with online instructional scaffolding)	Post-test

Procedure

The study involved two stages. In the first stage, the instructor conducted a pre-test in both groups. The test was conducted to assess students' achievement and level of knowledge construction in the Engineering Science course.

Three weeks later, the experimental group took part in the online SCL phase. There were two instructional approaches to stimulate knowledge construction through social negotiation in asynchronous e-discussions: social learning and collaborative learning [18]. In this activity, the 36 participants underwent experimental treatment activities with instructional scaffolding in asynchronous online discussion on Facebook. On the other hand, for the control group, the instructor did not use web-based instructional scaffolding. The 38 participants learned through the conventional approach in the classroom.

Immediately after the online social collaborative learning activities, a set of post-tests were conducted to find out participants' knowledge construction level. The instructor used Linear Motion topic to test the effects of both conventional collaborative learning and the online social collaborative learning environment. So that the results could be compared between groups or classes. In other words, the test is tied on current subject material taught in Engineering Science for this study.

Subsequently, structured interviews were conducted with ten participants from the experimental group to investigate the instructional scaffolding elements. Five of these interviewees had significantly improved their scores in the achievement test, and the other five had actively participated in the learning activity via the Facebook discussions and had also performed well in their tests. These interview sessions generally lasted for an average of 30 minutes depending on the interviewees and were audiotaped for later transcription. An open-ended question transcript was used as the interview instrument to obtain qualitative data.

Content Analysis and Thematic Analysis

The Outline Mapping Concept for content analysis and thematic analysis based on Braun and Clarke [19] was used to analyze the qualitative data. Coding is the initial stage of qualitative analysis [20]. There are different types of coding:

- *In vivo* codes: focusing on what is in the data (instructor needs to focus on instructional scaffolding that can enhance engineering students' knowledge construction level).
- Open codes: discovering abstract concepts in the data (the instructor labeled data from the interview transcripts).
- Axial codes: discovering connections between abstract concepts (the instructor has to identify patterns and connections between instructional scaffolding and engineering students' levels of knowledge construction).
- Selective coding: raising the level of abstraction again to the core category.

Figure 6 illustrates the different types and levels of coding. Thus:

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

Table 2 shows an example of the relationships between open coding, selective coding and core categories, as well as examples of interview statements to construct theme building [20].

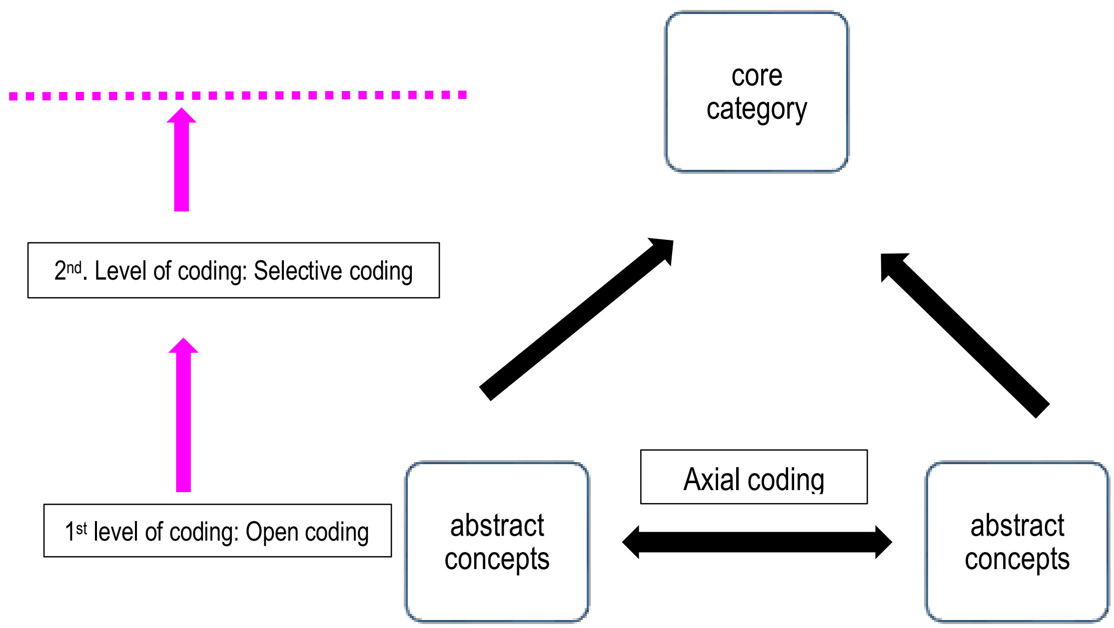


Figure 6 Different types and levels of coding (Source: Punch, 2005)[20]

Table 2: Interconnection between open coding, selective coding, core category and examples of interview statements for theme building

Core category	Selective coding	Description	Open coding	Examples of interview statement
Students' cognitive pre-engagement	Benefits	Asking group members to engage in the learning tasks	Learning via collaboration	What are the benefits when you are provided with guidelines for learning/learner generated content and learning activities for all the learning tasks and collaborative learning activities via Facebook discussions?
				How does it affect your knowledge construction?

The qualitative data analysis and interpretations were developed from the content analysis by using outline mapping and thematic analysis of the structured interviews. Then, the instructor entered the text into Microsoft Word for data analysis. The instructor 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 descriptions and themes. Each theme represents both specific quotes and subthemes. The results and findings are obtained through interpretation of this study.

The data from the test, field notes and transcribed data were 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 of themes [16]. According to Creswell [16], the coding process is an inductive process that reduces the initial list of categories into a few central themes.

The instructor 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 [16].

In order to construct the core category, the instructor needs to implement several processes:

Summative Content analysis (Probing or Keywords)

After conducting each interview, the recording was transcribed into Microsoft Word, with the date and time, name and contact number of the interviewees and for the responses to each interview question statement. After transcribing all the discourse or dialogue, the instructor replayed the audiotape to check that the Word transcription was free of errors. The content analysis scheme was applied to analyze the transcripts in order to look for similar probing words to construct a theme or core category for each interview statement. Next, the transcripts were coded independently.

Content review

After the coding activity, the instructor worked with the coding through the Mindjet Mind Manager software to produce an outline map to examine interviewees' ideas on the eight elements of instructional scaffolding [15].

An overview outline map was drawn for the qualitative data collection process for the ten interviewees. The map comprised interviewees' ideas on how instructional scaffolding processes embedded in the online social collaborative learning environment can enhance engineering students' knowledge construction, and also how important and less important of elements of instructional scaffolding when the instructor implemented a metacognitive learning activity via Facebook discussions.

In order to determine the qualitative reliability of open coding, selective coding and core categories or themes, the instructor invited a second coder to check the themes for inter-rater reliability before looking for patterns (paradigms) across interviews. The results showed that over 90% of the probing words or keywords were the same as the instructor's. This means that the second coder agreed with the instructor's analysis of the field notes.

Meanwhile, the interviewees were requested to examine the raw data again after the instructor had made corrections based on their feedback to determine the accuracy and reliability of data. The instructor also used the post-positivist lens or systematic paradigm to assess the validity of qualitative analysis, as summarized in Table 3. In addition, the instructor used thematic analysis to find the core category, which will be discussed in the next section.

Table 3: Validity procedures and paradigm assumptions

(Source: Adapted from Creswell and Miller, 2010)[21]

Paradigm assumption/lens	**Lens of the Instructor**	**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 instructor used an inductive approach relying on codes, categories or themes drawn directly from the field. The inductive method is used to draw generalizations and to reflect and elaborate on the process of interaction in the field notes. Thus, the instructor conducted thematic analysis based on Braun and Clarke [19]. Several steps are required when implementing this analysis to form the major theme or concept (core category):

1. Familiarization with the data

Repeatedly read the data in an active way, searching for meanings and patterns.

2. Generating the initial codes

The essential idea is about what the data is related to and what is interesting about it. Raw data can be evaluated in a way that is meaningful to the phenomenon [22].

3. Searching for the theme or category

Collect all the relevant codes 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 instructor 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 the second level and relate it to the entire data set.

5. Defining and naming theme

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

6. Producing the report

The instructor produces a full set of worked-out themes and then writes up a story about the data within and between the themes, providing a concise, coherent, logical, non-repetitive and interesting topic.

Memo Linkages

A memo linkage is a set of quotations and codes. This network view can be interpreted as follows: what the instructor writes in this memo is illustrated well by those eight quotations and they are related to the concepts represented by these codes. See Figure 7.

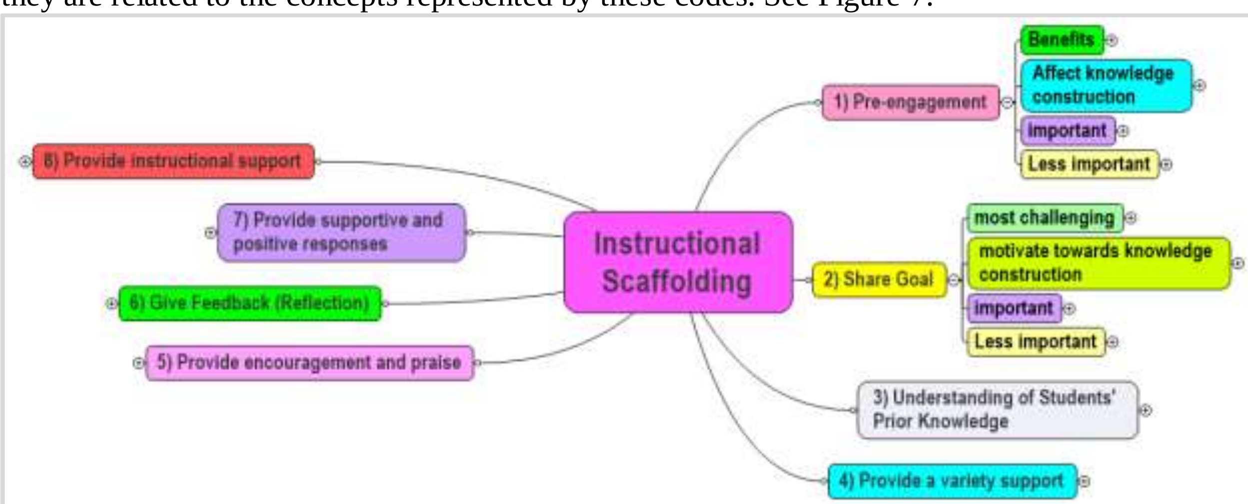


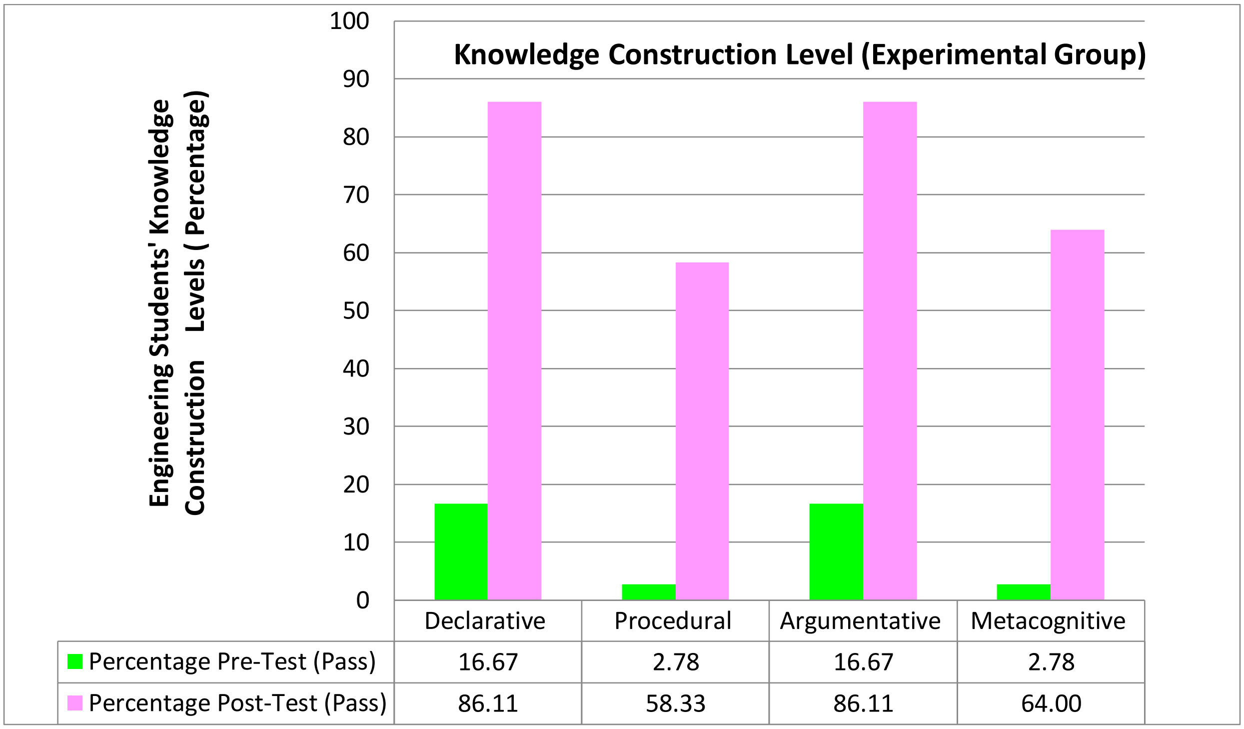
Figure 7 Network view of a memo

Representations connecting codes to codes, and quotations to quotations, can bring out the meanings. This network view represents a meaning that the instructor has defined through interpretation. Thus, the establishment of these linkages is an intrinsic component of the qualitative data analysis process whereby the instructor has to determine the way in which concepts, themes (categories) and the words of the interviewees relate to each other.
Figure 7 is a concept map representing the instructor's understanding of the instructional scaffolding affecting engineering students' knowledge construction processes, derived from the analysis of the raw data.

4.0 RESULTS

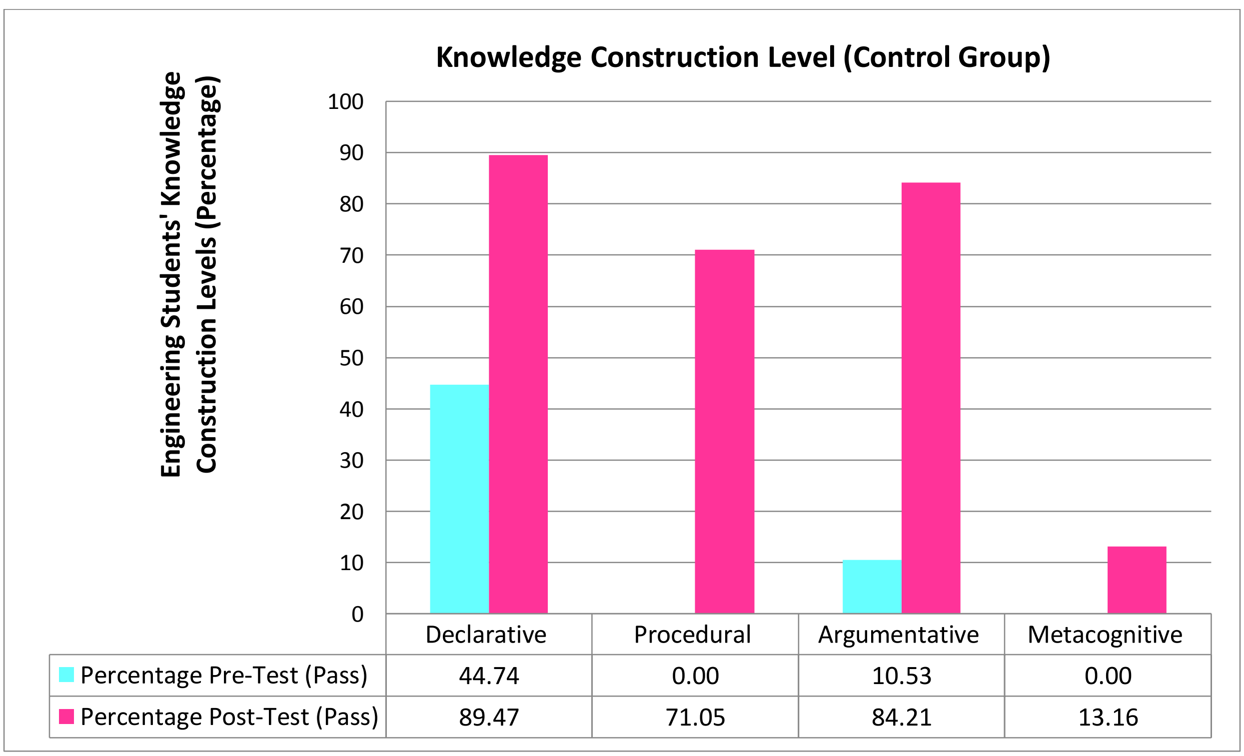
The methodology for the study of instructional scaffolding strategy involved both quantitative and qualitative approaches. In order to assess the impact of instructional scaffolding in enhancing engineering students' knowledge construction in online social collaborative learning, the quantitative data were analyzed using bar chart. The assessment target was students' knowledge construction level in their test achievement. Figures 8 and 9 present the results obtained from the assessment data. The two sets of data are illustrated the engineering students' passed the pre and post-tests at each level of knowledge construction for experimental and control groups. Subsequently, the combination of results in the test for both groups, as outlined in Figure 10.

The instructor merely looking the scores of the tests, there was a significant increase in each level of knowledge construction. For example, comparing the data between experimental and control groups, it appears that the engineering students improved their scores (marks) with a pass rate of 86.11 percent for argumentative knowledge construction and 64.00 for metacognitive knowledge construction in the experimental group. On the other hand, the engineering students in the control group had a pass rate of 84.21 percent for argumentative knowledge construction and 13.16 percent for metacognitive knowledge construction. The rest of the knowledge construction level, such as declarative knowledge and procedural knowledge, also showed that the students improved in their post-test.



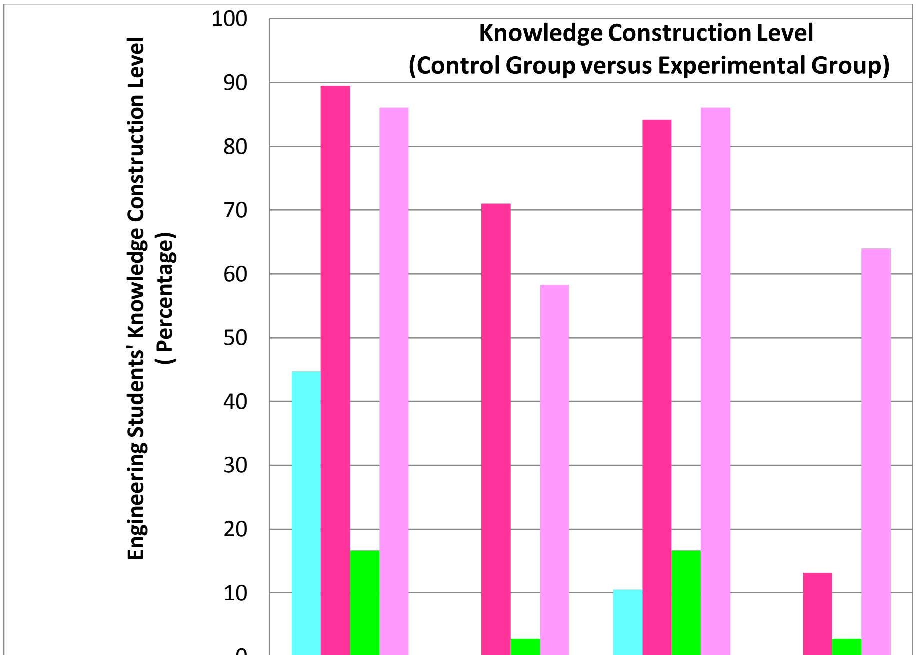
	Declarative	Procedural	Argumentative	Metacognitive
Percentage Pre-Test (Pass)	16.67	2.78	16.67	2.78
Percentage Post-Test (Pass)	86.11	58.33	86.11	64.00

Figure 8 Bar chart data with comparison between pre and post-test for experimental group



	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 9 Bar chart data with comparison between pre and post-test for control group



	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
Percentage Pre-Test (Pass)	16.67	2.78	16.67	2.78
Percentage Post-Test (Pass)	86.11	58.33	86.11	64.00

Control Group

Experimental Group

Figure 10 Combination of results in percentage of knowledge construction levels (control group versus experimental group)

Subsequently, the qualitative data were analyzed using coding and themes that can fully explore the students' perception and perspective on integrating the web-based instructional scaffolding elements in the social collaborative learning environment towards knowledge construction. Thus, the instructor employed concept mapping to determine the themes. There are some examples illustrated in Figures 11 to 18.

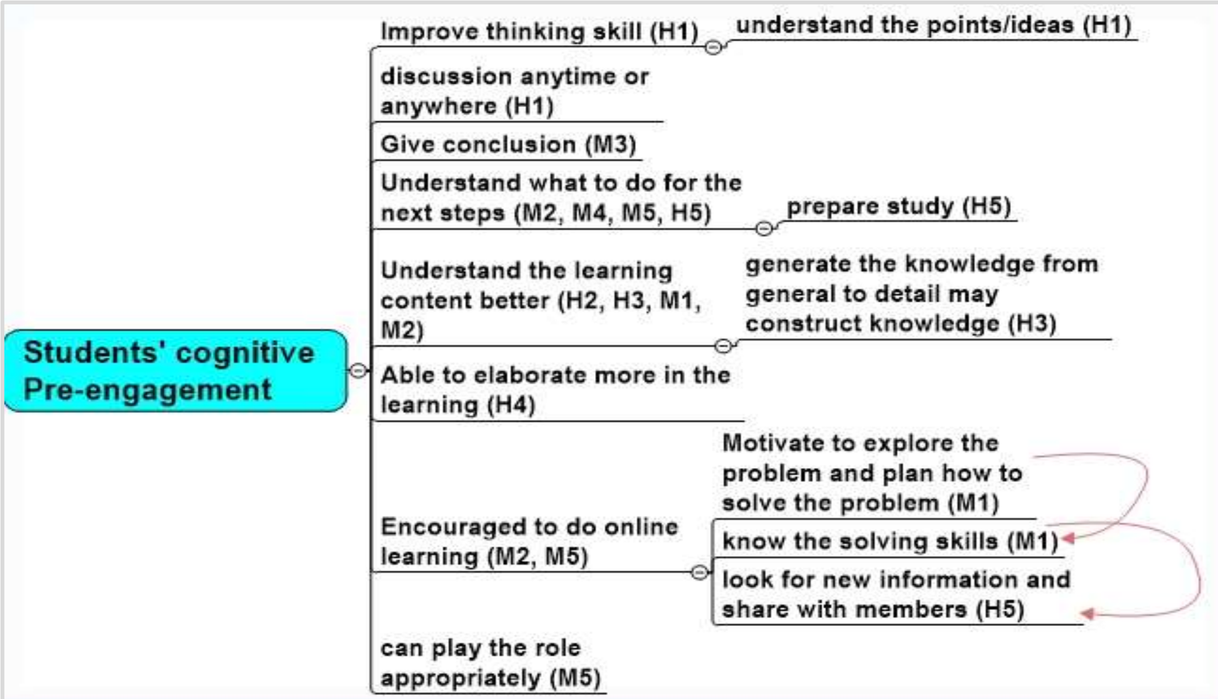


Figure 11 A part of the network diagram of the pre-engagement affecting knowledge construction

(Note: H= interviewees had significantly improved their scores in the achievement test, M=interviewees had actively participated in the learning activity via the Facebook discussions and had also performed well in their tests)

As can be seen in Figure 11, a picture quotation, illustrates what the interviewees said on how the pre-engagement element of instructional scaffolding affected their knowledge construction, which was provided by the instructor. For example, 'I discovered a lot of new knowledge about Linear Motion lesson with guidelines for my learning. I can learn very well that able to elaborate more the learning content. In fact, they are very good guidelines. Before that, I did not know how to start my learning. I can get knowledge from the e-activities and also increase my problem solving skills. I learnt a lot of new knowledge through the Facebook discussions such as I can understand about instantaneous velocity and average velocity with help from Miss Tan during the e-discussions'.

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 knowledge construction.

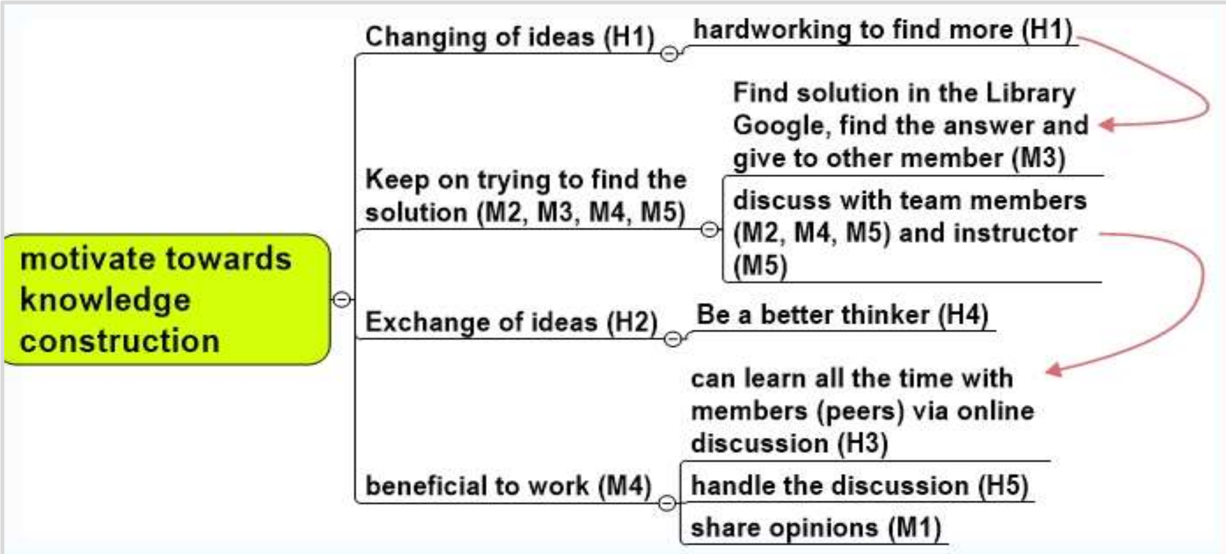


Figure 12 A part of the network diagram of the shared goal

Reviewing Figure 12, the instructor could see that the shared goal motivated interviewees to change their ideas in the online social collaborative learning environment. This is how an instructional scaffolding factor can enhance engineering students' knowledge construction. For example, one of the interviewees replied 'yes, it motivated me to change my ideas in a group discussion. 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'.

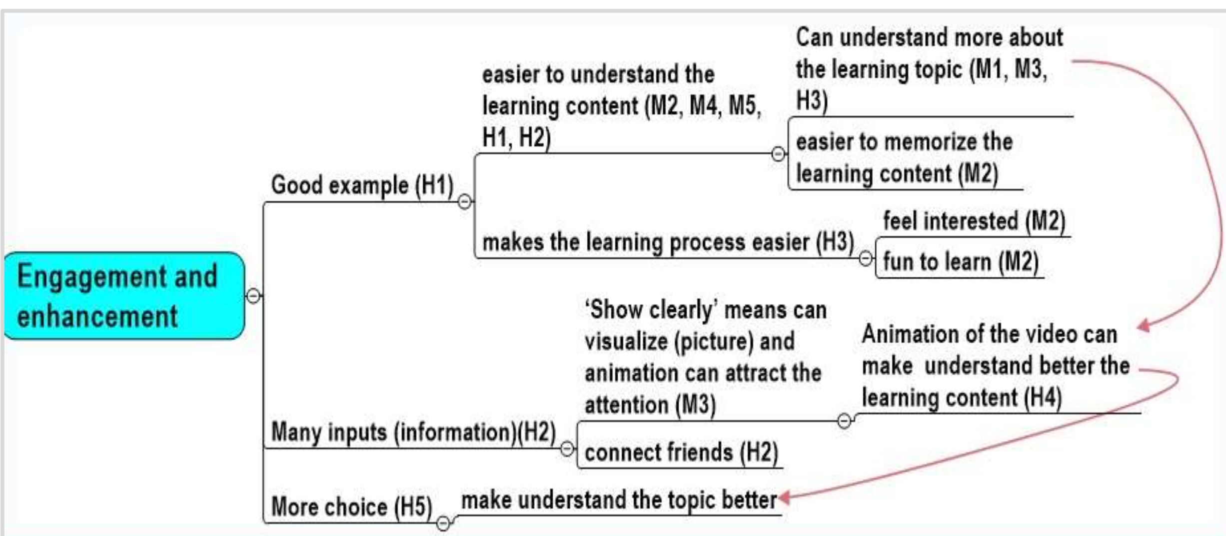


Figure 13 A part of the network diagram of understanding of students' prior knowledge

As Figure 13 shows, the engagement and enhancement elements led the engineering students to become active learners in their process of the learning. The elements of instructional scaffolding encouraged them to construct knowledge in order to understand students' prior knowledge. For example, the feedback from interviewees, 'there are many types of video. They helped me in asynchronous online discussion on Facebook. They made me understand the topic more. Also, Miss Tan posted, please search more videos related to the topic'.

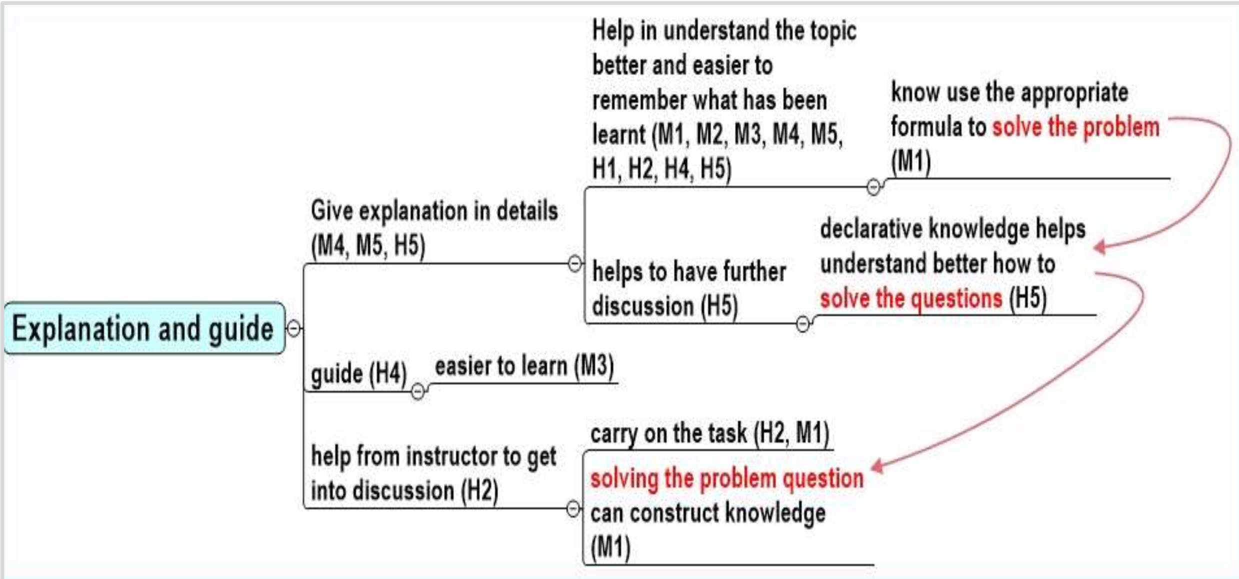


Figure 14 A part of the network diagram of providing a variety of support

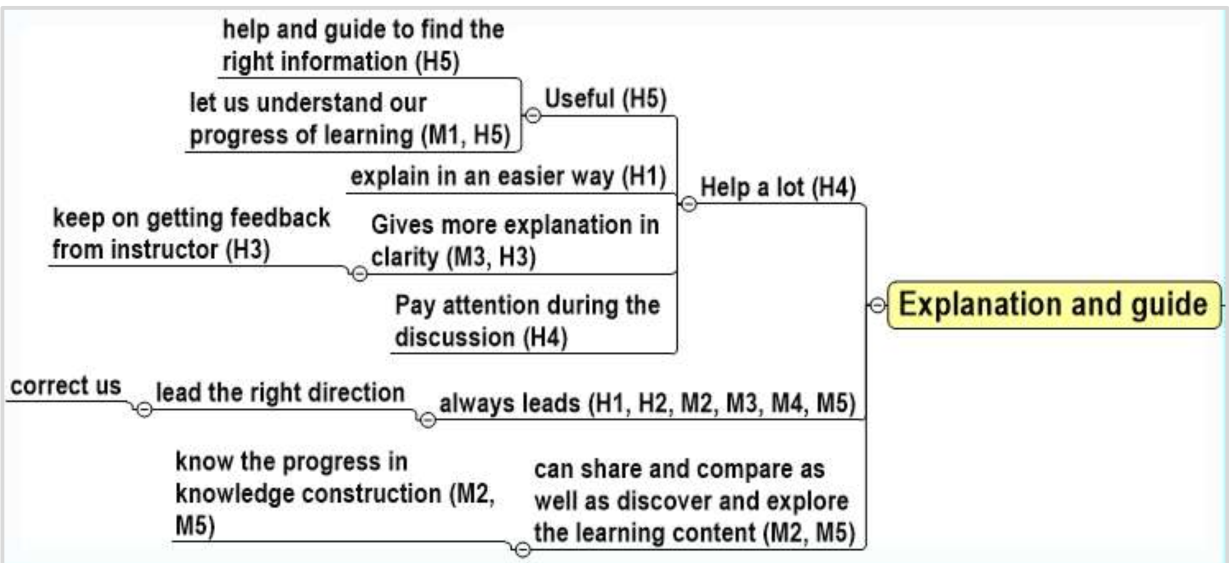


Figure 15 A part of the network diagram of giving feedback

Figures 14 and 15 indicate that the explanation and guide elements of instructional scaffolding help and enhance engineering students' knowledge construction in the online social collaborative learning environment. They felt it was easier to learn new knowledge when the instructor gave a detailed explanation and guided them in their learning process. All the interviewees felt the instructor's feedback could lead them towards knowledge construction. 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 interconnect and or interrelationship. 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 (interconnection) with providing a variety of support with instructional scaffolding elements from the instructor. It makes engineering students feel a degree of confidence, enabling them to acquire new knowledge, in turn, would enable enhance their knowledge construction into a higher level in the online social collaborative learning environment.

For example, the interviewee provided answers such as 'I feel good. It's easier to understand the subject. Miss Tan assisted me with appropriate statements. She posted the statement, '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'.

Another interviewee responded 'yes. It led me in the knowledge construction. The lecturer's feedback, such as, 'explain in an easier way', helped a lot. 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'.

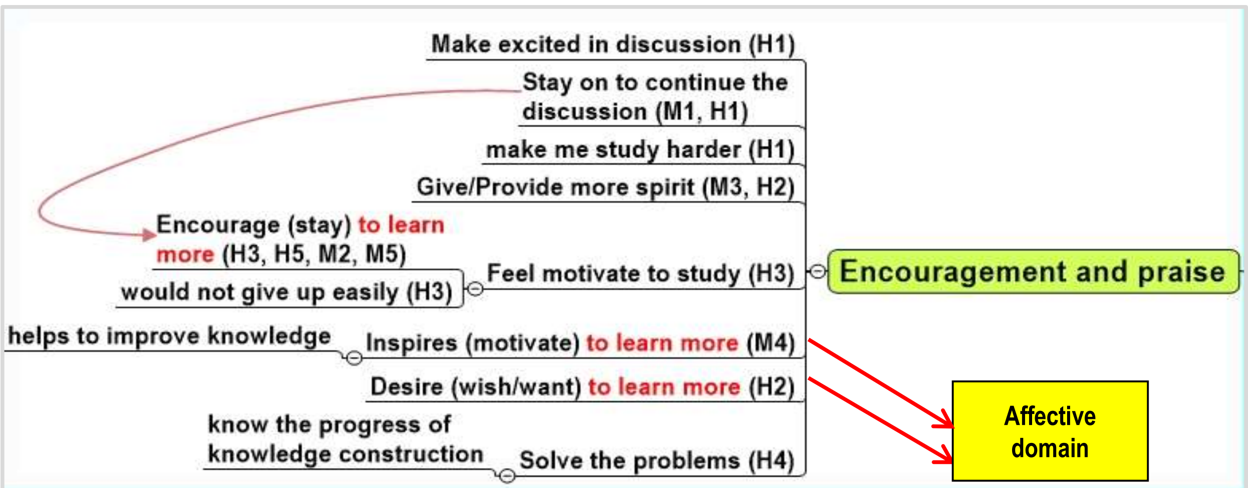


Figure 16 A part of the network diagram of complimentary statements

Figure 16 illustrates the findings of encouragement and praise on how instructional scaffolding enhanced the engineering students' knowledge construction. The complimentary statements made students feel excited to learn in the social collaborative learning environment. For instance, the statement from the interviewee, 'the compliments provide inspiration for me to study. I have a desire to study'.

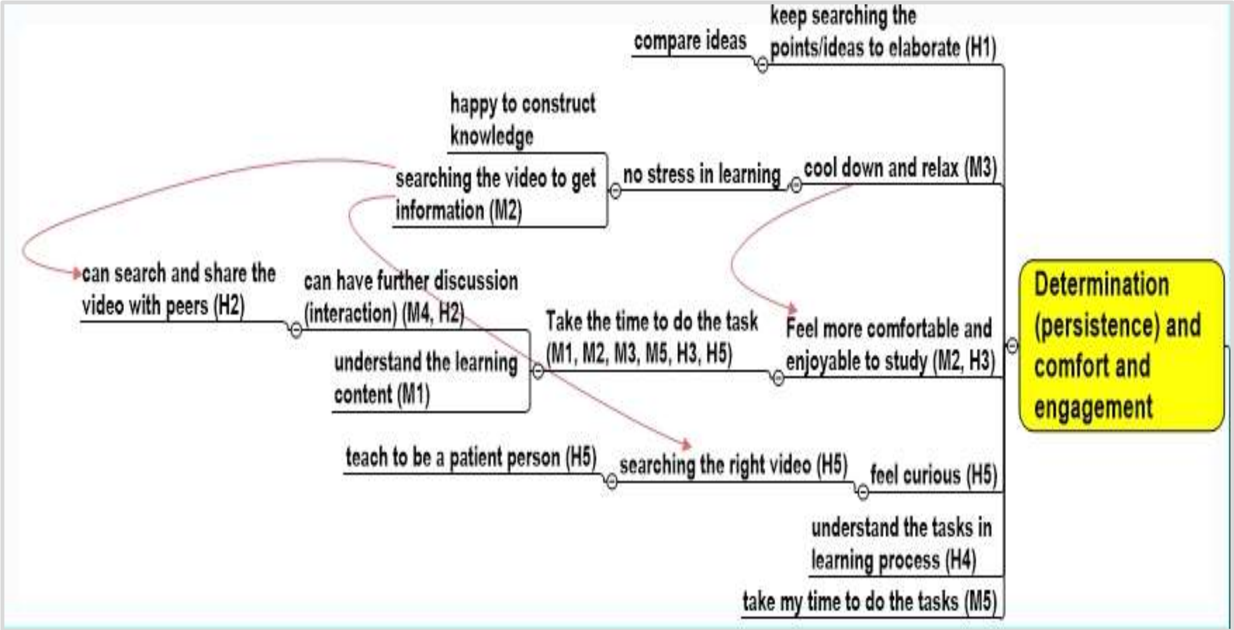


Figure 17 A network diagram of providing supportive and positive responses

There are two domains, namely, cognitive and affective, in the element of instructional scaffolding for providing supportive and positive responses, as presented in Figure 17. Hence, determination (persistence/persevere) and comfort and engagement themes are extracted from the domains of the instructional scaffolding strategy model. Such instructional scaffolding helps and assists engineering students' knowledge construction.

These are typical reports from interviewees, '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. 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'.

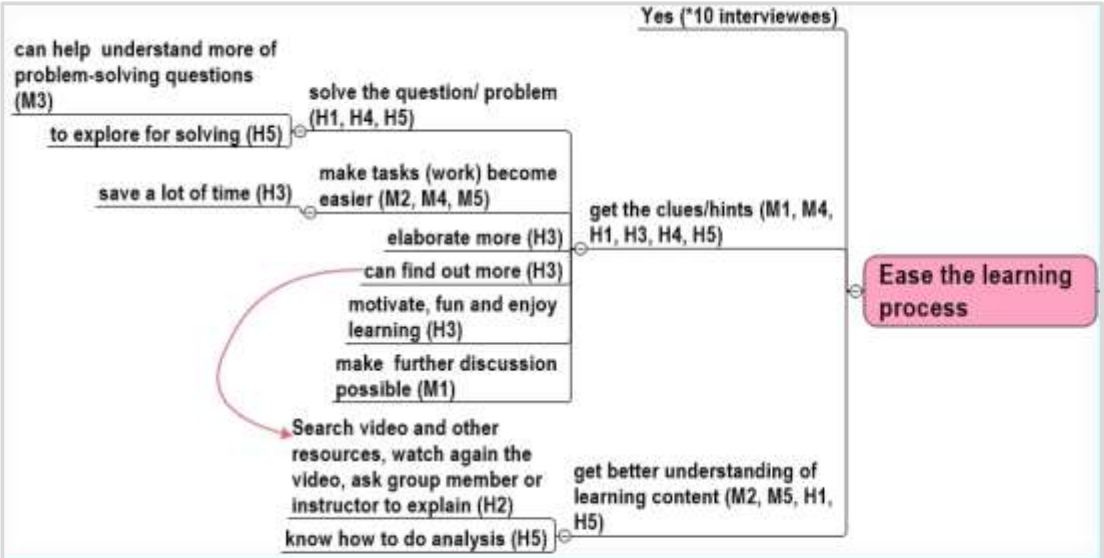


Figure 18 Part of the network diagram of providing instructional support

Figure 18 gives the results of providing instructional scaffolding that aided the engineering students' learning process when the instructor provided appropriate clues or hints through the Facebook platform in the online social collaborative learning environment. These instructional scaffolding may help them perform better in knowledge construction. 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 knowledge construction.

The typical answers from the interviewees' such as 'yes. The instructor always gave hints and clues to help me and the team members to explore the problem-solving questions. 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)'. This would help me know how to do analysis on the problem-solving questions'.

In the meantime, the instructor conducted the learning activities during asynchronous online discussion via the Facebook platform. The components of the instructional scaffolding strategy model were composed by categorizing the themes. Table 4 presents a summary of themes from the analysis of the instructional scaffolding elements. Consequently, an instructional scaffolding strategy model for online social collaborative learning environments was constructed, as illustrated in Figures 19.

Table 4: Summary of themes for eight elements of instructional scaffolding

Analysis	Element of instructional scaffolding	List of themes
1	Pre-engagement	Students' cognitive pre-engagement
2	Shared goals	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

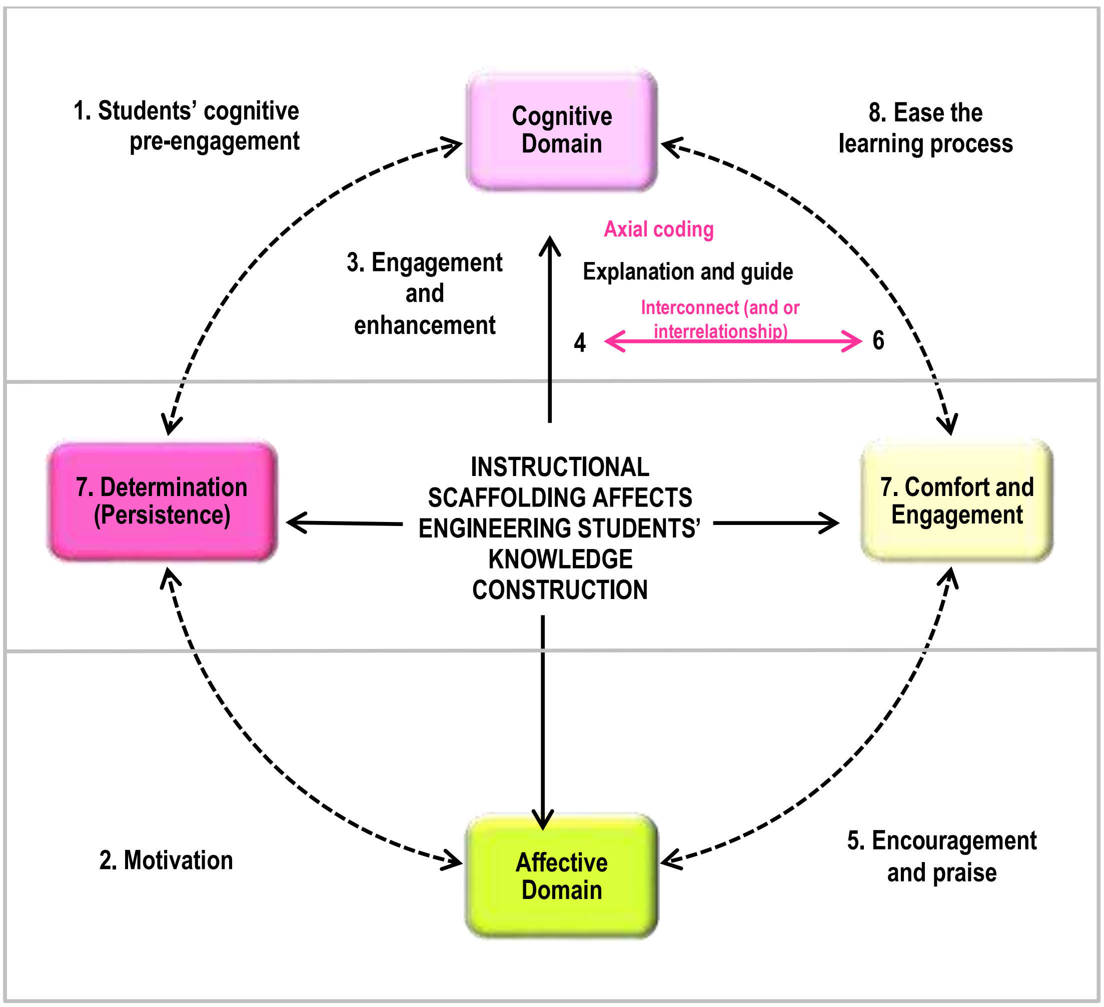


Figure 19 Instructional Scaffolding Strategy Model
(construct core category of elements of instructional scaffolding)

5.0 DISCUSSION

Discussion on the Impact on Knowledge Construction (Quantitative Analysis Part)

The difference before and after integrate instructional scaffolding through the e-discussions of Linear Motion lesson can be seen here. 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 instructional scaffolding to enhance engineering students' knowledge construction.

Pre- and post-tests were used as an instrument to identify the engineering students' levels of knowledge construction. This approach was designed to measure their levels of construction of Conceptual, Procedural, Argumentative and Metacognitive knowledge [23]. The study reveals that declarative knowledge affects procedural knowledge construction. Meanwhile, argumentative knowledge affects metacognitive knowledge construction, too. Moreover, the level of knowledge construction interrelates with each type of knowledge.

The findings in Figure 10, illustrated the comparison of knowledge construction level between control and experimental groups. Both learning environments whether in the collaborative learning or the social collaborative learning had a positive impact on the engineering students' knowledge construction, enabling them to reach a higher level of knowledge construction. In other words, the students improved their scores with a pass rate of 86.11% for argumentative knowledge construction and 64.00% for metacognitive knowledge construction in the experimental group. Apart from that the students in the control group had a pass rate of 84.21% for argumentative knowledge construction and 13.16% for metacognitive knowledge construction. Furthermore, the declarative knowledge construction and procedural knowledge construction also indicated that the students improved in their achievement tests.

Overall, the data in Figure 10 also depicted the students' metacognitive knowledge was much better in the online social collaborative learning environment than in the conventional collaborative learning environment. The instructor seems that such of learning approach would have a great impact on engineering students' knowledge construction. This means that students can learn and construct knowledge through social and collaborative learning supported by web-based instructional scaffolding when they actively participate on posting statements or comments on the Facebook discussions in terms of acquisition of new knowledge, such as argumentative knowledge or metacognitive knowledge.

This in line with Figure 16, the students were excited to discover and explore something new knowledge, experiencing something wonderful became part of their meaningful social activities in the process of learning. The key finding was that different learning environments had differing impacts on the outcomes of each level of knowledge construction for enhancing engineering students' knowledge construction.

Discussion of Instructional Scaffolding Strategy Model (Qualitative Analysis Part)

Participating students were asked about the effect of the instructional scaffolding elements embedded by the instructor during their metacognitive learning activity in the online social collaborative learning environment. Moreover, the instructor also considered the elements of instructional scaffolding to enhance engineering students' deep thinking.

The elements of instructional scaffolding were analyze for creating an instructional scaffolding strategy model in online learning as discuss below:

1. Pre-engagement

It is the priority element of instructional scaffolding to engage engineering students' knowledge construction. This is an essential stage, as the engineering students participated actively in e-discussions via the Facebook platform. The instructor utilized guidelines as a pre-engagement for the students to discuss the learning content so as to lead them to complete the learning task.

The findings in Figure 11 show each interviewee had different ideas about how the pre-engagement element of instructional scaffolding affects knowledge construction, 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 instructor assigned roles, groups, and tasks (see Figure 1) 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 online SCL environment.

2. Share goals

The most challenging part of knowledge construction for the engineering students was that team members cannot work together at the same time. The instructor 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 e-discussions.

Figure 12 depicted that 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 knowledge construction.

3. Understanding of students' prior knowledge

YouTube engaged and enhanced the engineering students' prior knowledge through Facebook discussions in the online learning. The instructor had a great deal of information to share and compare, discover and explore with others through 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. The students found it easy to memorize the learning topic.

Activate engineering students' prior knowledge by utilizing examples from YouTube video. Simultaneously, the instructor 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 example, five interviewees (M2, M4, M5, H1 and H2) said that the YouTube videos made it easier for them to understand the learning content, as depicted in Figure 13. These learning tools provided a successful integration of technology in the engineering classroom.

The instructor could understand better the engineering students' background, existing knowledge, and learning experience so as to integrate them with instructional scaffolding in the online learning activities. 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 due to enhance their knowledge construction.

4. Providing of variety of support

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 instructional scaffolding elements that support them to be more independent in constructing knowledge.

As can be seen in Figure 14, providing a variety of support helps 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.

5. Providing encouragement and praise

Giving complimentary statements can enhance the engineering students' knowledge construction. The instructor holds the view that encouragement can engage them to stay on to continue discussing the learning lesson through e-discussions (see Figure 16). 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. Also, they were not easily frustrated to construct knowledge through Facebook platform. Consequently, they found it exciting to learn and became responsible in their studies in online SCL environment.

6. Give feedback

The instructor gave prompt feedback to the engineering students when conducting the discussions in the online SCL environment. They frequently received feedback from the instructor in the metacognitive learning activities. The instructor found out the views of ten interviewees about which types of the instructor's feedback helped them most in knowledge construction 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 e-discussions supported by instructional scaffolding (refer Figure 15). In other words, the instructor monitored engineering students' progress comprehensively, so she could cognitively steer them towards knowledge construction.

7. Providing supportive and positive responses

Figure 17 depicts those kinds of responses that made engineering students feel happy, comfortable, and glad to study. They did not feel stressful about learning according to the opinions offered by the ten interviewees. The 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 via the learning activities.

8. Providing instructional support

From the data findings as stated in Figure 18, all the interviewees agreed the instructor 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 instructional scaffolding can enhance engineering students in an online SCL environment towards knowledge construction.

For example, 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 engineering students felt excited to construct knowledge even though they were facing difficulties in their learning process.

Thereby, based on all of the findings discussed above, an instructional scaffolding strategy model for online learning environments was constructed (see Figure 19) in which indicates clear support for the *cognitive* and *affective* domains.

The findings show that in terms of students' cognitive pre-engagement, the *cognitive domain* can improve engagement and enhance their learning process through participating in asynchronous online discussion on the Facebook platform. This seems to be a crucial element of instructional scaffolding in the online social collaborative learning environment towards knowledge construction. Additionally, the learning process for the engineering students' knowledge construction can be facilitated through explanation and guidance from the instructor when conducting metacognitive learning activities. The data in the figure show the connection between providing a variety of support and giving feedback to the students as an axial coding. The students were more active and reflective during the e-discussions on Facebook platform. This finding is similar to that of Du and Wagner [24], which revealed that online learning affects instructor-student and peer-to-peer interaction and has an impact on academic performance when compared to offline collaborative learning, as such a learning environment encourages peer involvement. These factors, then, have a positive impact on engineering students' knowledge construction.

It can be shown that elements of instructional scaffolding play an important role in improving engineering students' knowledge construction when the instructor delivers the lesson via a Facebook platform in online learning. For instance, instructional scaffolding elements such as providing praise – part of the *affective domain* – in asynchronous online discussion may motivate and 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 Memahon [25] that providing scaffolding for students helps them to bridge the gap between existing knowledge and newly constructed knowledge.

Meanwhile, determination and comfort provision constituted links between the *cognitive domain* and the *affective domain*. The students are influenced by a comfortable learning environment, which can lead them be more persistent throughout the online learning process. The instructional scaffolding strategy model can enhance engineering students' learning by implementing web-based instructional scaffolding support via an online social collaborative learning environment towards knowledge construction.

6.0 CONCLUSION

In terms of improving engineering students' test results, the elements of instructional scaffolding significantly affect these students' learning processes and pathways. The students feel fantastic, exciting, and comfortable to learn the lesson. They also feel 'something exciting is coming' to learn through online social collaborative learning environment. The instructor sees that flexibility of online social collaborative learning environment would assist students to learn more as well as increase the efficiency of the communication through e-discussions on Facebook platform.

To conclude, elements of instructional scaffolding play a vital role in the knowledge construction process because they assist engineering students to construct their knowledge and reach higher levels of thinking, such as critical, creative and innovative thinking. Thereby, more extensive research is required to design instructional scaffolding strategies for online learning that can be used by instructors to assist students to reach excellent achievements in their engineering studies.

7.0 REFERENCES

[1] Streveler, R.A., Litzinger T.A., Miller R.L., and Steif, P.S. (2008). Learning Conceptual Knowledge in the Engineering Sciences : Overview and Future Research Directions, *Journal of Engineering Education.* 97(3), 279-294.

[2] Felder, R. M. (2012). Engineering education: A Tale of Two Paradigms. *Shaking the Foundations of Geo-engineering Education*, 9-14. Leiden: CRC Press.

[3] Salmon, G. (2004). *E-moderating – the key to Teaching and Learning Online*. (2nd ed) London: Routledge Falmer.

[4] Davenport, T.H., and Prusak, L., (2000). *Working Knowledge — How Organisations Manage What They Know*. Harvard Business School Press, Boston.

[5] Ravenscroft, A., and McAlister, S., (2008). Investigating and Promoting Educational Argumentation: Towards New Digital Practices. *International Journal of Research and Method in Education*. 31(3), 317–335.

[6] Ravenscroft, A., Wegerif, R. B. and Hartley, J. R., (2007). Reclaiming Thinking: Dialectic, Dialogic and Learning in the Digital Age. In J. Underwood, & J. Dockrell (Ed.) *Learning*

Through Digital Technologies, British Journal of Educational Psychology Monograph Series. 2(5), 39–57.

[7] Ibrahimi, F., and Essaaidi, M. (2012). Collaborative Learning and Wiki. *International Conference on Multimedia Computing and Systems*, 870–875.

[8] Sharma, P., and Hannafin, M. J. (2007). Scaffolding in Technology-Enhanced Learning Environments. *Interactive Learning Environments*. 15(1), 27–46.

[9] Popescu, E. (2014). Providing Collaborative Learning Support with Social Media in an Integrated Environment. *Springer Science Business Media*. 17(2), 199–212.

[10] Hannafin, M., Land, S., and Oliver, K. (1999). Open Learning Environments: Foundations, Methods, and Models In Charles M.Reigeluth (Ed). *Instructional Design Theories and Models: A New Paradigm of Instructional Theory, Volume II*. New Jersey, Lawrence Erlbaum Associates.

[11] Jonassen, D. H., Peck, Kyle L., and Wilson, Brent G., (1999). *Learning with Technology: A Constructivistic Perspective.* Upper Saddle River, NJ: Pearson Prentice Hall, Inc.

[12] Zuniga and Shahin (2015). Social Media and Their Impact on Civic Participation. Retrieved from New Technologies and Civic Engagement: *New Agendas in Communication. Third Avenue*, New York,Taylor and Francis, 78-90.

[13] Teo, Y. H., and Chai, C. S. (2009). Scaffolding Online collaborative Critiquing for Educational Video Production. *The International Journal of Knowledge Management and E-Learning*. 1(1), 51–66.

[14] Gunawardena, C. N., Lowe, C. A., and Anderson, T. (1997). Analysis of a Global Online Debate and the Development of an Interaction Analysis Model for Examining Social Construction of Knowledge in Computer Conferencing. *Journal of Educational Computing Research.* 17(4), 397–431.

[15] Hogan, K., and Pressley, M. (1997). Scaffolding Scientific Competencies within Classroom Communities of Inquiry. In K. Hogan and M. Pressley (Ed.). *Scaffolding Student Learning: Instructional Approaches and Issues*. Cambridge, MA: Brookline Books.

[16] Creswell, W.(2014). *Educational Research: Planning, Conducting and Evaluating Quantitative and Qualitative Research*. (4th ed.) Edinburgh Gate, England: Pearson New International Edition.

[17] Zainudin Awang (2012). *Research Methodology and Data Analysis* (2nd ed) Subang Jaya: Selangor. UiTM Press.

[18] De Wever B., Schellens T., Van Keer H., and Valcke M. (2008). Structuring Asynchronous Discussion Groups by Introducing Roles: Do Students Act in line with Assigned Roles? *Small Group Research*. 39(6), 770–794.

[19] Braun, V., and Clarke, V. (2006). Using Thematic Analysis in Psychology. *Qualitative Research in Psychology*. 3(2), 77-101.

[20] Punch, K. F. (2005). *Introduction to Research Methods in Education: Chapter 9 The Analysis of Qualitative Data*. Sage: London.

[21] Creswell, J. W., and Miller, D. L. (2010). Determining Validity in Qualitative Inquiry. *Theory into Practice*, 39(3), 124–130. Retrieved from http://www.jstor.org/stable/1477543

[22] Boyatzis, R.E. (1998). *Transforming Qualitative Information: Thematic Analysis and Code Development*. Sage.

[23] Ling, T.M. and Harun, J. (2014). Instructional Scaffolding in Online Collaborative Learning Environment for Knowledge Construction among Engineering Students. In *Engineering Education (ICEED), 2014 IEEE 6th Conference on* (pp. 40-45). IEEE.

[24] Du, H. S., and Wagner, C. (2007). Learning with Weblogs: Enhancing Cognitive and Social Knowledge Construction. *IEEE Transactions on Professional Communication*. 50(1), 1–16.

[25] Luca, J. and McMahon, M. (2002). Scaffolding the Development of Students' Cognitive Self-Regulatory Skills. In P. Barker and S. Rebelsky (Eds.), Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications 2002 (1299-1304).