ONLINE INSTRUCTOR SCAFFOLDING IN ENHANCING UNDERGRADUATE STUDENTS' CRITICAL THINKING

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Specially dedicated to my beloved Mother

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I really love and miss you.

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ABSTRACT

This study aims to investigate the influence of four types of instructor scaffolding (i.e. Technical, Content, Procedural, and Metacognitive) via an asynchronous online discussion forum on students' (i) Critical Thinking Engagement (CTE), (ii) Cognitive Performance Test (CPT), and (iii) General Critical Thinking (GCT) test. Students' perceptions of the intensity of instructor scaffolding as well as their own critical thinking engagement performance conducted during the discussion activities within the conversion of explicit and tacit knowledge processes were also studied. This study employs a mixed methods approach, utilizing the pre-experimental, one-group pre-test post-test design with the concurrent triangulation of quantitative and qualitative data that facilitate the comparison and corroboration of results. A sample of 56 final year undergraduate students selected via random cluster sampling from the Faculty of Education and enrolled in the CD-ROM-based Multimedia Development course were the subjects of the study. The dominant type of instructor scaffolding offered was the Metacognitive scaffolding, both at individual and group levels. The findings of this study show that students' higher levels of critical thinking processes could be influenced by instructor scaffolding, with Metacognitive scaffolding having the most impact on students' CTE while Content scaffolding had the most impact on students' CPT, although it was not effective in improving students' GCT. It was also found that Metacognitive scaffolding benefited the high-ability students while Content scaffolding as well as indirect instructor scaffolding benefited the low-ability students. These high-ability students were also likely to improve their CPT and GCT. Students' perceptions of the influence and benefits of instructor scaffolding on their critical thinking skills were positive, thus suggesting the types of instructor scaffolding influenced the intensity of the explicit and tacit knowledge conversion processes. When considering the students' individual different needs, closer investigation through the construction of three decision or prediction pathway models revealed the six most important instructor scaffolding sub-type predictors that could enhance the students' performance in three critical thinking measures: CTE, CPT, and GCT. The findings of this research have implications on online instructors, online course designers and educational technology practice.

ABSTRAK

Kajian ini bertujuan untuk menyiasat pengaruh empat jenis bimbingan oleh pensyarah iaitu (Teknikal, Kandungan, Prosedural, dan Metakognitif) melalui forum perbincangan dalam talian terhadap (i) Penglibatan Pemikiran Kritis (CTE), (ii) Ujian Prestasi Kognitif (CPT), dan (iii) ujian Pemikiran Kritis Umum (GCT) pelajar. Persepsi pelajar terhadap intensiti bimbingan pensyarah serta prestasi penglibatan pemikiran kritis mereka sendiri dalam aktiviti perbincangan yang melibatkan proses penukaran pengetahuan tersurat dan tersirat juga dikaji. Kajian ini menggunakan pendekatan kaedah campuran, melibatkan reka bentuk pra-eksperimen, satu kumpulan ujian-pra dan ujian-pasca dengan triangulasi serentak data kuantitatif dan kualitatif bagi memudahkan perbandingan dan sokongan yang menguatkan keputusan kajian. Sampel terdiri daripada 56 orang pelajar tahun akhir ijazah sarjana muda, yang dipilih melalui persampelan rawak kelompok daripada Fakulti Pendidikan, yang mendaftar dalam kursus Pembangunan Multimedia berasaskan CD-ROM merupakan subjek kajian ini. Jenis bimbingan pensyarah yang dominan diberikan adalah bimbingan Metakognitif di peringkat individu dan kumpulan. Hasil kajian ini menunjukkan bahawa proses pemikiran kritis peringkat tinggi pelajar dapat dipengaruhi oleh bimbingan pensyarah, dengan bimbingan jenis Metakognitif paling berkesan ke atas pelajar CTE pelajar, manakala bimbingan jenis Kandungan paling berkesan dipindahkan ke atas CPT pelajar walaupun tidak berkesan dalam meningkatkan prestasi GCT pelajar. Dapatan juga mendapati bahawa bimbingan Metakognitif memanfaatkan pelajar berkeupayaan tinggi manakala bimbingan Kandungan dan juga bimbingan pensyarah secara tidak langsung memanfaatkan pelajar berkeupayaan rendah. Para pelajar berkeupayaan tinggi juga lebih berpotensi meningkatkan CPT dan GCT mereka. Persepsi pelajar terhadap pengaruh dan manfaat bimbingan pensyarah terhadap kemahiran pemikiran kritis mereka adalah positif, sekali gus mencadangkan bahawa jenis bimbingan yang diberi oleh pensyarah mempengaruhi intensiti proses penukaran pengetahuan tersurat dan tersirat. Apabila mempertimbangkan keperluan individu pelajar yang berbeza, kajian lebih mendalam melalui tiga model keputusan atau ramalan laluan yang dibangunkan mendedahkan enam peramal sub-jenis bimbingan pensyarah yang boleh meningkatkan prestasi pelajar dalam tiga pengukuran pemikiran kritis: CTE, CPT dan GCT. Hasil kajian ini mempunyai implikasi kepada pensyarah dalam talian, pereka bentuk kursus dalam talian dan praktis dalam teknologi pendidikan.

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LIST OF ABBREVIATIONS

AODF	-	Asynchronous Online Discussion Forum
HEIs	-	Higher Education Institutions
LMS	-	Learning Management Systems
MoHE	-	Ministry of Higher Education
IPTAs	-	Public Higher Education Institutions
CTPS	-	Critical thinking and problem solving skills
My3S	-	Malaysian Soft Skills Scale
CMC	-	Computer Mediated Communication
SECI	-	Socialization, Externalization, Combination, Internalization
EDM	-	Educational Data Mining
ZPD	-	Zone of Proximal Development
MaCTIv4	-	Malaysian Critical Thinking Instrument - Version 4
WGCTA	-	Watson-Glaser Critical Thinking Appraisal
CCTT	-	Cornell Critical Thinking Test
CCTST	-	California Critical Thinking Skills Test
CCCTDI	-	California Critical Thinking Disposition Inventory
EWCT	-	Ennis-Weir Test of Critical Thinking Test
RO	-	Research Objective
RQ	-	Research Question
PBL	-	Problem Based Learning
3C3R	-	3C: content, context and connection 3R: researching, reasoning and reflecting
WEKA	-	Waikato Environment for Knowledge Analysis
ARFF	-	Attribute-Relation File Format
PSST	-	Problem Solving Scenario Tasks
TIOS	-	Tool for Analyzing Instructor's Online Scaffolding

CTCSS	-	Critical Thinking Coding Scheme Sheet
SECIQ-CT	-	Knowledge Conversion Processes of Critical Thinking based on the SECI model Questionnaire
P_1	-	Poor performance during pre-test
W_1	-	Weak performance during pre-test
L-A_1	-	Low-Achiever during pre-test
M-A_1	-	Medium-Achiever during pre-test
H-A_1	-	High-Achiever during pre-test
O_1	-	Outstanding performance during pre-test
P_2	-	Poor performance during post-test
W_2	-	Weak performance during post-test
L-A_2	-	Low-Achiever during post-test
M-A_2	-	Medium-Achiever during post-test
H-A_2	-	High-Achiever during post-test
O_2	-	Outstanding performance during post-test
H	-	High-level critical thinking engagement
HL	-	High-Low level critical thinking engagement
L	-	Low-level critical thinking engagement
TCTE	-	Total Critical Thinking Engagement
HCTE	-	High Critical Thinking Engagement
LCTE	-	Low Critical Thinking Engagement
CTE	-	Critical Thinking Engagement
CPT	-	Cognitive Performance Test
GCT	-	General Critical Thinking Test
TS	-	Techinal Scaffolding
CS	-	Content Scaffolding
PS	-	Procedural Scaffolding
MS	-	Metacognitive Scaffolding
TS1	-	Techinal Scaffolding 1 sub-type
CS1	-	Content Scaffolding 1 sub-type
CS2	-	Content Scaffolding 2 sub-type
PS1	-	Procedural Scaffolding 1 sub-type
PS2	-	Procedural Scaffolding 2 sub-type

MS1	-	Metacognitive Scaffolding 1 sub-type
MS2	-	Metacognitive Scaffolding 2 sub-type
MS3	-	Metacognitive Scaffolding 3 sub-type
MS4	-	Metacognitive Scaffolding 4 sub-type
MS5	-	Metacognitive Scaffolding 5 sub-type
MS6	-	Metacognitive Scaffolding 6 sub-type
MS7	-	Metacognitive Scaffolding 7 sub-type
S	-	Static
P1	-	+1 Improvement
P2	-	+2 Improvement
P3	-	+3 Improvement
P4	-	+4 Improvement
P5	-	+5 Improvement
GCT0	-	General Critical Thinking Static
GCT+	-	General Critical Thinking with an increment
GCT-	-	General Critical Thinking with a decrement

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Introduction

Skill in critical thinking is one cognitive outcome in the education process. Higher Education Institutions (HEIs) are centres for raising human capital with the ultimate goal of producing critical thinkers (Golding, 2011). Students, who will be leading the national development agenda in the future, need to be educated and nurtured to think critically. It is more important than ever for HEI students to become better at critical thinking. This is due to the current situation where students are surrounded by and have access to an infinite amount of information from newspapers, magazines, radio, television, or across the Internet, which may lead to misinformation. Critical thinkers should be able to consider, understand, analyse, and make reasoned judgments about that information in terms of its accuracy and credibility, and finally, should be able to act on that information in an effective and responsible way. Therefore, teaching students to become critical thinkers is not just to increase their knowledge but to improve their reasoning and judgment skills (MacKnight, 2000).

Obviously, pressure for HEIs to cultivate critical thinking among undergraduates is growing. Unfortunately, it is a global issue that even by the time they graduate, most HEI students have not reached the higher-levels of critical thinking that involve true reflective judgment. Results from previous investigations by King, Wood, and Mines (1990), Guest (2000), Lipman (2003), and Gelder (2005) have raised concerns regarding the low-level of critical thinking skills demonstrated

by undergraduate students in HEIs in Western Europe and the United States of America. Given this situation, it is not surprising that the same scenario can be seen in the Malaysian context. Rosnani Hashim and Suhailah Hussein (2003) highlighted that while teachers were expected to teach both the content and higher-order thinking skills using the infusion approach, students were still not proficient in applying to real problems the content knowledge they had acquired. Thus, educators are urged to give serious consideration to improving critical thinking skills among students in higher education. Indeed, this target should be set as one of the major desirable outcomes of undergraduate education (Halpern, 1999; Halpern, 2001; Ratcliff et al., 2001; Mclean, 2005).

In order to produce students who can become successful critical thinkers, the instructor plays an important role to educate and nurture a culture of high-level thinking among the students as novices, through the process of teaching and learning. It involves the process of constructing critical thinking skills among the students as novices under the guidance of the instructor as the expert in their respective areas of knowledge and expertise accumulated within the specialist field of expert critical thinkers. The expertise of an instructor is divided into two aspects of knowledge, namely, tacit knowledge and explicit knowledge. Critical thinking can be seen as forming part of the tacit knowledge of an expert (Merza Abbas & Mazida Ahmad, 2007; Osman, 2008; Hosseini, 2010). Tacit knowledge is an aspect of knowledge that cannot be taught directly. The tacit and explicit knowledge that have been formed in the consciousness of the expert through the collection of their skills and past experiences can be transferred to their students through ongoing guidance from the subject matter expert (Merza Abbas & Mazida Ahmad, 2007; Mazida Ahmad, 2010; Golding, 2011). It is believed that it is through the iterative or repetitive acculturation process of the interaction and transaction of tacit and explicit knowledge between the expert and novices that the expertise and quality of thinking of the expert can be transformed and internalized by their students.

Since it is more difficult to express and communicate tacit knowledge compared to explicit knowledge, Nonaka and Takeuchi (1995) introduced the four modes of tacit and explicit knowledge exchange and creation known as the SECI model (i.e. *Socializatio*n, *Externalization*, *Combination*, *Internalization*). The SECI

model is a spiral knowledge process of interaction and transaction between tacit knowledge and explicit knowledge (Nonaka & Takeuchi, 1995). It describes how the expert's tacit knowledge is processed into explicit knowledge and finally absorbed as an individual's or as a group's tacit knowledge.

A guided and structured knowledge creation process influences students' critical thinking skills. A study conducted by Merza Abbas and Mazida Ahmad (2007) revealed that the SECI model has contributed effectively to the context of hierarchical transaction involving experts and novices. Guidance and scaffolding from the instructor as the expert in the delivery and transformation of their knowledge to their students as the novices in the learning environment will enhance the students' ability to a greater or higher extent than would have been possible with their previous capability.

Research findings have consistently shown that scaffolding is effective in fostering the development of critical thinking skills (Rosenshine & Meister, 1992; Sharma & Hannafin, 2005). Scaffolding refers to the help, guidance, assistance, suggestions, recommendations, advice, opinions, and comments that the instructor provides to support the students in their attempt to master the materials and move to a higher-level of understanding. Findings from Osman (2008), Reingold, Rimor, and Kalay (2008), Angeli and Valanides (2009) and Cranney et al. (2011) have demonstrated that students' critical thinking seems to improve most in teaching environments where the learning is mediated and where the instructor provides scaffolding and engages with the students as they perform tasks such as learning, thinking, making decisions, solving problems, and working cooperatively and collaboratively. The instructor could continuously monitor students' progress in every task and at every stage to ensure that specific aspects of their own tacit knowledge are transferred to the students. These processes are repeated until the students develop for themselves a version of tacit knowledge or thought processes that are very similar to the ones modelled by the instructor (Merza Abbas & Mazida Ahmad, 2007; Osman, 2008; Hosseini, 2010).

Students learn to become critical thinkers through their participation in a critical thinking community developed by the lecturer as the expert. Typically, the

process of interaction and transaction of tacit and explicit knowledge between the lecturer and students happens through the process of face-to-face contact during lectures and in assessment guidance activities, including a teaching and learning method based on problems and projects. However, with the help of technology, the interaction and transaction of tacit and explicit knowledge is now extended into online learning or an e-learning method through the use of a Learning Management System (LMS), such as Moodle, Blackboard, WebCT, and Sakai. These LMS are now offering various facilities, such as asynchronous and synchronous forum discussions, quizzes, assessment, lecture notes, and tutorials in an online mode.

A number of advantages have been associated with asynchronous online discussion forum (AODF), a form of text-based computer mediated communication technology used in the LMS to foster collaboration among instructors as the experts and students as the novices for various purposes. Abdul Malek Abdul Karim et al.'s (2012) findings suggest that in addition to offering specific courses to improve the attainment of critical thinking skills, alternative ways to inculcate critical thinking should be embedded in teaching and learning. As the face-to-face in-class contact hours with students are quite limited in HEIs, AODF can be seen as an alternative practical environment for the instructor to actively engage students and guide the students in their thinking and reasoning. Hence, AODF can function as a supplementary method of teaching critical thinking from the infusion of higher-order thinking into content instruction perspective. Moreover, a meta-analysis conducted by Abrami et al. (2014) on strategies for teaching students to think critically revealed that dialogue via AODF environment and authentic instruction are effective in combination in promoting critical thinking, particularly when scaffolding is added to the mix.

1.2 Background of Problem

Critical thinking skills are important in everyday life. Indeed, they form the backbone of soft skills. However, critical thinking is particular to individuals, as each individual perceives and analyses problems or issues differently. Thus, some

individuals have better critical thinking in certain areas, but other individuals have better critical thinking in different areas (Fisher, 2001). According to Abrami et al. (2008:1103), "Critical thinking is a complex and controversial notion that is difficult to define and, consequently, to study". Therefore, the teaching of such skills through instructional interventions is difficult to operationalize.

There are many definitions of critical thinking have been proposed thus scholars of philosophy, cognitive psychology, and education have different approaches when defining critical thinking. According to the psychological viewpoint, critical thinking requires gaining mastery of a series of discrete skills or mental operations and dispositions that can be generalized across a variety of contexts. These skills include concepts such as interpreting, predicting, analysing, and evaluating (Abrami et al., 2008). Accordingly, Lun (2010:21) defined critical thinking as follows:

> Critical thinking can be understood as the purposeful use of various cognitive strategies in an attempt to make a decision, judgment, or to solve a problem. It consists of a cognitive skills dimension and a dispositional dimension. The cognitive skills dimension is comprised of higher-order thinking skills essential for information processing and reasoning. The disposition of the person who performs critical thinking is also important. A critical thinker should be open-minded, flexible, and persistent whilst engaging in critical thinking and be aware and responsive to different situations where critical thinking is needed.

Generally, educators and researchers agree about the importance of teaching and developing students' critical thinking skills in HEIs. Nonetheless, the unpalatable truth indicated by Gelder (2005) is that critical thinking is difficult to acquire as it involves a complicated process, and it takes a long time to achieve a good level. Therefore, as critical thinking is not a guaranteed or natural outcome, educators should instead teach students "how to think" rather than teaching them "what to think" (Pithers & Soden, 2000). However, some experts argue that in practice, little attention has been paid to teaching students how to think due to the current situation where educators often focus on teaching the theory of critical

thinking and expect that the students will eventually become better critical thinkers (Gelder, 2005).

Findings regarding the current state of critical thinking in HEIs have revealed that students do not acquire these skills as much as they could or should. Results from previous research in the United States of America and Western Europe have pointed to the lack of critical thinking ability among undergraduate students (e.g. King, Wood, & Mines, 1990; Guest, 2000; Lipman, 2003; Gelder, 2005). Moreover, Behar-horenstein and Niu (2011) argued that the results of studies examining the impact of instruction on the development of HEI students' critical thinking vary substantially, which suggests more empirical research is required if there is to be an improvement in the teaching of such skills. Even though teaching critical thinking might be difficult, it is certainly not impossible as long as the necessary time and effort are applied (Gelder, 2005).

In the context of Malaysian Higher Education, the Ministry of Higher Education (MoHE) as the governing body of HEIs in Malaysia has put great emphasis on transmitting critical thinking skills to undergraduate students. Critical thinking and problem solving skills (CTPS) is one of the core competencies in the Malaysian Soft Skills Scale (My3S) sets agreed upon for Malaysian public university undergraduates to master before graduation. Thus, developing critical thinking and problem solving abilities among undergraduates is a primary objective in HEIs (Ministry of Higher Education Malaysia, 2006). Starting from July 2010, Public Higher Education Institutions (IPTAs) nationwide have administered the My3S to measure the level of soft skills mastery among undergraduate Malaysian students (Abdul Malek Abdul Karim et al., 2012). The My3S instrument, which consists of 180 items covering 7 aspects of soft skills, namely, critical thinking and problem solving, communications, teamwork, moral and professional ethics, leadership, lifelong learning and entrepreneurial skills, has to be administered three times to each student, that is, when the students first enter IPTAs, again during their mid-term, and finally, when they have completed their studies.

A Malaysian nationwide study was administered through the My3S instrument to compare the students' soft skills in private and in public HEIs. It

revealed consistent findings that students in both private and public HEIs scored second lowest on critical thinking and problem solving skills with the scores for entrepreneurship skills being the lowest compared to other elements (Abdul Malek Abdul Karim et al., 2012). Therefore, by evaluating the findings, it can be understood that there is a need for further improvement in these two elements of soft skills, that is, critical thinking skills and entrepreneurship skills. However, the My3S assessment is based on the students' perceptions, as it is a self-rated instrument and is not in the format of a test. The My3S instrument is not directly testing students' cognitive abilities but rather explores who the students believe they are and what level they belong to. Unfortunately, the disadvantage of a self-rated instrument is that respondents may exaggerate or under-report their responses when responding to items.

So how could it be possible to assess their real critical thinking ability? The actual current state of critical thinking in Malaysian higher education is still vague. The training or teaching of such skills in Malaysia is lagging behind (Akbariah Mohd Mahdzir, 2009). Verbalizing critical thinking, unfortunately, is not a social-cultural norm of the Asian culture. However, this phenomenon can be seen not only in the context of Malaysia, as many of the undergraduate students around the world struggle when asked to engage in critical thinking (Browne, Hough, & Schwab, 2009). Merza Abbas and Mazida Ahmad (2007) thus emphasised the need for alternatives across curricula to provide a gradual immersion in and infusion of the teaching of such skills. They pointed out that lecturers' demonstrations of their own thinking are important in immersing students in critical thinking and in encouraging students to verbalise their critical thinking in the teaching and learning process.

There are two viewpoints on teaching critical thinking. The first one is the generalist view, which suggests that critical thinking is transferable between different contexts, without regard to specific subject matter (Siegel, 1988; Fisher, 2001). On the other hand, the second perspective is the specifist view, which argues against general critical thinking. The specifist believes that critical thinking is always linked to a specific discipline or content or subject domain (McPeck, 1990; Fisher, 2001). Therefore, the methods employed by the universities to teach critical thinking can be classified into two methods, namely, the direct method, which follows the specifist

view and is based on specially designed courses; and the indirect method, which follows the generalist view, with the skills factored in and embedded across the programme courses (Ennis, 1989; Ministry of Higher Education Malaysia, 2006). Findings from reviews, including a meta-analysis on instructional interventions affecting critical thinking, have also confirmed that the indirect or embedded method, which combines both the specific content and general critical thinking instructions, significantly outperforms the direct method (Abrami et al., 2008; Angeli & Valanides, 2009; Bensley, Crowe, Bernhardt, Buckner, & Allman, 2010). However, a systematic review conducted by Tiruneh, Verburgh, and Elen (2014) suggested that by itself, the method employed for teaching critical thinking may not determine the effectiveness of the intervention, but it may indicate that the teaching strategies employed, student and the instructor-related variables, including critical thinking measures, are also important contributing factors for greater improvement in critical thinking.

Merza Abbas and Mazida Ahmad (2007) believed that expert behaviour lies in the domain of tacit knowledge. According to Nonaka and Takeuchi (1995), tacit knowledge is personal, and so it is difficult to communicate or share it with other people. In addition, it is difficult to express tacit knowledge and to present in the form of words and numbers. Tacit knowledge is in the brain and body of an individual, but the individual does not know how to explain it, because it is derived from personal experience and so is hard to formalise. Critical thinking is a part of the tacit knowledge of an expert that cannot be taught directly**.** Thus, the process an expert uses to teach behaviours within his tacit knowledge to a novice does not involve the expert directly telling the student what to do. Instead, the process can occur through employing the four modes of the SECI knowledge conversion processes under the guidance, scaffolding, and supervision of experts (Merza Abbas & Mazida Ahmad, 2007; Eun, 2008; Mazida Ahmad, 2010).

Critical thinking is a product of hard work and must be developed through intentional educational activity. Each lecturer must first examine his own teaching, as critical thinking is often transferred through a lecturer's communication (Golding, 2011). Lecturers' communication and demonstration of their own thinking is important for immersing students in critical thinking and encouraging them to

verbalise their critical thinking in the teaching and learning processes. In fact, students engage in the process of problem solving, decision making, reasoning, and critical thinking through communication, discussion, argumentation, debate, and negotiation with expert critical thinkers (Hosseini, 2010). During the process of knowledge creation, students learn to seek knowledge, to think while processing the knowledge, and finally to make a decision on how to apply the knowledge. Therefore, students are able to improve their learning, their thinking skills, and their decision making skills through the process of knowledge conversion and knowledge creation.

An asynchronous online discussion forum (AODF) is an interactive facility provided in the LMS e-learning system that allows lecturers and students to discuss and exchange information by posting threads in the forum area. AODF provides a space for various interactive and dynamic discussion activities, and has become an increasingly common component used across a range of curriculum areas and at all levels of education. Meaningful online lecturer-student interaction normally takes place in asynchronous discussion forums (Townsend, 2009; Strang, 2011). However, this technology is also no longer limited only to distance learning education, but AODF is now used as a support in addition to traditional on-campus teaching activities (Angeli, Valanides, & Bonk, 2003; Slough & Mueller, 2006; Darabi, Liang, Suryavanshi, & Yurekli, 2013; Loncar, Barrett, & Liu, 2014). Therefore, an AODF environment offers a great venue for the transfer of knowledge from the expert to the novice (i.e. the teaching, sharing, and integration of knowledge). It also contributes to the creation of knowledge (i.e. individual and group learning and the acquisition and production of knowledge). Allowing students to compose their thoughts in writing will provide opportunities for the instructor to scaffold such discussions. The use of well-organized and well-facilitated discussions within structured online forums is exactly the component that is needed in higher education to achieve the larger instructional goal of developing students' critical thinking (Dabbagh, 2003; Darabi et al., 2013).

While critical thinking skills are not designed to be developed through the use of an AODF environment, the use of the AODF environment in the Moodle LMS in this study is justified because the AODF environment is an extension of the

embedded method of teaching critical thinking. This environment allows for the activities of socialization, externalization, combination, and internalization to be conducted iteratively over the length of the course. These SECI dimensions or stages will be explained in more detail later in section 2.12. MacKnight (2000), Merza Abbas and Mazida Ahmad (2007), Lee (2009), Mazida Ahmad (2010), and Hosseini (2010) supported the view that the transfer of knowledge from tacit into explicit can happen through instructor online scaffolding in an online discussion forum within the dynamic dialogue between the instructor and their students. Discussions with the encouragement and scaffolding from the instructor are especially important to enhance the delivery of the instructor's tacit knowledge to the students. Rosenshine and Meister (1992), MacKnight (2000), McLoughlin and Marshall (2000), Lee (2009), Angeli and Valanides (2009), Ferreira and Santos (2009), and Darabi et al. (2011) also strongly supported the idea that scaffolding is especially effective in teaching higher-level cognitive strategies.

Most learners need scaffolding for critical thinking (Rosenshine & Meister, 1992; Osman, 2008; Browne, Hough & Schwab, 2009). However, Townsend (2009) and Wu (2010) further commented that strategies for instructor online scaffolding are not specified. A major challenge facing the instructor in online learning settings is how to structure and scaffold online discussion forums in order to engage students in critical thinking in a primarily text-based environment (Dabbagh, 2003). There is a lack of research on the design and implementation of scaffolding developed and implemented to support critical thinking development in an online learning environment (An, 2010). Furthermore, there is also a lack of research investigating the quantity and types of scaffolding needed to intellectually engage students in an online learning environment (Shi, 2005; Wu, 2010). Therefore, there is a need to identify the dominant instructor scaffolding type and to develop a better understanding of how the intensity of the scaffolding in a structured AODF can promote the development of students' critical thinking.

1.3 Problem Statement

Since 2000, there has been a rapid rise in the use of AODF as a promising and effective instructional tool whereby instructors can cultivate and enhance students' reflective and critical thinking by allowing them to discuss, debate, and exchange ideas in the electronic environment. This is because AODF combines the best features of writing exercises and of online discussions (MacKnight, 2000; Bai, 2009; McLoughlin & Mynard, 2009; Darabi et al., 2013; Loncar, Barrett, & Liu, 2014). From the educational technology perspective, the emphasis on fostering students' critical thinking engagement through AODF is encouraging as it is the extension or supplement of teaching critical thinking in the embedded or infusion method. Nonetheless, although this approach is interesting, studies have shown that there is still a lack of critical thinking at high-levels in the AODF environment (Nykvist, 2008; Osman, 2008; Redmond, 2011) and that more instructor effort is crucially needed (Dabbagh, 2003; Maurino, 2006; Palloff & Pratt, 2007; Williams & Lahman, 2011; Coll, Rochera, & de Gispert, 2014; Loncar, Barrett, & Liu, 2014; Cho & Cho, 2014) to promote the internalization of critical thinking skills and knowledge within this environment (Cheong & Cheung, 2008; Arend, 2009). Moreover, a closer investigation from an extensive literature review conducted for the current study, including a meta-analysis of studies assessing critical thinking and scaffolding through AODF (see section 2.11 and see Table 1.1 for the summary and the simplified version), reveals several gaps that need to be addressed.

First, previous researchers have focused more on students and very few have focused on instructor involvement and effort (Perkins & Murphy, 2006; Cheong & Cheung, 2008). To date, information regarding the current state of scaffolding as an instructor activity applied via an AODF environment remains abstract and general because the design, strategies, and implementation of scaffolding that will allow the instructor to support the development of critical thinking are not specified and well

Table 1.1: Simplified version of 32 studies reviewed (Appendix A - full version)

No	Year	Author	Location	Facilitator Role	IV (Instructor Scaffolding)	DV1 - CT Engagement via AODF	DV2 - Cognitive Performance/ Subject-specific CT	DV3 - General CT
1	1998	Bullen (1998)	British Columbia	Provided questions.	×	√	×	×
2	2000	Garrison, Anderson, & Archer (2000)	Canada	Active moderators and passive instructors.	×	√	×	×
3	2000	Garrison, Anderson, & Archer (2000)	Canada	Active instructor.	×	√	×	×
4	2003	Meyer (2003)	USA	Active instructor.	×	√	×	×
5	2005	Yang, Newby, & Bill (2005)	USA	Teaching and modeling of Socratic questioning.	√	√	×	√ **(*CCTST)**
6	2005	Deloach & Greenlaw (2005)	USA	Focus, prompting to reflect, managerial	×	√	×	×
7	2006	Cheung & Hew (2006)	Singapore	Relatively passive instructor	×	√	×	×
8	2007	Yang (2007)	Taiwan	Teaching and modeling of Socratic questioning (5 graduate students).	√	√	×	√ **(*CCTST)**
9	2008	Cheong & Cheung (2008)	Singapore	Relatively passive instructor	×	√	×	×
10	2008	Jacob & Sam (2008a)	Malaysia	Minimally moderated/ scaffolded	×	√	×	×
11	2008	Jacob & Sam (2008b)	Malaysia	Instructor scaffolded and modeled the process	×	√	√	×
12	2008	Jacob & Sam (2008c)	Malaysia	Relatively passive instructor	×	√	√	×
13	2008	Reingold, Rimor, & Kalay (2008)	Israel	Four types of instructor's scaffolds (i.e. technical, content, procedural, metacognitive)	√	√	×	×
14	2008	Osman (2008)	USA	Students were individually scaffolded via email	√	√	×	×
15	2009	Wang (2009)	Taiwan	Relatively passive instructor	×	×	√	√ **(*CCTST)**
16	2009	Bai (2009)	No information	Relatively passive instructor	×	√	×	×
17	2009	Jacob (2009)	Malaysia	Scaffold with Socratic questioning	×	√	×	×
18	2009	Jacob, Lee, & Lueckenhausen (2009)	Malaysia	Scaffold with Socratic questioning	×	√	×	√ **(*CCTST)**
19	2009	McLoughlin & Mynard (2009)	Japan	Relatively passive instructor	×	√	×	×
20	2009	Prasad (2009)	Fiji	(Before intervention) natural setting, (during the intervention period) - active.	√	√	×	×
21	2010	Irfan Naufal Umar & Noor Hazita Ahmad (2010)	Malaysia	Relatively passive instructor	×	√	×	×
22	2010	Jacob & Sam (2010)	Malaysia	Scaffold with Socratic questioning during the first session	×	√	×	×
23	2010	Richardson & Ice (2010)	USA	No information provided	×	√	×	×
24	2011	Williams & Lahman (2011)	USA	Relatively passive instructor	×	√	×	×
25	2011	Szabo & Schwartz (2011)	USA	Monitoring and facilitation, mostly in the beginning of the semester (first three weeks).	×	√	×	√ **(* EWCT)**
26	2011	Zhang & Toker (2011)	USA	Instructor moderations and peer reviews	√	√	×	×
27	2012	Lin, Hong, & Lawrenz (2012)	Taiwan	Only one hour of scaffolding provided to the experimental group.	×	√	×	×
28	2013	Too (2013)	Malaysia	The instructor summarised feedback on the quality and used a question and answer format.	×	√	×	×
29	2013	Cho & Kim (2013)	USA	Measured as one from eight independent variables	√	×	×	×
30	2014	Yang et al. (2014)	Taiwan	Adaptive individualised feedback - but were Not Measured as IV.	×	√	√	√ **(*CCTST)**
31	2014	Cho & Cho (2014)	USA	Online instructors' scaffolding for interaction.	√	×	×	×
32	2014	Coll, Rochera, & de Gispert (2014)	Spain	Measured types of feedback as IV but in a natural setting, the researchers did not control the variables.	√	×	×	×
This study consider ALL variables				Four types of instructor's scaffolds (i.e. technical, content, procedural, metacognitive)	√	√	√	√ **(*Mactiv4)**

*CCTST - the California Critical Thinking Skills Test ; *EWCT – the Ennis-Weir Test of Critical Thinking Test ; *Mactiv4 – Malaysian Critical Thinking Test

addressed in the literature (An, 2010). Thus, the questions of (i) which is the dominant type of instructor scaffolding via AODF addressed at the individual versus the group level, (ii) which type or types of instructor support have the most impact in promoting students' critical thinking skills, and (iii) how much or what is the appropriate volume or frequency of scaffolding that should be addressed, remain unanswered. Consequently, numerous authors (e.g. Salmon, 2003; Maurino, 2006; Cho & Cho, 2014; Loncar, Barrett, & Liu, 2014) have suggested that there is a need for additional research to be conducted from the perspective of the instructor.

Second, in most of the studies reviewed, the instructor postings were not analysed. Indeed, the relationship between instructor scaffolding and critical thinking has not been clearly investigated. Very few studies have empirically investigated how best to scaffold critical thinking via an AODF environment to make the discussions more productive and to contribute to deep and meaningful learning.

Third, Tiruneh, Verburgh, and Elen (2014) highlighted that the conditions in the critical thinking instructional environment (i.e. critical thinking instructional approach, teaching strategy, instructor-related characteristics, and critical thinking measurement) will influence the effectiveness of the intervention. They revealed that the aspects that have been neglected in previous studies in assessing critical thinking via the AODF environment are (i) the information about the targeted critical thinking components, (ii) a clear explanation that the design of tasks or problems is for either the retention of facts or for the application to other scenarios or contexts, and (iii) the type or types of scaffolding provided by the instructor. Moreover, applying a single measure critical thinking skills will probably add little to our understanding of this complex cognitive skills development (Bensley et al., 2010). As can be seen from Table 1.1, to date, there has been no research that has simultaneously examined three different perspectives of critical thinking measurement, that is, critical thinking engagement via AODF, and the transfer to subject-specific critical thinking and general critical thinking. Yet, these multiple measurements are strongly related to each other in assessing an individual‘s abilities in using different cognitive skills in critical thinking. How do students' critical thinking and idea development differ across the three different types of measurement based on the patterns of the instructor scaffolding types received? Thus, it is not yet known whether students' acquisition

and manifestation of critical thinking within a scaffolded AODF context may influence the development of their subject-specific and general critical thinking skills.

In sum, the existing body of research is obviously too small, and very few peer-reviewed journal articles could be located to provide any strong theoretical and practical grounding regarding how to promote critical thinking through instructor scaffolding via AODF (Wu, 2011). Given these significant gaps, further empirical examination is clearly warranted to better determine if instructor scaffolding via AODF using the infusion approach to teaching critical thinking truly might be able to inculcate students' critical thinking skills. For the above reasons, this study is conducted to investigate the types of online scaffolding provided by an instructor in relation to students' critical thinking engagement via AODF. In addition, in order to further determine which type or types of scaffolding instructors might employ to optimize students' cognitive outcomes, the dominant type of instructor scaffolding via AODF directed at the individual and the group levels were also identified. Online instructors and online course designers, including educational technology researchers, could benefit from knowing more about the appropriate empirically proven scaffolding strategies so that they can utilize and further emphasize the most important type of scaffolding identified to fit the students' needs and ability in promoting students' higher-levels of critical thinking.

As it has been argued that critical thinking is in the domain of the tacit knowledge of an expert (Merza Abbas and Mazida Ahmad, 2007; Osman, 2008; Hosseini, 2010), including the argument that an AODF environment might facilitate the exchange of tacit knowledge (Horton & Horton, 2003; Bryceson, 2007; Tammets & Pata, 2014), this study extends the application of Vygotsky's socio-cultural scaffolding theory with the application of the SECI model by Nonaka and Takeuchi (1995), which emphasizes strong interactions and transactions between the instructor as an expert and the students as novices (Mazida Ahmad, 2010). Furthermore, this study demonstrates how these two theories complement each other to define the online instructor scaffolding process and its implications for students' critical thinking. This study proposes the application of the SECI model as a guiding framework for instructor-students (one-to-many) and student-instructor (one-to-one)

interaction via the AODF environment. The idea of scaffolding is to capture and externalize the instructor's tacit knowledge, make it explicit, and share it within the AODF environment. The SECI model best reflects current research as most of the AODF hidden processes are also applied to the process of knowledge conversion involving socialization, externalization, combination, and internalization. However, while this model is appealing, it has not been shown to be applicable specifically in the AODF environment. Moreover, most studies related to the application of the SECI model in online learning (e.g. Hardaker & Smith, 2002; Huang & Liaw 2004; Kutay & Aurum, 2007) lead to a method that lacks the strong guidance and scaffolding of the instructor in developing individual knowledge, and the research findings have not been convincing. Thus, this study further investigates whether the SECI model could explain the knowledge conversion processes specifically in the AODF context. Improved understanding is needed regarding if and how AODF in the e-learning environment can be utilized and optimized as a medium to externalize and transfer expert (instructor) tacit knowledge to the novices (students) in the effort to promote students' critical thinking skills.

1.3.1 Decision or Prediction Pathway Model

The compilation of meta-analyses (refer section 2.11) mentioned earlier reveals that previous studies that investigated students' critical thinking engagement via AODF as the independent variable have tended to assess the effectiveness of AODF in improving students' critical thinking engagement by attempting to evaluate students' performance either through subject-specific critical thinking (post-performance or final examination scores) or general critical thinking assessment in order to measure the learning outcomes. In fact, the existing studies have also separately evaluated the effectiveness of AODF in enhancing students' cognitive processes during both online and offline learning activities without considering combining both data simultaneously. Thus, the influence of the relationship between the instructor's scaffolding behaviour and the students' critical thinking contributions, as seen in the AODF environment (online), on the transfer and development of students' subject-specific and general critical thinking skills, including students' perceptions of the instructor's scaffolding performance (offline),

is not well understood. Therefore, this merits further investigation for new knowledge discovery.

However, online learning practitioners, such as online instructors, and online course designers, including researchers, are continually seeking improved techniques to observe and monitor students' online learning behaviour to improve the decision making process and make customized learning more efficient. Thus, data mining has emerged as a promising approach in mining instructors' and students' behavioural activities. Educational data mining (EDM) is a new and growing research area, which has attracted researchers especially from the educational technology field, to venture into this latest data analysis technique, which was previously popular in a variety of fields, such as manufacturing, marketing, finance, and bio-medicine (Romero & Ventura, 2007).

EDM, which has emerged from the machine-learning discipline and relies on statistics, offers an alternative approach to making sound, data-driven decisions. One of the data mining techniques that is most suitable, promising, and of practical relevance for analysing educational questions is the decision or prediction pathway model popularly known as decision trees (Romero & Ventura, 2006; Witten, Frank, & Hal, 2011; Peña-Ayala, 2014). A decision tree is a predictive model that refers to a hierarchical model of decisions and their consequences and which can be employed by the decision maker to identify the strategy most likely to achieve a particular expected goal. A decision tree can be viewed as a predictive model that is a mapping from the observations of the selected input attributes to the conclusion about its classification. It is also a simple and highly effective technique originally derived from logic and statistics for predicting and explaining the relationship between input attributes (independent variables - observations) and a target attribute (dependent variable - outcome) and finally represented as a model (Rokach & Maimon, 2008). Hence, an increasing application of EDM might be due to its use of the decision-tree technique to extract hidden but useful information on the behaviour of instructors and students via the online learning environment and to transform meaningless server log data into meaningful information in order to predict students' academic achievement and, later, students' future performance, which is expected to provide a significant added value to improve the quality of higher education.

By using EDM techniques, important but hidden students' AODF learning and instructors' scaffolding behaviour patterns can be extracted and identified for predicting and classifying students' critical thinking engagement, and their subject-specific and general critical thinking achievement. Important informed guided decisions to fulfil online instructors' needs in identifying struggling students, identifying the appropriate type of scaffolding, providing personalized feedback, or adjusting instructors' scaffolding strategies in promoting critical thinking can be addressed by the decision or prediction pathway model (decision trees). The applicability of the decision-tree algorithm to the complexity of online and offline instructor and student behaviour allows a degree of cross checking, which is central to the idea of triangulation.

So far, unfortunately, the majority of the available decision or prediction pathway models have been constructed only by considering the quantity and frequency of students' login, the number of messages read, the number of messages posted, the frequency of accessing course materials, or the frequency of viewing resources, all of which were available and readily retrieved from LMS server log data (Hung, Rice, & Saba, 2012) without considering the instructor's postings and the quality of the students' cognitive processes, such as critical thinking engagement evidence. This might be due to the time consuming procedure of manually coding and categorizing the instructor's and the students' messages from the AODF transcripts. However, an ideal decision or prediction pathway model should consider both the quantitative and qualitative variables involved simultaneously. Moreover, Hung, Hsu, and Rice (2012) suggested that EDM should incorporate multiple sources of evidence, such as AODF server log data, AODF transcripts content analysis findings, and perceptional survey data including performance assessment scores or status, for an effective and in-depth data interpretation. By considering both quantitative and qualitative variables simultaneously, a multiple dimensional decision or prediction pathway model can be constructed that will enable online instructors to discover pathways to engage students in online critical thinking discussion successfully. Students need multiple pathways to demonstrate that they have achieved the required learning outcome, which results in the need for differentiation for every student. Thus, each individual student needs specific nurturing and scaffolding.

The present understanding of how instructors should scaffold critical thinking and how the enhancement of critical thinking happens in the AODF environment, not to mention the shift towards both subject-specific and general critical thinking, is limited. To be able to draw useful conclusions, a combination of multiple forms of data is necessary to provide a richer and deeper analysis. Thus, given the aim to connect this study with the potential application of EDM, the construction of the decision or prediction pathway model may assist online instructors to recognize how their particular types of scaffolding influence students' participation and critical thinking engagement patterns. This may further their understanding of different students' needs in a discussion via the AODF, and so sufficient facilitation strategies can be developed for improvement to better support students and move them towards more advanced forms of critical thinking engagement. Ultimately, the 'work best' scaffolding type, including other key predictors of students' critical thinking performance, can be identified.

In conclusion, the independent variable in this study is on one level: instructor online scaffolding types via AODF. Three dependent variables were evaluated, namely, students' critical thinking engagement (CTE) contributions via AODF, students' subject-specific cognitive performance test (CPT), and students' general critical thinking (GCT) test. There is a heated debate between the general and the subject-specific scholars regarding how critical thinking should be conceptualized and should be taught. On one side, from the perspective of the generalist view such as Ennis (1989), critical thinking has been conceptualized as a generic skill while on the other hand, from the specifist perspective those like McPeck (1990), it has been conceptualized as a subject-specific skill. Therefore, this study attempts to consider both perspectives, and planned to examine not only the influence of the instructor scaffolding type on students' CTE via AODF but also the transfer towards students' CPT and students' GCT ability. This study argues that instructor scaffolding via AODF has a direct influence on students' CPT and students' GCT. Apart from the investigation of the application of knowledge conversion processes via AODF, this research is also expected to construct decision or prediction pathway models that reveal the key predictors that could enhance students' CTE, CPT and GCT performance.

1.4 Research Objectives

1. To identify the dominant type of instructor scaffolding types directed at individual versus group level and their influence on students' CTE via AODF, CPT, and GCT.

2. To identify the students' level of CTE contributions via AODF and investigate how they reach the higher-level of CTE, CPT, and GCT based on the patterns of the instructor scaffolding types.

3. To measure the knowledge conversion processes of CTE based on the SECI model, assisted by instructor scaffolding between the one-to-many (instructor-students), and one-to-one (student-instructor) interaction.

4. To construct three decision or prediction pathway models of knowledge conversion processes via AODF nested with instructor scaffolding that enhance students' CTE via AODF, CPT, and GCT.

1.5 Research Questions

1. What is the dominant type of instructor scaffolding via AODF directed at individual versus group level?

2. What is the students' level of CTE contributions via AODF?

3. What is the influence of the instructor scaffolding types on:
   (i) students' CTE via AODF?
   (ii) students' CPT?
   (iii) students' GCT?

4. How do students reach the higher-level of CTE, CPT, and GCT based on the patterns of the instructor scaffolding types?

5. What is the knowledge conversion processes of CTE based on the SECI model, assisted by instructor scaffolding in the one-to-many (instructor-students), and one-to-one (student-instructor) interaction?

6. What are the three decision or prediction pathway models of knowledge conversion processes via AODF nested with instructor scaffolding that enhance:
   (i) students' CTE via AODF?
   (ii) students' CPT?
   (iii) students' GCT?

1.6 Theoretical Framework

According to Vygotsky (1978) and social constructivism theory, it will be most appropriate to generate higher-level thinking through the medium of social interaction. Thus, Vygotsky's social constructivism can be applied through the AODF medium. Critical thinking emerges and develops as a result of the interaction processes with the mindset of the expert critical thinkers (instructor) in the form of a dialogue before it is formulated to be the self-thought of the novice (student). AODF provides a venue for the instructor and students to express their critical thinking verbally. Therefore, AODF has been identified as an excellent venue for the instructor to implement online scaffolding to increase students' critical thinking (Strang, 2011). The AODF environment can contribute greatly to the transfer and sharing of valuable knowledge. Therefore, it is important to optimize the capacity for interactive social learning to happen in the AODF environment for instructors to transfer their knowledge to students, thus helping the students to develop their critical thinking. How to maximize the interaction in teaching to improve critical thinking in the AODF environment is an important issue that should be studied to produce empirical evidence on the effectiveness of the interaction and transaction of knowledge in this medium.

Nonaka and Takeuchi (1995) introduced the spiral SECI model (socialization-externalization-combination-internalization) in order to describe the process of learning through the sharing, creation, conversion, and transformation of knowledge. According to Nonaka and Takeuchi (1995), knowledge conversion refers to a continuous process of the sharing and transfer of existing knowledge and the creation of new knowledge between the individuals and groups through the interactions of tacit and explicit knowledge. Additionally, knowledge is created, shared, and transferred through interactions among individuals and their environment.

The SECI model describes in detail the transformation and delivery of individual (expert) tacit knowledge to explicit knowledge, which the individuals (novices) within a group later combine, internalize, and reorganize to transform it into the tacit knowledge of the individuals (novices) within a group. The SECI model has four modes, that is, knowledge sharing, creation, conversion, and transformation. Socialization (tacit to tacit) includes sharing existing and creating new tacit knowledge between people through shared experience. It involves the process of accumulating and transferring tacit knowledge. Externalization (tacit to explicit) is a process of articulating and translating tacit knowledge into explicit knowledge through dialogue and reflection so that it can be shared by others to become the basis of new knowledge. Combination (explicit to explicit) is a process of gathering, applying, integrating, transferring, and editing explicit knowledge into more complex sets of explicit knowledge. Internalization (explicit to tacit) is the process of embodying explicit knowledge through action and practice into tacit knowledge. Knowledge is applied and used in practical situations and becomes the base for the creation of new knowledge. Figure 2.2 in Chapter 2 in section 2.13 describes the iterative process of knowledge conversion according to Nonaka and Takeuchi (1995).

1.6.1 Application of Knowledge Conversion Processes to the AODF

The SECI model is suitable for implementation in the context of online scaffolding in the AODF environment in which the process requires a strong

interaction and transaction between instructor and students at the beginning of the process of creating a knowledge-based approach to problem solving. Exploring the knowledge to find the best solution requires students to participate in the process of socialization, externalization, combination, and internalization of knowledge through relevant activities.

Discussions through the online learning environment, specifically in the context of AODF, can be explained by Vygotsky's socio-cultural theory, which states that student performance can be improved by guidance and scaffolding from the instructor. The basic idea behind the SECI model is that the guidance and scaffolding from the expert will be able to raise the novice's knowledge from their existing level of knowledge to a higher-level through interactions and transactions involving tacit and explicit knowledge. The SECI model describes a method of guidance and scaffolding from the perspective of an expert in order to implement Vygotsky's theory.

If viewed from the requirements of Vygotsky's theory (1978), the SECI model, when implemented properly, will ensure that the guidance or scaffolding from the instructor will be focused on the knowledge base of the student and not be based on the subject matter knowledge alone. However, Vygotsky (1978) did not recommend a proper procedure, so it is up to the creativity of the instructor and students to find the method that suits them best. Figure 1.1 refers to the theoretical framework of the present study, the aim being to investigate the influence of instructor scaffolding types on students' critical thinking skills via AODF. This framework describes the interactions between instructor and students via the AODF environment when analysed using Nonaka and Takeuchi's SECI model.

Interactions between students and instructor during the teaching and learning process is the most important stage where the instructor imparts knowledge and students absorb knowledge in order to transform tacit knowledge into explicit knowledge. The essence of teaching and learning higher-order thinking is the process that takes place between instructor and students of transforming tacit knowledge into explicit knowledge. Tacit knowledge can be socialized and externalized while explicit knowledge can be combined and internalized. Given that AODF is a

common place for communication between the instructor and students in the e-learning environment, AODF can be seen as an environment to create chances and conditions to transform knowledge, in which knowledge can be shared, created, transferred, and used. Instructor and students exchange their tacit and explicit knowledge via dialogue. The SECI model can explain the processes of the direct and indirect scaffolding practice that could occur between the instructor and the students. In the socialization process, interaction and discussion occur between the instructor and his students. Through the discussion and communication process, students are able to absorb the instructor's tacit knowledge. In the externalization process, the instructor externalizes his thoughts through different types of online scaffolding to scaffold students' critical thinking. Thus, the instructor externalizes his tacit knowledge and thoughts through the scaffolding process. The scaffolding encourages the students to think, explore, and analyse problems. Therefore, during the question and answer session with the instructor, the tacit knowledge is disclosed, assembled, and edited to become explicit knowledge. The different types of expert guidance and scaffolding are prompted from the dialogue occurring through the instructor-students and student-instructor interactions via the AODF environment. In the combination process, students articulate their thoughts while engaging in a critical thinking dialogue. Students later make sense of and combine the explicit knowledge through their experience, including taking responsibility for the task assigned to them. Finally, in the internalization process, students internalize their experience and later on apply their knowledge to a new context. Taken as a whole, the appropriate scaffolding from the expert influences the intensity of the socialization, externalization, combination, and internalization processes in the SECI model and shapes a meaningful learning experience to enhance students' critical thinking.

1.6.2 Instructor Scaffolding

The present study examines the role of instructor scaffolding via the AODF environment in developing students' critical thinking skills. This study proposes that instructors should instead look to online discussions as evidence of students' current critical thinking levels and then, through appropriate scaffolding, facilitate activities

to move the students forward so that they are able to think critically and work at higher-levels of critical thinking.

After an extensive literature review on scaffolding was conducted in order to define instructor scaffolding via the AODF environment (see sections 2.9 and 2.10), Reingold, Rimor, and Kalay's (2008) tool was chosen for analysing online instructor scaffolding (TIOS-Tool for analysing Instructor's Online Scaffolding), which consist of four types of scaffolding (i.e. technical, content, procedural, metacognitive). Hence in this study, the instructor scaffolding types are adopted from Reingold, Rimor, and Kalay's (2008) TIOS tool in order to identify the type of scaffolding that is most dominant and most frequently given to the students and to find which of the various types of scaffolding will allow the instructor to scaffold students' critical thinking most effectively, especially in the AODF environment.

1.6.3 Critical Thinking Skills

Due to the different versions and definitions of critical thinking and the need for better instruments for testing critical thinking, this study aims to explore how online instructor scaffolding via AODF relates to measurement of three different perspectives of critical thinking (i.e. students' CTE, students' CPT, and students' GCT). The goal is to identify if there is any correlation between online instructor scaffolding and students' CTE, students' CPT, and students' GCT. That is, does online instructor scaffolding make a difference to students' CTE, CPT, and GCT scores? Furthermore, this study is interested in seeing if there is a relationship between the CTE demonstrated by students in AODF and their CPT and GCT ability. The main purpose is to see if students who exhibit a higher-level of CTE via AODF might have better CPT and GCT scores. However, assessing or measuring critical thinking is a challenging endeavour. The next section discusses the CTE, CPT, and GCT in the context of the present study.

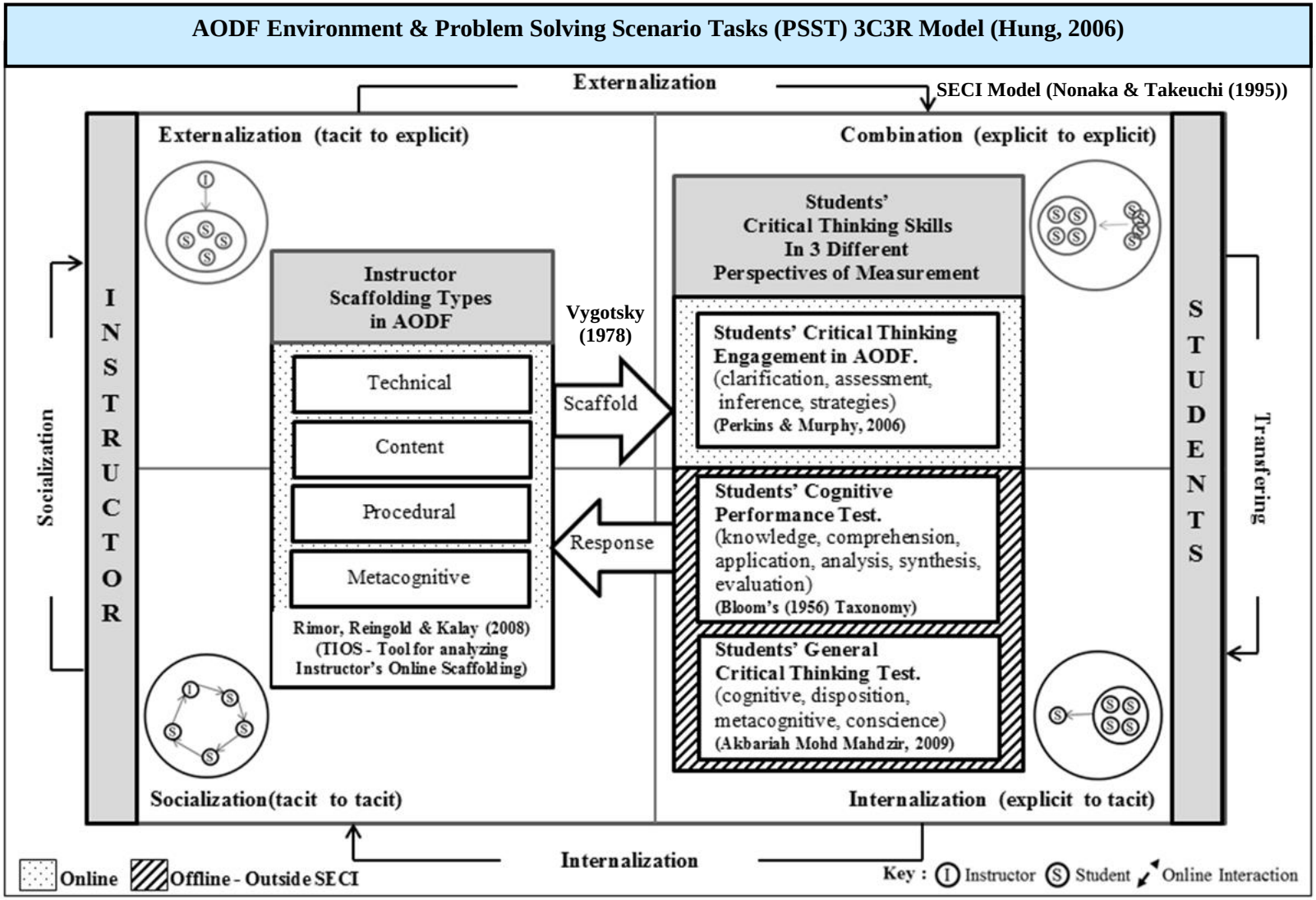

Figure 1.1: Theoretical framework to investigate the influence of instructor scaffolding types on students' critical thinking skills via AODF

1.6.3.1 Critical Thinking Engagement (CTE)

The definition of students' CTE via AODF is adopted from Perkins and Murphy (2006) model for identifying critical thinking processes or assessing individual CTE in the context of online discussions. Four critical thinking processes were identified (i.e. clarification, assessment, inference, strategies). *Clarification* includes all aspects of proposing, describing, or defining an issue; *Assessment* refers to various types of judgments, including the use of evidence to support or refute an argument; *Inference* covers inductive and deductive reasoning, and all other thinking skills; while *Strategies* includes proposals for dealing with the issue under consideration. Therefore, in this study, students' CTE was measured by the Perkins and Murphy (2006) model.

1.6.3.2 Cognitive Performance (CPT)

In order to test for critical thinking changes in the subject area using instruments appropriate for that content, students' subject-specific CPT was employed. The definition of student's CPT used in this study is adopted from Bloom's (1956) taxonomy of educational objectives that describe all learning as a progression through six phases (i.e. knowledge, comprehension, application, analysis, synthesis, and evaluation). However, while the majority of researchers still refer back to Bloom's (1956) taxonomy in characterizing critical thinking, other scholars refer critical thinking to higher-levels of Bloom's taxonomy, namely, application, analysis, synthesis, and evaluation (Weltzer-Ward, 2011). Even though this taxonomy has been widely used as a basis for classification systems for the construction of examination questions at all levels in Malaysia, a detailed justification for remaining with the original version compared to the revised version by Anderson and Krathwohl (2001) is offered in section 2.4.2. Therefore, in this study, students' CPT was measured by Bloom's (1956) taxonomy as the classification of educational objectives because the cognitive domain is still dominated by Bloom (Ben-hur, 2006; Moseley et al., 2005), and the majority of education researchers have consistently based their theories upon Bloom's idea.

1.6.3.3 General Critical Thinking (GCT)

The definition of student's GCT in this study is adopted from the conceptualization of the Malaysian Critical Thinking Model by Akbariah Mohd Mahdzir (2009). The conceptualization of this model is derived from the consensus obtained from the experts involved in the qualitative requirements of her study. The Malaysian Critical Thinking Instrument - Version 4 (MaCTIv4) developed from the model was adopted for this research in order to measure undergraduate students' GCT skills. MaCTIv4 will be discussed in more detail in sections 2.4.1 and 2.4.4. MaCTIv4 was designed to measure four areas (i.e. cognitive complexity, disposition of mind, metacognition, and conscience). Specifically, cognitive complexity components are used to address the primary skill areas of issue identification, evaluation of the credibility of statements, induction, deduction, assumption, inference, and evaluation of arguments. The second measure addresses the disposition to think critically, and the third measure addresses metacognition. The fourth component, conscience, addresses the values that one holds as the basis for decision making or for evaluating a situation (Akbariah Mohd Mahdzir, 2009). Thus, in this study, students' GCT was measured by a standardized test (MaCTIv4) developed by Akbariah Mohd Mahdzir (2009).

1.6.4 Problem Solving Scenario Tasks (PSST) for AODF Environment

A CD-ROM-based Multimedia Development course was chosen as the learning subject, and the rationale for the selection of this course is discussed in detail in section 5.2. This course offers several opportunities to teach argument analysis and critical thinking skills. The instructor can infuse critical thinking that fits into the subject-content by having students critically evaluate, for example, the advantages and disadvantages of a variety of instructional design theories and instructional design models and an appropriate combination of learning theories, which can be applied in producing highly presentable educational multimedia courseware. This, in turn, could help students demonstrate critical evaluations and competencies as instructional designers in the development of interactive multimedia courseware especially for teaching and learning purposes. The assessment via AODF involved a set of discussion activities designed to provoke or motivate students to

think critically in an attempt to solve realistic educational multimedia courseware development problems while the instructor assists them by scaffolding their thinking at the group and individual levels within the AODF environment. With the need to design and develop suitable authentic and realistic tasks to be embedded within the AODF environment to meet the research objectives, a scenario-based learning instructional design approach was considered an important element to be included in the design and development of such discussion activities. The problems were designed and implemented in the course structure according to the proposed steps in Hung's 3C3R model (Hung, 2006) and by adopting the guiding questions from Tawfik, Trueman, and Lorz (2013). The relevance of using the 3C3R model as the problem design model and the way this model was used to develop the problem solving scenario tasks is discussed further in section 5.4.

1.7 Significance of the Study

While researchers such as Garrison, Anderson, and Archer (2001), Darabi et al. (2013), Cho and Cho (2014), and Loncar, Barrett, and Liu (2014) have revealed the importance of online instructor scaffolding in their research findings, there is a clear trend for an increasing amount of research into automated scaffolding (e.g. computer-embedded-scaffolding, and software-tool-based-scaffolding), which has led to a lack of research into human dynamic scaffolding. The widespread use of automated scaffolding has outpaced our understanding of how human dynamic scaffolding can be designed to best meet students' individual needs during online discussions (Osman, 2008; Wu, 2011). This has led to a phenomenon of "teacher-less" learning, although human dynamic scaffolding can actually be practised and implemented by a huge number of online instructors compared to automated scaffolding, which is often impractical as it can be applied to only a limited context.

In order to bring about improvements in e-learning development programs, much more must be known about how instructors understand and conduct scaffolding specifically via the AODF environment. This study will provide some useful insights into the scaffolding and measurement of critical thinking via AODF

including help clarify the relationship between instructor scaffolding types and students' critical thinking skills in shaping the SECI spiral. The knowledge conversion processes as defined by the SECI factors will help course designers or instructors to redefine the roles and activities of the instructor and the students in order to make learning via AODF environment more efficient and productive to improve students' cognitive learning and critical thinking. The findings in this study could be used as a basis for further research into the AODF environment from the perspective of the SECI model. The majority of the previous research implementing the SECI model in online learning was limited to virtual learning environments or LMS perspectives as a whole. Thus, this research places the model in a new environment, and indicates that instructors can use the indicators of the SECI factors to plan a course via AODF. This research also examines the impact of the instructor scaffolding type on students with different levels of critical thinking ability. Thus, the findings of this research indicate which dominant instructor scaffolding type influences the students' critical thinking the most and which works best for students with a particular level of critical thinking ability. It is therefore felt that the findings of this research will not only help stakeholders, such as online instructors, course designers, and educational technology researchers, to plan, manage, and improve the impact on knowledge creation and high-quality critical thinking using dynamic human scaffolding within the AODF environment, but will also have significant implications for the development of novice online instructors in providing guidelines for online scaffolding practice. Furthermore, this study will also help to improve the capacity for teaching critical thinking via the AODF environment and will help explain the processes and the intensity of the interactions and transactions from the instructor's tacit knowledge to the students' tacit knowledge. Understanding such factors could guide our frameworks for critical thinking promotion, scaffolding, and instruction. Finally, the findings and implications of this study will guide the design, instruction, and facilitation of online discussion forum at the undergraduate level in order to enhance and develop students' critical thinking.

1.8 Operational Definition

The following are definitions of some of the terminology used in this dissertation. The definitions represent how the researcher chose to conceptualize the particular concept for the purposes of this study.

i. **Online Instructor Scaffolding** refers to the help, guidance, assistance, suggestions, advice, opinions, feedback, and comments given by the instructor as an expert to help students as novices master the learning and extend their thinking processes, which can result in improving students' critical thinking skills as they engage in the asynchronous online discussion forum (Vygotsky, 1978; Wood, Bruner, & Ross, 1976). In this study, the online instructor scaffolding is measured by Reingold, Rimor, and Kalay's (2008) TIOS, which consists of four types of scaffolding (i.e. *technical*, *content*, *procedural*, and *metacognitive*).

ii. **Instructor Scaffolding Directed at Individual Level** (one-to-one, student-instructor interaction) refers to the help, guidance, assistance, suggestions, advice, opinions, feedback, and comments addressed by the instructor to each student on an individual basis. In this study, each student received a different frequency of online instructor scaffolding directed at their individual level.

iii. **Instructor Scaffolding Directed at Group Level** (one-to-many, instructor-students interaction) refers to the help, guidance, assistance, suggestions, advice, opinions, feedback, and comments addressed by the instructor to the entire group of students enrolled in the course. In this study, each student received the same frequency of online instructor scaffolding directed at the group level.

iv. **Total Instructor Scaffolding Received** refers to the combination frequency of online instructor scaffolding received directed at the individual level and of online instructor scaffolding received directed at the group level for each student.

v. **Enhancing** means to raise to a higher-level.

vi. **Undergraduate Student** refers to students at Year 4 who are undergoing a Bachelor's Degree of Education program at the Faculty of Education, in one of the Malaysian HEIs prior to becoming graduate teachers.

vii. **Critical Thinking** in this study refers to students' three different critical thinking perspectives of measurement (i.e. CTE, CPT, and GCT).

viii. **Critical Thinking Engagement (CTE)** refers to four critical thinking processes, namely, *clarification*, *assessment*, *inference*, and *strategies* via the AODF environment. *Clarification* is associated with the processes that seek understanding of the issue or that express understanding at a low-level. Such processes include asking questions, stating, clarifying, describing, or defining the issue. The second process, *Assessment*, involves the use of judgments, evaluating some aspects of the debate, and the use of assessments. The third process, *Inference*, describes the use of hypotheses and making generalizations, as well as the use of deductive and inductive reasoning. The process of *Strategies* covers all aspect of proposing, discussing, or evaluating possible actions in an attempt to resolve the issue. *Strategies* in this case does not mean the use of an algorithm to analyse or solve the problem, but refers to practical proposals for dealing with the issue (Perkins & Murphy, 2006). In this study, the students' CTE is measured by the Perkins and Murphy (2006) model.

ix. **Cognitive Performance (CPT)** refers to critical thinking from the perspectives of Bloom's taxonomy of educational objectives with six different categories: *basic knowledge*, *comprehension*, *application*, *analysis*, *synthesis*, and *evaluation*. The first two categories, namely, *basic knowledge* and *comprehension*, do not require critical thinking skills and are categorized as lower-order thinking skills, but the last four, namely, *application*, *analysis*, *synthesis*, and *evaluation*, require critical thinking skills and are categorized as higher-order thinking skills (Bloom, 1956). In this study, the students' CPT is measured by Bloom's (1956) taxonomy. The increment in students' CPT refers to the increment in the mean scores of students' CPT pre-test and post-test.

x. **General Critical Thinking (GCT)** is a set of thinking skills with cognitive and affective elements of *cognitive complexity* ability, *disposition of mind*, *metacognition*, and *conscience*, which is strongly influenced by individual experience and based on a person's values. It is an active, consistent, and careful construction of mental processes and behaviour. The first measure is to address the *cognitive complexity* ability, which refers to the primary skill areas of issue identification, evaluation of the credibility of statements, induction, deduction, assumption, inference, and the evaluation of arguments. The second measure is to address the *disposition* to think critically, and third measure is to address *metacognition*. The fourth component, *conscience* is to address values that one holds as the foundation in decision making or in evaluating a situation (Akbariah Mohd Mahdzir, 2009). In this study, the students' GCT ability is measured by a standardized test (MaCTIv4) which was developed by Akbariah Mohd Mahdzir (2009). The increment in students' GCT ability refers to the increment in the mean scores of students' before and after MaCTIv4 test.

xi. **AODF** is the abbreviation of Asynchronous Online Discussion Forum. It is one of the computer-mediated communication (CMC) tools widely used in educational institutions to promote learning. It is a place where instructors and students can engage in text-based conversation organised into topic-based discussion threads. Asynchronous means it can occur at any time rather than simultaneously with another person. Specifically in this study, it is a part of the Moodle Learning Management System (LMS). It allows time-delayed discussions on networks where instructor and students do not have to be logged in at the same time but can read and respond to each other's messages whenever convenient (Moore & Marra, 2005).

xii. **Tacit Knowledge** refers to the intuition, ideas, experiences, and perceptions that underlie the conscious or unconscious nature of the expert and which form part of their discipline or subject-specific critical thinking capabilities and their general critical thinking skills (Nonaka & Takeuchi, 1995).

xiii. **Explicit Knowledge** refers to the ideas, experiences, perceptions, structured and routine thoughts in the form of easily transferred knowledge associated

with the discipline or subject-specific critical thinking knowledge that can be articulated in formal language (Nonaka & Takeuchi, 1995).

xiv. **Socialization** refers to the process of social interaction and transaction between students and instructor and students with other students via the AODF to communicate their tacit knowledge and explicit knowledge (Nonaka & Takeuchi, 1995).

xv. **Externalization** refers to the process of individual and collective group knowledge construction that will be controlled and monitored by the instructor. It refers to the transformation process from the instructor's tacit knowledge to explicit knowledge through the different types of scaffolding provided via the AODF (Nonaka & Takeuchi, 1995).

xvi. **Combination** refers to the process whereby the students gather, share, and reflect their explicit knowledge into new knowledge that can be shared individually and collectively as a group. Students will later make of sense and combine their explicit knowledge through their experience (Nonaka & Takeuchi, 1995).

xvii. **Internalization** refers to the process whereby the students internalize their experience and later apply and construct new knowledge or enhance and improve their existing individual critical thinking skills (Nonaka & Takeuchi, 1995).

xviii. **Knowledge Conversion Processes** refer to a process that explains the interaction between tacit and explicit knowledge or, in simpler terms, a 'conversion' from tacit to explicit knowledge and vice versa. This process explains how tacit and explicit forms of knowledge dynamically interact with each other in challenging activities between the instructor as an expert and the students as novices within the AODF environment in order to create new knowledge. The outcome of the knowledge conversion is the improvement and development of students' critical thinking skills (Nonaka & von Krogh, 2009).

1.9 Summary

This chapter provides a background study and rationale for this research by providing an overview of critical thinking, AODF, and the importance of instructor dynamic online scaffolding in the promotion of students' critical thinking skills. The main goal of the present study is to further extend the socio-cultural Vygotskian theory of scaffolding with the application of knowledge conversion processes by Nonaka and Takeuchi's SECI model to the AODF environment in order to investigate the socialization and externalization of the expert tacit knowledge to the students' tacit knowledge through a practice of verbalizing their critical thinking in the AODF environment. In the context of this study, the different types of scaffolding provided by the instructor as an expert represent a means of externalizing (making explicit) the instructor's tacit knowledge, which will later be combined by the students with other explicit information from the online discussions on related topics, thus helping students to internalize the accumulation of knowledge for the improvement and development of their critical thinking skills. It aims to identify which particular scaffolds may be best applied to which individual student in order to help instructors select the most effective type or types of scaffolding that will allow them to scaffold students' critical thinking best especially in the AODF environment. In the next chapter, Chapter 2, a detailed review and analysis of the literature in key areas of relevance to the study will be presented.

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