COGNITIVE ENGAGEMENT IN A COMPUTER-SUPPORTED COLLABORATIVE LEARNING ENVIRONMENT

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UNIVERSITI TEKNOLOGI MALAYSIA
COGNITIVE ENGAGEMENT IN A COMPUTER-SUPPORTED COLLABORATIVE LEARNING ENVIRONMENT

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Al-Fatihah, A. Shukor A. Majid. Father, this is for you.
For your patience, understanding and infinite love,
Abdul Wafi Yahaya
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My heartiest thanks to my supervisor, Assoc. Prof. Dr. Zaidatun Tasir; for all the guidance, patience, and care. Thank you for everything that you’ve put me through, making me realize that the world is not round and it takes two people to have things work.

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Thank you Allah.

–Nijmegen, 19 April 2012
ABSTRACT

The quality of online learning is determined by students’ cognitive engagement. Recent research reported that students are cognitively engaged but mostly at the low-level of cognitive engagement (CE). High-level of CE is more beneficial as it shows that new knowledge is constructed. This research is proposing the usage of online computer-supported collaborative learning (CSCL) environment to promote students’ CE to the higher-level. Samples were undergraduate students from two different cohorts who enrolled in the Web-based Multimedia Development subject. Cohort I (n = 61) consists of students who involved in earlier investigation on students’ CE in online learning environment and cohort II (n = 20) consists of students who learned in CSCL environment. Through pre-experimental research design, students from cohort II answered the pre and post performance tests. Next, they were asked to solve CSCL tasks through online discussions in CSCL environment. Their online discussion scripts were collected and analyzed using content analysis method to obtain CE codes. The students’ server log files, CE codes and performance test score were gathered to structure a performance predictive model using WEKA data mining software. Findings show that 34.04% of students from cohort I contributions in online discussion were at the low level. As for students in cohort II, they shows 70.23% cognitive contributions in nature but the percentages of low-level CE remains higher than the high-level CE. However, the CSCL environment was found to provide positive impact on students’ performance in test (p < 0.05). Meta analysis (Cohen’s $d = 1.858$) of t-test shows that the effect size of CSCL environment towards students’ performance in test is significant. Even if this experiment is repeated, the power value (0.970) implies that the same result will be obtained. The performance predictive model predicts ‘argumentation’ as important for better performance in test. Conclusively, CE can be nurtured in CSCL environment but it is influenced by factors such as the group functions, the instructor’s role, and the type of CSCL task. For better future performance in test, this research suggests that students should be encouraged to provide more arguments on statements while solving CSCL tasks such as justifying statements and giving critics with elaboration.
ABSTRAK

Kualiti pembelajaran atas talian ditentukan oleh penglibatan kognitif (PK) pelajar. Kajian terkini mendapati bahawa pelajar terlibat secara kognitif, namun kebanyakan PK pelajar berada di aras yang rendah. PK di aras yang tinggi adalah lebih bermakna kerana ia menunjukkan terdapatnya pembinaan pengetahuan baru. Kajian ini mencadangkan penggunaan persekitaran pembelajaran kolaboratif berbantuan komputer (PKBK) untuk menggalakkan PK pelajar di aras yang lebih tinggi. Sampel terdiri daripada pelajar pra siswazah daripada dua kohort yang berlainan yang mendaftar subjek Pembangunan Multimedia berasaskan Web. Kohort I (n = 61) terdiri daripada pelajar yang terlibat dalam kajian awal tentang PK pelajar dalam persekitaran pembelajaran atas talian dan kohort II (n = 20) terdiri daripada pelajar yang belajar di persekitaran PKBK. Melalui reka bentuk kajian pra eksperimental, pelajar kohort II menjawab ujian pencapaian pra dan pos. Seterusnya mereka diminta untuk menyelesaikan tugas PKBK melalui perbincangan atas talian dalam persekitaran PKBK. Skrip hasil perbincangan mereka dikumpulkan dan dianalisis menggunakan teknik analisis kandungan untuk memperoleh kod PK. Rekod log data pelajar, kod PK dan markah ujian pencapaian pelajar dikumpul dan digunakan untuk membentuk model peramal pencapaian menggunakan perisian perlombongan data WEKA. Dapatkan kajian mendapati 34.04% catatan pelajar kohort I dalam perbincangan atas talian adalah di aras yang rendah. Bagi pelajar kohort II, mereka menunjukkan 70.23% catatan secara semulajadi berbentuk kognitif walaupun peratusan PK aras rendah tetap melebihi PK aras tinggi. Walau bagaimanapun, persekitaran PKBK didapati memberi impak positif terhadap pencapaian pelajar dalam ujian (p < 0.05). Meta analisis (Cohen $d = 1.858$) ujian t mendapati kesan persekitaran PKBK terhadap pencapaian pelajar dalam ujian adalah signifikan. Walaupun jika kajian ini diulangi, nilai kuasa (0.970) menunjukkan dapatan yang sama akan diperoleh. Model peramal pencapaian menjangkakan ‘perdebatan’ sebagai aspek penting untuk memperoleh pencapaian ujian yang lebih baik. Kesimpulannya, PK boleh dibentuk dalam persekitaran PKBK tetapi dipengaruhi oleh faktor seperti fungsi kumpulan, peranan pengajar dan jenis tugasan PKBK. Bagi pencapaian yang lebih baik dalam ujian di masa hadapan, kajian ini mencadangkan pelajar harus digalakkan untuk memberikan perdebatan dalam pernyataan semasa menyelesaikan tugas PKBK seperti mengeluarkan pendapat yang beralasan dan memberikan kritikan dengan penerangan.
**NEDERLANDSE SAMENVATTING**

De kwaliteit van online leren is afhankelijk in de mate waarin studenten cognitief betrokken zijn bij het onderwerp dat zij bestuderen. Deze betrokkenheid wordt ook wel “cognitive engagement” genoemd. Men maakt een onderscheid in hoog niveau van cognitive engagement (CE) waar nieuwe kennis wordt geconstrueerd en van een laag niveau, waar kennis gereproduceerd wordt. Bij online leren, zo heeft recent onderzoek uitgewezen, is de CE meestal van een laag niveau. In deze studie wordt een computer supported collaborative learning (CSCL) omgeving gebruikt om het niveau van CE te verhogen. De deelnemers aan het onderzoek waren bachelor studenten van twee verschillende Cohorten die een cursus volgden in Web-based Multimedia Development. Cohort I bestond uit 61 studenten die de cursus deden in een online leeromgeving (individueel) en Cohort II bestond uit 20 studenten die de cursus deden in een CSCL omgeving. Er werd gewerkt met een quasi-experimenteel design met een cognitieve toets als pre-test en post-test. Cohort II loste een aantal problemen op door met elkaar te discussiëren in de CSCL omgeving. De discussies werden online verzameld en inhoudelijk geanalyseerd met behulp van een codeerschema, om de mate van CE te bepalen. De logfiles van de studenten, de CE codes en de resultaten van de cognitieve test werden met een datamining techniek geanalyseerd (WEKA software) om te komen tot een model met voorspellende waarde. De resultaten lieten zien dat 34.04% van de bijdragen van Cohort I van een laag CE-niveau was. Ook de studenten in Cohort II produceerden meer bijdragen van een laag niveau dan van een hoog niveau. Daar staat tegenover dat 70.23% van de bijdragen van cognitieve aard was. De CSCL omgeving had een positieve invloed op de cognitieve test ($p < 0.05$). De effect size gemeten met Cohen’s $d$ was 1.858. De power value van 0.970 geeft aan dat dezelfde resultaten behaald zullen worden bij herhaling van het experiment. Uit het predictive model kan afgeleid worden dat het geven van argumenten in de discussie leidt tot betere resultaten in de cognitieve test. We kunnen concluderen dat CE gestimuleerd kan worden in een CSCL omgeving, maar dat de CE beïnvloed wordt door een aantal factoren zoals de samenstelling van de groep, de rol van de online docent en het type taak. Om beter te presteren zouden studenten uitgedaagd moeten worden om meer te argumenteren en meer te elaboreren op de aangeboden stof.
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CHAPTER 1

INTRODUCTION

1.1 Introduction

The current learning situation proves that surfing the internet (which is relatively considered ‘online’, will have the following benefits. It will: get people connected, share information (Kwisnek, 2005), make life more cost effective (Twigg, 2003), provide flexibility (O’Leary, 2005) and render distance is no longer a factor (Bonanno, 2005; Goldsmith, 2002). For some time, online learning has been a learning option, Whether or not online learning is efficient for training, distance learning, or in-class supporting teaching and learning systems (Cavanaugh, 2009; Kwisnek, 2005), it is apparently useful to support and enhance learning processes (O’Leary, 2005; Zhang et al., 2004). Therefore, the purpose of online learning should deploy the advantages of being online.

Curran (2001) cited that it is undeniable that technology can enhance the quality of education and open up more opportunities for learning, however, to what extent? Reviewing the perception that learning is possible when students are actively constructing knowledge, it implies that the cognitive tools can be anything as long as they engage learning processes (Jonassen, 1991). Furthermore, there remain mixed results about the effectiveness of online learning despite world-wide implementation some years. Results vary with respect to educational tasks, as well as student populations (Curran, 2001). Variations in results being obtained with respect to students’ learning outcomes in online learning situations have led current researchers
to proceed to investigate the process of learning, rather than determining the success of learning outcomes in particular (Dennen & Paulus, 2005; Sieber, 2005; Van der Meijden, 2005). For effective online learning, the ‘product’ of learning is now regarded as something that will be obtained at the end of learning. It is now the ‘process’ of learning that that appears to matter (Sieber, 2005).

The quality of online learning was regularly recognized through students’ satisfaction and perception towards their experiences in learning through this method (Ituma, 2011; Palmer & Holt, 2009), however, the transparency of this method remains an issue (Shank, 2010). It would be more well-founded if quality validation was made pedagogically throughout the online learning activity, such as investigating their cognitive engagement in an online learning environment. Cognitive engagement has been an area under discussion for authenticating students’ learning in traditional classrooms for quite some time until the present (Rotgans and Schmidt, 2011b; Helme and Clarke, 2001; Corno & Mandinach, 1983).

Various perspectives were chosen to evaluate cognitive engagement in online learning, such as taking the view of knowledge construction (Schellens et al., 2008; Van der Meijden, 2005; Flynn, 2004). Knowledge construction can vary from a low to a high level, where deep engagement is reached at the higher level. This occurs when students can finally manipulate the knowledge that they have and be able to come up with new concepts about same (Van Aalst, 2009). It involves a variety of cognitive processes (Van Aalst, 2009; Beers et al., 2005). As such, on-going research is being carried out to boost students’ levels of knowledge construction, and aim towards a higher level for harmony in meaningful online learning (Schellens et al., 2008; Van der Meijden, 2005).

In a collaborative learning environment, it was found that students’ cognitive engagement can be potentially increased since interaction with peers promotes sharing of ideas resulting in knowledge construction (Veerman and Veldhuis-Diermanse, 2001). Studies found that collaborative learning provides opportunities for sharing information, which in turn will encourage self-reflection on their own learning (Mukama, 2010). Also, collaborative learning increases students’
acquisition of knowledge and encourages their cognitive development accordingly (Nyikos and Hashimoto, 1997). In fact, Valcke et al (2009) found that students learning in a collaborative learning environment are able to reach a higher level of cognitive processing and metacognitive regulations. Researchers suggest that higher cognitive engagement in a collaborative learning environment is attributed to arguments, critiques and idea generations evolving through a series of discussions among group members during collaborative learning. This results in increased involvement of students’ thinking, which subsequently leads to higher cognitive engagement (McLoughlin and Luca, 2000).

1.2 Background of Problem

Despite the blessings of learning online, do the students actually learn while studying online? The quality of online learning remains questionable, particularly with regard to the effectiveness of online learning (Chen, Lambert & Guidry, 2010). The rapid growth of online learning triggers the need to have quality online programmes (Kim & Bonk, 2006). It is important to note that learning online is significantly more complex than in traditional settings. Sixty percent of the students in a study reported that online learning is more challenging than face-to-face learning (Kim, Liu & Bonk, 2005). As such, online learning should function as a way to learn new skills rather than simply being regarded as a luxury (Kwisnek, 2005). It requires students to be highly responsible for their learning (Nedelko, 2008; Sieber, 2005), as online learning is often learner-centred, active learning, independent learning, and requires a degree of self-motivation (Nedelko, 2008; Kerr et al., 2006).

In fact, compare with face-to-face communication, Kim, Liu and Bonk (2005) reported that students communicating online are not able to perceive gestures, tones, and body languages while interacting as in face-to-face interaction. Thus, this could conceivably cause misunderstanding. Text-dependency in most online learning environments can trigger misinterpretation or worse, misconception. As indicated by Stahl and Hesse (2009), it is necessary for both readers and writers to be at the same
level for knowledge to be shared in an online learning environment. Accordingly, Savery (2005) also mentioned that the absence of verbal communication in online learning environments can be unpleasant for both students and instructors who are unfamiliar with this scenario.

As such, successful online learning demands dynamic students with highly-developed dimensions of cognitive and communicative aspects (Bai, 2003). It is also important to note that online learning might bring about effects where students feel isolated due to the difficulty of building up close interaction between learners in online settings (Graff, 2006). Thus, it is important that students are indeed learning in online learning settings. This goal can be achieved through observation of students’ cognitive engagement in online discussions (Zhu, 2006).

1.2.1 Cognitive Engagement in Online Learning

Due to the complexity and diversity of learning online, students’ online learning processes should be monitored closely to ensure that learning, and indeed meaningful learning, does in fact occur. For learning to be truly meaningful, students need to be cognitively engaged (Solis, 2008). Cognitive engagement is an indication of the learning process taking place where students exert an amount of mental effort to become engaged with the learning material (Richardson & Newby, 2006; Walker, Greene and Mansell, 2006). Research explaining cognitive engagement in online learning is plentiful (see works by Wysocki (2007) and Zhu (2006)), as cognitive engagement is a prerequisite for students’ meaningful learning (Solis, 2008; Bai, 2003). It is also critical for the creation of new knowledge and understanding (Zhu, 2006).

In a face-to-face learning environment, cognitive engagement is visible when students give sustained attention to a given task requiring mental effort (Corno & Mandinach, 1983). Typically, cognitive engagement is measured from the dimension of, namely: students’ time on task (Nystrand & Gamoran, 1991), students’
participation (Sparkes, 2007), students’ control and relevance of schoolwork, and future aspirations and goals (Appleton et al., 2006). There are also few research works associating cognitive engagement with motivational constructs such as self-efficacy (Scott & Walczak, 2009; Walker, Greene & Mansell, 2006; Greene et al., 2004). Students will then assess themselves by answering surveys and questionnaires, such as the Student Engagement Instrument (Spanjers, 2007; Appleton et al., 2006), National Survey of Student Engagement (Chen, Lambert & Guidry, 2010) and Student Engagement Questionnaire (Coates, 2005).

However, due to the complexity of the online learning context, cognitive engagement seeks for an innovative method of evaluation where different ways of observing cognitive engagement in online learning are necessary. Beer, Clark and Jones (2010) argue that using such a method does not reflect the quality of engagement. Zhu (2006) further explains that it is almost impossible to observe cognitive engagement in an online learning environment but it can be understood from the richness of discussion messages. Regarding online learning context, Zhu (2006, p. 454) clarifies cognitive engagement as:

“.. attention to related readings and effort in analyzing and synthesizing readings demonstrated in discussion messages. Cognitive engagement, as defined, involves seeking, interpreting, analyzing, and summarizing information; critiquing and reasoning through various opinions and arguments; and making decisions.”

Discussion messages in online learning are text-based and computer-mediated. Warschauer (1995) described writings as the intersection between interaction and reflection. By this tenet, several researchers are found to measure cognitive engagement through different lenses for an online learning context based on students’ written discourse (Janssen et al., 2010; Oriogun, 2006; Veerman & Veldhuis-Diermanse, 2001). For example, students’ cognitive engagement is explored through their argumentations in discussion (Weinberger & Fischer, 2006; Veerman, 2000) and higher order thinking and critical thinking (McLoughlin & Luca, 2000; Stoney & Oliver, 1999). It is also investigated through students’
knowledge construction in asynchronous or synchronous communication (Schellens et al., 2008; Beers et al., 2005; Van der Meijden, 2005; Veerman & Veldhuis-Diermanse, 2001; Gunawardena et al., 1997). The emerging trends indicated that previous researches utilized students’ written discourses to reflect their cognitive engagement in online learning. By collecting students’ online learning written discourses, they infer that:

“.. by externalising thinking processes, students make statements and counter statements, defend and challenge each other’s assumptions.” (McLoughlin & Luca, 2000, p. 3).

By this proposition, investigating cognitive engagement through knowledge construction has gained the greatest attention. Several analyzing coding schemes have been developed to analyze students’ knowledge construction in online learning. However, previous studies found that students' level of cognitive engagement (or knowledge construction) were at the low-level (McLoughlin and Luca, 2000; Zhu, 2006; Schellens et al., 2008). For example, Zhu (2012) found that despite the variety of cultural backgrounds involved in the online discussion (Chinese and Flemish students), similar results were observed; that is, fewer messages that reached a high level of knowledge construction.

A low level of cognitive engagement signifies that students were only externalising their thinking processes using their existing knowledge, for example, by sharing and comparing information (Zhu, 2012). Learning at a low level of cognitive engagement is only beneficial to sustain the discussion and online interaction (Zhu, 2012). Constructing knowledge at a higher level is more important for students’ learning, particularly online, because it ensures students are experiencing meaningful learning (Rahman et al., 2011). At the high-level of cognitive engagement, students externalise thoughts that involve arguments, justification, or decision making. Those are the attributes that help students to be critical thinkers and thereby able to construct new knowledge (McLoughlin and Luca, 2000).

As such, what can be done to increase students' level of cognitive engagement in online learning? Students have to be positioned at the level where they are able to
construct new knowledge by arguing, justifying or asking and answering questions. A specific environment has to be designed to nurture these behaviours that enable the construction of new knowledge.

1.2.2 Knowledge Construction and Computer-supported Collaborative Learning

Knowledge construction develops in a collaborative learning environment where students communicate by sharing information in groups for solving given tasks (Dillenbourg & Fischer, 2007; Alavi & Dufner, 2005; Crook, 1998). Knowledge construction per se, is the vivid evidence of collaborative learning taking place (Alavi & Dufner, 2005; Veerman & Veldhuis-Diermanse, 2001; Crook, 1998), as students learning in a collaborative learning environment have to make their thoughts clear (Ding, 2009; van Boxtel, 2000).

With the growing usage of computers and technological affordances, computer-supported collaborative learning has become an emerging educational technology paradigm (Gros et al., 2005; Lipponen, 2002; Koschmann, 1996) that provides principles to design effective online learning environments. Originating from collaborative learning, computer-supported collaborative learning (CSCL) occurs where the processes of peer interaction, working in groups, sharing and distribution of knowledge are supported by technology (i.e computers) (Lipponen, 2002). CSCL highlights methods whereby technology-assisted collaborative learning increases interaction with peers and cooperativeness in group. The purpose of collaborative learning is to enable students to learn by working together to solve learning tasks (Gros, 2001; Kumar, 1996). This occurs where students are found to possess knowledge sharing behavior in a CSCL environment through the implemented peer-assisted learning (Auttawutikul & Natakuatoong, 2008).

Thus, students were exposed to the CSCL environment to trigger knowledge construction among students learning online. Previous records of students’ knowledge
construction in online learning indicated that, for some period, most of the students’ online discourses were information-sharing statements which fell into the lower degree of cognitive engagement (Ma, 2009; Schellens et al., 2008; Zhu, 2006; Schellens & Valcke, 2005; McLoughlin & Luca, 2000). There was no empirical remark that a higher order learning process such as construction of new knowledge and critical analysis of peer interaction had taken place in their discussions (Van der Meijden, 2005; Veerman & Veldhuis-Diermanse, 2001; McLoughlin & Luca, 2000).

Recent studies also reported that interaction in the CSCL environment is of high density (Leon et al., 2010; Rimor, Rosen & Naser, 2010; Lipponen et al., 2003). However, students tend to interact at the level of ‘rapid consensus’, where students tend to accept peers’ opinions not necessarily because they agree with each other, but merely to hasten the discussion (Rimor, Rosen & Naser, 2010). A great number of students also entered the collaborative learning space for the main purpose of downloading materials (Leon et al., 2010). Although messages were posted, the contents related to social regulations rather than task-related activities (Janssen et al., 2010). Stoney and Oliver (1999) previously noted that off-task activities usually signify that students are deviating from the programme. Also, even though students are highly motivated, they are found not to be reaching deep cognitive engagement (Blumenfeld, Kempler and Krajcik, 2006).

The addressed issues are due to several influencing factors. The first is the use of communication media during the collaboration process. Researches indicate that students communicating in asynchronous medium posted more messages of a higher-level of knowledge construction compared to messages in synchronous communication (Schellens & Valcke, 2005; Van der Meijden, 2005; Veerman & Veldhuis-Diermanse, 2001). This is because asynchronous communication provides retention time for: self-reflection (such as the time to provide opinions and reflecting information) (Veerman & Veldhuis-Diermanse, 2001), processing information (Kim, Liu & Bonk, 2005) and being aware of how group dynamics evolve (Solimeno et al., 2008). It also allows the students to review the threaded discussion to gain better insights about the discussion topic (Kim, Liu & Bonk, 2005).
Another influencing factor is related to the structure of the collaborative tasks. Several studies reported that the collaborative tasks should be structured to initiate social interaction (Dixon, Dixon & Axmann, 2008; Van der Meijden, 2005; Blake & Rapanotti, 2001). Veerman and Veldhuis-Diermanse (2001) mentioned that a structured task is a task which is very complex, requiring students to regulate their activities in order to solve a given task. Dixon, Dixon and Axmann (2008) reported that discussion can cause confusion and that the collaborative exercises must be structured so that the students are aware of the expected interactions. Furthermore, most findings reported that interacting in the CSCL environment, mainly in asynchronous mode of communication, is time-consuming. This is due to the time that the students have to spend on reading, reflecting, and responding to the threaded discussion (Dixon, Dixon & Axmann, 2008). This is supported by Blake and Rapanotti (2001) who reported that the structured collaborative tasks will prepare students for a comfortable environment to work with (Blake & Rapanotti, 2001). Hence they will be more aware of the key centres of their activities (Lipponen et al., 2003).

Above all, Garrison (1993) and Kreijns, Kirschner and Jochems (2003) emphasized that, despite the numerous variables associated with the effectiveness of a CSCL environment, they all led to a similar conclusion, namely; social interaction. Through the perspective of socio-cultural theory, social interaction plays a central role for individual cognitive development (Dillenbourg et al., 1996). Later, knowledge is internalized by an individual at the individual plane (Dillenbourg et al., 1996). “Social” and “individual” are perceived as unity rather than being dichotomous (John-Steiner & Mahn, 1996). Thus, the psychological tools useful for internalization are not individually constructed, but are “a product of socio-cultural evolution to which individuals have access by being actively engaged in the practice of their communities” (John-Steiner & Mahn, 1996). Placing students in an environment where social interaction is possible technologically is insufficient to drive social interaction. Dillenbourg (1999) mentioned that something has to be done in order for the desired interaction to occur.
This is equally agreed upon by Chung et al., (2008) who mentioned that simply positioning students in a group does not guarantee that their learning skills will improve. Dillenbourg and Fischer (2007) indicated that the success of collaborative learning is subject to productive interactions. They cited that interaction in a collaborative learning environment has to be designed (Dillenbourg & Fischer, 2007). Most CSCL environments that have been developed can function very well, but they are lacking in terms of the sociability of the environments (Kreijns & Kirschner, 2004). It is therefore important to design the CSCL environment in a way that triggers interactions, particularly towards achieving learning outcomes and considers constraints that may inhibit interactions. Strijbos, Martens and Jochems (2004) suggest six considerations to design interaction in a CSCL environment. These consider:

i. determining the type of learning objective to be achieved,

ii. determining the expected interaction,

iii. selecting the task-type with respect to the learning objective and the expected interaction,

iv. determining whether structure is necessary with respect to the learning objective, expected interaction and the task-type,

v. determining the group size that suits the learning objectives, expected interaction, task-type and level of pre-structuring, and

vi. determining how a computer will be utilized to support learning and expected interaction.

Upon defining the interaction for CSCL environment in a productive interaction, it is then useful to assess students’ learning processes in online learning. The success of learning processes can be measured in various ways. The most common way of assessing students’ learning gain would be through their performance in achievement tests.
1.2.3 Performance Predictive Model to illustrate students’ cognitive engagement in CSCL environment

Crook (1998) stated that the typical method of assessing the effectiveness of a collaborative learning environment is by assessing students’ learning outcomes in performance tests (post-performance test scores). Subsequently, research methodology emerged where researchers tended to investigate whether collaborative learning can predict better academic performances. Crook (1998) added that what ‘is lacking is how collaborative learning is ‘resourced’. This is true for the fact that the existing researches in collaborative learning tend to test on different influencing factors that enable collaborative learning to be successful. Dillenbourg (1999) pointed out that this is meaningless as there are too many variables involved and it all depends on the context of investigation.

In a case where collaborative learning is assessed to determine the quality of learning through students’ cognitive engagement, a performance predictive model is useful to illustrate such a case. Other than assessing students’ performance tests, by using a decision tree algorithm, researchers will be able to understand the processes that took place that finally point to the obtained results (Witten, Frank and Hall, 2011). From the performance predictive model, the researcher would be able to see the actual factors that caused certain specific outcomes. Different performance outcomes might be caused by different cognitive engagement behaviours, or it may be resourced from the same cognitive engagement behaviour.

The available performance predictive model did not capture the importance of illustrating students’ cognitive engagement in online learning. Instead, the common variables used to construct students’ performance predictive model are variables that are readily retrieved from online learning databases such as: students’ login frequency, number of messages posted, number of read messages or the frequency of viewing resources (Macfadyen and Dawson, 2010; Hung and Zhang, 2008). What is lacking are the variables to determine the quality of the discussion messages (in this case cognitive engagement), since those are often assessed separately where instead both should be investigated simultaneously. Researchers subsequently found that
students’ participation in online learning is plentiful, the students were found to be actively learning in an online learning environment and the density of interaction is high (Leon et al., 2010; Rimor, Rosen & Naser, 2010). However, it can not necessarily be concluded that students’ are indeed ‘learning’ because most of them result from social regulations rather than on-task discussions (Janssen et al., 2010). By analyzing the variables that include both cognitive engagement and students’ participation in online learning, a two-dimensional performance predictive model can be constructed which considers both qualitative and quantitative aspects of students’ learning online.

Research needs to be carried out to investigate how to increase students' level of cognitive engagement, particularly in online learning. Using a performance predictive model, researchers as well as educators will know which cognitive contribution is important for online learning success. In the future, educators will be able to encourage specific cognitive contributions (emerging from a performance predictive model) to enable students' better cognitive engagement, as well as their academic performances.

1.3 Problem Statement

Online learning has been cited as one of the emerging methods of learning possessing multiple learning approaches. Evaluation of online learning has been carried out in several ways and one of them evaluates students’ discourses in online learning to investigate their respective cognitive engagement (Zhu, 2006). Students’ cognitive engagement is vivid evidence of the learning process taken place. Through analysis of students’ discourse, students’ cognitive engagement can then be measured from a knowledge construction point of view (Rotgans & Schmidt, 2011a).

Knowledge construction which develops in a collaborative learning environment is useful in understanding students’ cognitive engagement in online learning. However, previous researches indicated that students’ knowledge construction in online learning remains at the lower level (McLoughlin and Luca,
2000; Van der Meijden, 2005; Schellens et al., 2008). Interaction has been found to be of high density, but tends to focus on social regulations (Janssen et al., 2010). These are due to several influencing factors such as the use of communication mode, the structure of the collaborative tasks and lack of interactions. A properly designed CSCL environment is proposed to be able to enhance students' level of knowledge construction towards the higher degree and thus be able to address the aforementioned influencing factors.

Therefore, the purpose of this research is to first, analyse students’ levels of cognitive engagement without having to go through a systematic group learning activity. Next, this research developed an online CSCL environment with the aim of increasing students’ cognitive engagement, as well as their academic performances. Upon implementation, it is important to evaluate the effectiveness of the developed CSCL environment towards students’ academic performances. A performance predictive model is a useful illustration by which to provide the overall picture that leads us to the conclusion of the research. It will provide the interaction route that the students took to achieve specific levels of engagement and academic performances.

1.4 Research Objectives

The objectives of this research are, namely:

i. To analyze students’ level of cognitive engagement in online learning,
ii. To develop a computer-supported collaborative learning environment,
iii. To investigate the influence of CSCL environment on:
   a. level of cognitive engagement,
   b. students’ performance in tests.
iv. To investigate students’ attainment of a higher level of cognitive engagement in the CSCL environment,
v. To construct a performance predictive model of students’ cognitive engagement in the CSCL environment.
1.5 Research Questions

The research questions are, namely:

i. What are the students’ levels of cognitive engagement in online learning?

ii. What are the influences of the CSCL environment in regard to:
   a. levels of cognitive engagement?
   b. performance in tests?

iii. How do students reach higher levels of cognitive engagement in the CSCL environment?

iv. What is the performance predictive model of students’ cognitive engagement in a CSCL environment?

1.6 Theoretical Framework

The theoretical framework of this research is presented in Figure 1.1. Initially, the term ‘cognitive engagement’ is made transparent for future reference. Prior analysis works have explained that computer-supported collaborative learning (CSCL) can support both co-construction of knowledge (Lipponen, 2002; Lehtinen et al., 1999) and greater social interaction (Lehtinen et al., 1999; Paavola et al., 2002). Thus, the CSCL environment is developed for the purpose of enhancing students’ cognitive engagement in online learning, which accords with the principles of CSCL by Bonk and Cunningham (1998) and the CSCL interaction principles of Jochems, Marten and Strijbos (2004).

For the development of a CSCL environment, a systematic approach has to be used. The Three-Phase Design (3PD) instructional design model (Sims & Jones, 2003) is used for developing the CSCL environment. The model, as according to Sims (2003, p. 6), is shown in Figure 1.1:
Figure 1.6: Research Theoretical Framework.

Cognitive Engagement in Online Learning & Performance

Students' attention to discussion messages that can be illuminated by activities such as (Van der Meijden, 2005):
- Seeking
- Interpreting
- Analyzing
- Summarizing
- Critiquing
- Reasoning through various opinions and arguments
- Making decisions (Zhu, 2006)

Performance:
- Pre & Post Tests

Computer-supported Collaborative Learning Environment

Three-phase Development Model

Functionality
- Peer review
- Evaluation
- Maintenance

Performance predictive model of students' cognitive engagement in CSCL environment
“The implication of applying the 3PD model is that the original functional system will always be subject to change, and that development environments need to schedule resources for the lifetime of that course. The continual process of gathering and incorporating evaluation data caters for the sustainability of the course”.

Upon implementation of the CSCL environment, the data obtained from students’ server log files and students’ discussion scripts is analysed using an integrated analytical model. From these processes, this research hopes to ascertain the levels of students’ cognitive engagement in the CSCL environment, how students were cognitively engaged and how they performed in performance tests based on the construction of a performance predictive model. The following sub-topics will provide greater insight on each element of the proposed theoretical framework.

1.6.1 Cognitive Engagement in Online Learning

The definition of cognitive engagement is adapted from Zhu’s (Zhu, 2006) previous work. His definition of cognitive engagement relates to the students’ attention to discussion messages, which can be observed from behaviour seen in several postings (Zhu, 2006). According to Zhu (2006), students’ mental efforts can be translated into activities such as seeking, interpreting, analyzing and summarizing information, critiquing and reasoning through various opinions and arguments, and, finally, making decisions. The related activities are respectively the characteristics of collaborative co-construction of knowledge (Van der Meijden, 2005). Hence, cognitive engagement in this respect can also be understood as being students’ sustained mental efforts towards co-construction of knowledge while solving a given task.

Addressing cognitive engagement as being students’ “sustained mental effort for co-construction of knowledge” will be useful particularly in an online learning
context where observation is almost impossible to be carried out. Students’ textual material being produced during discussions can serve as a representative of their mental activities and interactivity (Muirhead, 2000).

### 1.6.2 Computer-supported Collaborative Learning Environment

The proposed CSCL environment in this research integrates both CSCL principles (Bonk and Cunningham, 1998) and CSCL interaction design principles by Jochems, Marten and Strijbos (2004). The following discussions will provide detailed descriptions on how both principles are integrated to boost cognitive engagement in online learning.

#### 1.6.2.1 CSCL principles based on Socio-cultural Theory

Socio-cultural theory views learning as a process that should occur in a social context (Jeon, 2000). The social context is the primary dimension in this theory, where Vygotsky (1978) asserts that a child’s development appears between people (social plane) (that is, the inter-psychological category) and between a child (individual plane) (that is, intra-psychological category). Nevertheless, individual learning remains applicable in this theory, but as a secondary dimension (Jeon, 2000).

For the development of educational tools, Bonk and Cunningham (1998) are convinced that specific learning theory should be the basis so that the educational tools function respectively. They further elaborated the theoretical foundations of CSCL environments with respect to socio-cultural theory. They discussed the principles for a CSCL environment as indicated in Table 1.1.
### Table 1.1: Socio-cultural Theory and Principles for CSCL Environments  
(Bonk & Cunningham, 1998)

<table>
<thead>
<tr>
<th>Principles</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mediation</strong></td>
<td>Mediated tools are used to assist individual psychological activities.</td>
</tr>
<tr>
<td><strong>Zones of Proximal Development (ZPD)</strong></td>
<td>Collaborative learning is monitored by Zone of Proximal Development where it indicates the distance between the actual developmental level and the potential developmental level (Vygotsky, 1978).</td>
</tr>
<tr>
<td><strong>Internalisation</strong></td>
<td>Internalisation is successful if an individual is able to perform the collaborative task independently.</td>
</tr>
<tr>
<td><strong>Cognitive Apprenticeship</strong></td>
<td>The more capable peers help the less capable so that the less capable can carry out tasks independently.</td>
</tr>
<tr>
<td><strong>Assisted Learning</strong></td>
<td>Learning is assisted by specific teaching strategies.</td>
</tr>
<tr>
<td><strong>Tele apprenticeship</strong></td>
<td>Technologies are used to aid collaborative learning.</td>
</tr>
<tr>
<td><strong>Scaffolded Instruction</strong></td>
<td>More capable or expert peers assist the less capable whenever necessary by giving hints, elaborations, guidance, questions, prompting and other similar techniques.</td>
</tr>
<tr>
<td><strong>Inter subjectivity</strong></td>
<td>Collaborative group members shared temporary understanding about certain concepts or facts.</td>
</tr>
<tr>
<td><strong>Activity Setting as Unit of Analysis</strong></td>
<td>Activity has to be the central of collaborative learning where collaborative group members understood their roles for collaborating.</td>
</tr>
<tr>
<td><strong>Distributed Intelligence in Learning Community</strong></td>
<td>The knowledge gained from collaboration should be spread around the learning community.</td>
</tr>
</tbody>
</table>
1.6.2.2 The designing principles of CSCL environment for interaction

To tackle interaction issues that have previously been described, interaction in a CSCL environment has to be properly designed so that it triggers communication leading to knowledge sharing, and thus knowledge is constructed (Strijbos, Martens and Jochems, 2004). Veerman and Treasure-Jones (1999) quoted that for students to argue in a collaborative problem-solving environment, task characteristics and structured interaction play an interconnected role. Strijbos, Martens and Jochems (2004) proposed a process-oriented methodology for which the influence of interaction factors is composed of six designing steps. These are, namely:

i. learning objectives,
ii. type of interaction
iii. task-type
iv. level of pre-structuring,
v. group size, and
vi. computer support.

For designing the CSCL environment to foster interaction, questions should be addressed with respect to the six designing steps which are discussed clearly in Chapter 5 (Strijbos, Jochems & Martens, 2004).

1.6.3 Three-phase Development Instructional Design Model

According to Beach (2008), the Three-phase Design (3PD) model is based on Weaver’s Emergence theory (Weaver, 1948). The model, which is developed by Sims and Jones (2003), supports revision, enhancement and adaptability. The model emphasized collaboration and ongoing works of the team over various phases. It allows analysis of instructional problems and immediate accurate solutions (Beach, 2008).
In relation to the instructional design, the model considers the following issues with respect to online learners, namely:

i. learners have the potential to advance and define their own essential knowledge base,
ii. the very uncertainty and lack of predictability of learning outcomes will be the key factors that add value to a learning community,
iii. emergent systems will provide the necessary triggers to enhance knowledge and understanding, and
iv. emergent learning will be one of the critical triggers by which individual creativity will be unleashed (Kays & Sims, 2006).

1.6.4 Integrated Analytical Model for Analyzing Students’ Cognitive Engagement in Online Learning

In this research, an integrated approach model is suggested to assess both aspects of students’ online learning. To investigate the quality of online learning, students’ cognitive engagement is assessed through their written messages in online discussions using the content analysis technique. A specific coding scheme by Van der Meijden (2005) is used to code the messages.

On the other hand, the data on students’ participation in online learning for quantitative assessment is retrieved from the available Learning Management System (LMS) databases (students’ server log files) and is further analyzed using the data mining technique.

Students’ scores in performance tests, coded messages and students’ server log files formed a complete data set that was used to construct a performance predictive model for students’ cognitive engagement during online learning.
1.6.5 Students' performance predictive model

A students' performance predictive model will illustrate the overall activities occurring within the CSCL environment. The model will be able to predict which cognitive attribute(s) is/are beneficial for students' attainment of a higher degree of cognitive engagement.

1.7 Research Rationale

The rapid and continuous growth of online learning provides the reason for conducting the present research. There are plenty of instructional designs, as well as pedagogical aspects, being incorporated within online learning websites. Evaluations of the effectiveness of developed websites are also studied. However, research on the pedagogical aspects, such as students’ cognitive engagement in the learning processes, will provide a greater insight into online learning. The relevance of cognitive engagement being narrowed down as the main scope of this research is due to several reasons.

Firstly, online learning is widely applied, but the quality of such learning context on students’ knowledge gains remain dubious. Although several efforts have been made to investigate students’ level of cognitive engagement in online learning, it was found that, for some time, students’ cognitive engagement remains at the low level. This scenario is worth researching, for online learning should be able to trigger students to achieve a higher level of cognitive engagement. Additionally, previous researches were also unable to fill the empty gap about the way in which students’ cognitive engagement in online learning can be related to their academic performances.

Overall, online learning that provides support for cognitive engagement will facilitate students’ learning and enhances academic performances even more. The
idea of using the CSCL approach to promote cognitive engagement in online learning is based on the premise that it might enable an increase in students’ academic performances and social skills by providing a set of guiding principles for learning and interacting.

1.8 Relevance of Research

The findings from this research are very useful to illustrate the current degree of students’ cognitive engagement in online learning settings. Upon recognising the degree of students’ cognitive engagement in online learning discussion, this research provides the framework for elevating the students’ lower degree of cognitive engagement in online learning context to the higher degree. The research would also examine varying impacts of a collaborative learning environment on students with differing levels of performance in tests.

1.8.1 Relevance of Research to Students

Students can benefit from the present research by being able to ascertain their degree of cognitive engagement in online learning. Being at a low-level, students can further propose self-intervention to enhance their learning performance. Similarly, students at the higher-level will be encouraged to maintain their current performance. Other than that, the students will be able to discover the important aspects of learning that should be emphasized for better future learning performance (for example, the importance of either sharing information or arguing). From the knowledge discovered in this research, students are able to maximize their mental efforts in an engaged learning environment, so that they can excel in the learning course, together with the skills that will be refined in this research.
1.8.2 Relevance of Research to the Educators

As noted by Tu and Yen (2007), it is important to investigate individuals’ reactions towards the mediated environment. Thus, the findings of the research would suggest to academicians and educators the domains of collaborative learning that most affect students’ performances. It would be comprised of either the scaffolding instructions, the group composition or a result from other domains.

Also, educators will be able to ascertain important aspects that contributed to better cognitive engagement in online learning and thus enhance learning performances. It would be by way of either encouraging students to share information and elaborate on it, arguing on facts, asking and answering questions or due to other aspects. From the knowledge gained in this research, the educators can put in more emphasis to specific areas that can contribute to better cognitive engagement among the students.

Other than that, this research will explain the factors that either contribute to or might inhibit students’ cognitive engagement and learning performances in online learning. Thus, educators can benefit by proposing early planning, mediation or intervention to their students at hand.

1.8.3 Relevance of Research to Ministry of Higher Education, MOHE

Online learning has been widely applied in higher education institutions throughout Malaysia with the aim of aiding students’ learning at any time and in any place. In this research, the Ministry of Higher Education, MOHE, will be informed on how cognitive engagement can predict students’ future performance. MOHE will be informed on the effects of instilling cognitive engagement for students’ learning online. In the near future, MOHE should spread awareness of observing students’ cognitive engagement while learning online through activities involving collaborative learning, CSCL.
1.8.4 Relevance of Research to Society

To a greater extent, the culture of building knowledge within a community, as is being applied in this research, will be able to produce valuable human resources. These resources will possess a variety of skills such as; being socially interactive, problem-solvers, and decision-makers, rather than simply being academically outshined.

1.9 Scope and Limitation of Research

This section provides information on the area being covered by this research. The limitations are also clearly stated to provide useful guidance for future research.

1.9.1 The Context

The research focuses on the students’ cognitive engagement in the online learning context, specifically through their online learning discussions under the influence of a collaborative learning environment. Cognitive engagement in this research’s context is reflected from students’ construction of knowledge in discussion messages while solving the given tasks.

The tasks are problem-solving tasks for the subject of Web-based Multimedia Development, as being taught in the Faculty of Education, Universiti Teknologi Malaysia.
1.9.2 The Samples

Samples in the present research are Malaysian undergraduate students who have basic computer skills, such as ability to operate Microsoft Word, PowerPoint, and Excel. The samples have also learned several computer subjects such as Basic Computer Programming and Digital Video and Animation. Simply said, they are computer literate, and thus, skills for learning online are not discussed but rather their cognitive engagement while completing the given task. However, limitations consisting of their differences in basic computer skills, as well as gender factors, are not being considered in this research.

1.10 Operational Definition

Following is a description of how different terminologies are used in the research.

1.10.1 Knowledge Construction

Van Aalst (2009, p. 11) defined knowledge construction as involving a variety of cognitive processes such as:

“.. explanation-seeking questions and problems, interpreting and evaluating new information, sharing, critiquing, and testing ideas at different levels and efforts to rise above current levels of explanation, including summarization, synthesis and the creation of new concepts”.

From the quotation, Van Aalst (2009) stated that during the process of knowledge construction, there is ‘effort’ to move to a higher degree from current
levels. Van der Meijden (2005) further explained that students’ knowledge construction can be categorized into low and high levels. A low level of knowledge construction generally does not involve students making significant cognitive efforts when elaborating facts or arguments. However, a high level of knowledge construction involves cognitive efforts of elaborating facts and arguments (Van der Meijden, 2005).

Students are cognitively engaged whenever knowledge is constructed through the variety of cognitive processes (for example, explanation-seeking questions and problems, interpreting and evaluating new information, sharing, critiquing, etc.). These cognitive processes are observed from students’ written messages and thus students are cognitively engaged from the emergence of these behaviours (Zhu, 2006).

1.10.2 Cognitive Engagement

The term ‘cognitive engagement’ in this research is defined by the employment of mental effort that students exert to solve a given task (Scott & Walczak, 2009; Blumenfeld, Kempler and Krajcik, 2006; Connell & Wellborn, 1991; Corno & Mandinach, 1983).

As in an online learning context, cognitive engagement is visible in this research through the perspective of Zhu (2006, p.454). He mentions that, in order to be cognitively engaged, students should be observed as being able to seek, interpret, analyze and summarize information. Other than that, they are able to critique and rationalise statements by giving opinions, arguments and making decisions.

The availability of such behaviours as described by Zhu (2006) in online discussions indicates that students are able to construct knowledge and thus become cognitively engaged. In a more specific manner, Van der Meijden (2005) describes knowledge construction as the ability to elaborate discussion messages in the form of:
i. asking comprehensive questions requiring explanations,
ii. presenting answers with arguments or justification,
iii. presenting new ideas with explanations,
iv. acceptance or rejection of others’ ideas with justification.

With respect to these behaviours, cognitive engagement is used interchangeably with knowledge construction on the understanding that when knowledge is constructed through provision of these behaviours in discussion messages, students are cognitively engaged in online learning (at low or high level).

### 1.10.3 Online Learning and Learning

For the purposes of this research, online learning is clearly defined as the platform of delivering instructions, learning and assessing through the web and hence utilizing various media and intra/internet resources to achieve the desired educational goals (Michigan Virtual University, 2005).

Learning, on the other hand is viewed as:

“.. a process, demonstrated through conversation, in which learners reflect upon what they currently know and negotiate meaning and knowledge creation with others through conversation” (Dennen & Paulus, 2005, p. 97).

As such, learning is said to be the product of students’ mental knowledge (re)construction (de Jong, Veldhuis-Diermanse and Lutgens, 2002). This research will investigate the learning processes that underly learning outcomes, that is, to what extent are students cognitively engaged in their learning discussions for knowledge construction.
1.10.4 Collaborative Learning

Collaborative learning in this research entails the following properties:

i. a small group working together (Gol & Nafalski, 2007; Barkeley, Cross & Major, 2005; Smith & MacGregor, 1992),
ii. having specific learning activities or tasks (Barkeley, Cross & Major, 2005; Dillenbourg et al., 1996),
iii. knowledge being created upon collaboration (Dillenbourg & Fischer, 2007; Alavi & Dufner, 2005; Crook, 1998; Blumenfeld et al., 1996).

1.10.5 Computer-supported Collaborative Learning

Computer-supported collaborative learning (CSCL), as termed in this research, emerged from socio-cultural theory and socio-cognitive theory. The present research applies CSCL from the view of socio-cultural theory. It is a learning approach designed with the goal of putting students in a group to learn together to solve deliberate tasks in a computer-mediated environment (Lipponen, 2002). Each group member holds a role in order to accomplish the groups’ learning goal. The absence of one of the roles will cause the group to malfunction. This is one of the elements that differentiates collaborative learning from cooperative learning (Roschelle & Teasley, 1995).

1.10.6 Social Interaction

The term “social interaction” is inseparable from the CSCL environment, where CSCL itself is a “special form of social interaction” (Lipponen, 2002). Although there are many factors that might influence collaborative learning, Garrison
(1993) asserts that social interaction happens to be the fundamental principle of collaboration (Garrison, 1993). In this research, social interaction is defined according to Bornstein and Bruner (1989) as follows:

“Social interaction is the transmission of ideas, thoughts, emotions, knowledge, or processes between at least two people, where the learner and tutor interact with each other in a crucially patterned manner”.

Three main forms of interactions are: the student-student interaction, student-content interaction and student-teacher interaction (Moore, 1969). However, student-student interaction (peer interaction) will be the focus of this research. As indicated by Dillenbourg (1999), CSCL values all types of interactions, however, peer interaction should be emphasized as it is the type of interaction that results in collaborative knowledge building.

1.11 Summary

The need to evaluate the quality of online learning has brought forward the extent of students’ cognitive engagement in online settings. The ability to educate students for higher order learning in an online learning context is an important indicator that online learning does enhance the learning processes as compared to the traditional settings. To the best of our knowledge, few studies are conducted on the students’ degree of cognitive participation in online learning. Therefore, it is hoped that research would report on the degree of students’ cognitive engagement in online learning and to provide ways to increase it to a higher degree.
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