MODELING CRITICAL THINKING IN INFORMATION SEEKING PROCESS OF POSTGRADUATE STUDENTS

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THESIS SUBMITTED IN FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

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ABSTRACT

Critical thinking is an important outcome of higher education in the 21st century. However, there are several reports about the lack of critical thinking skills among students in workplaces and industries. Critical thinking helps students to seek information better than persons who cannot think critically. This study examines critical thinking skills among postgraduates and investigates its relationship with information seeking processes. Therefore, the following objectives were put forward: i) to investigate the association between critical thinking skills and information seeking process; ii) to design and develop a prototype, namely "Learning System for Critical Thinking in Information Seeking" (LeCTIS) to encourage critical thinking skills in information seeking process; iii) to evaluate the usability and functionality of the LeCTIS prototype in facilitating critical thinking in the information seeking process. Quantitative research approach is employed in this research using survey and interview. The sample population was derived from postgraduates in University of Malaya. The survey was conducted to examine the level of critical thinking among postgraduates and to investigate the relationship between critical thinking skills and information seeking processes using RED model and WGCTA-UK edition and the Information Seeking Process (ISP) model. The interviews were conducted to grab deep information on how postgraduates assess the information they received, the user's requirements, and the influenced factors on critical thinking skills. The development of the LeCTIS prototype was conducted using the results of the analysis of the interviews and surveys, which revealed the association between critical thinking skills and information seeking processes. To analyze the survey, descriptive and inferential statistics were used and selective, open, and axial coding was used to analyze the interview. The survey and interview findings provided the requirements, which determined the design consideration for the LeCTIS prototype development. The findings from the survey and interview indicated that there was an association between critical

thinking skills and information seeking processes among respondents at a different level. Therefore, the development of the LeCTIS helps students learn to use critical thinking skills while seeking for information. The LeCTIS prototype was evaluated using Software Usability Measurement Inventory (SUMI) as well as pre-test post-test experiment. The results indicated a positive feedback on its usability and functionality. This study is significant for higher learning institutes, instructors, and education system with the aim of training qualified students in critical thinking skills.

ABSTRAK

Pemikiran kritikal adalah hasil pembelajaran pengajian tinggi yang sangat penting pada abad ke 21 ini. Akan tetapi, ada beberapa laporan daripada majikan dan industri yang menyatakan bahawa kemahiran pemikiran kritikal di kalangan pelajar dan graduan adalah tidak memuaskan. Pemikiran kritikal membantu pelajar mencari dan mendapat maklumat dengan lebih berkesan. Kajian ini adalah untuk menyelidik kemahiran pemikiran kritikal di kalangan pascasiswazah dan hubungan antara pemikiran kritikal dengan proses pencarian maklumat. Untuk tujuan kajian ini, objektik yang dikenalpasti adalah: i) menyelidik kaitan antara kemahiran pemikiran kritikal dan process pencarian maklumat; ii) reka dan bina suatu prototaip, LeCTIS (Learning System for Critical Thinking in Information Seeking) untuk menggalak kemahiran pemikiran kritikal dalam proses pencarian maklumat; dan iii) mentafsir fungsi dan kegunaan prototaip LeCTIS dalam memudahkan pemikiran kritikal dalam proses pencarian maklumat. Pendekatan kajian kuantitatif dalam penyelidikan ini menggunakan soalselidik dan temuduga. Pemilihan sampel kajian ini terdiri daripada pascasiswazah Universiti Malaya. Kajian tersebut dijalankan untuk menentukan tahap pemikiran kritikal di kalangan pascasiswazah dan untuk menyelidik hubungan kemahiran pemikiran kritikal dengan proses pencarian maklumat dengan menggunakan model REL dan edisi WGCTA-UK dan model ISP (Information Seeking Process). Temuduga dijalankan untuk mendapat maklumat secara mendalam mengenai bagaimana pascasiswazah menilai maklumat yang diterima, kehendak pengguna, dan faktor-faktor yang mempengaruhi kemahiran pemikiran kritikal. Pembinaan prototaip LeCTIS menggunakan hasil analisa temuduga dan soalselidik, yang menunjukkan kaitan antara kemahiran pemikiran kritikal dan proses mendapat maklumat. Untuk menganalisa soalselidik, statistik inferens dan descriptif dan pengekodan terbuka (open), terpilih (selective) dan paksi (axial) di gunakan untuk menganalisa temuduga. Hasil penemuan soalselidik dan temuduga menentukan

keperluan yang menentukan rekabentuk yang diperlukan untuk LeCTIS prototaip. Hasil penemuan daripada soalselidik dan temuduga juga menunjukkan bahawa kemahiran pemikiran kritikal dan proses pencarian maklumat ada kaitan di kalangan responden disemua tahap. Oleh itu, rekabentuk LeCTIS boleh membantu pelajar mempelajari kemahiran pemikiran kritikal semasa mencari dan mendapat maklumat. Prototaip LeCTIS telah diuji dengan menggunakan Perisian SUMI (Software Usability Measurement Inventory) dan juga pra dan pos eksperimen. Hasil kajian menunjukkan maklumbalas positif dari segi penggunaan dan fungsinya. Kajian ini adalah penting untuk instituit pengajian tinggi, pengajar, dan sistem pendidikan secara umum untuk tujuan melatih pelajar yang layak meningkatkan kemahiran pemikiran kritikal.

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LIST OF SYMBOLS AND ABBREVIATIONS

CCTST	:	California Critical Thinking Skills Test
CCTT	:	Cornell Critical Thinking Test
LeCTIS	:	Learning System for Critical Thinking in Information Seeking
CT	:	Critical Thinking
$(CT)^2$	:	Computerized Training in Critical Thinking
ICT	:	Information and Communication Technology
ID	:	Identification
ISB	:	Information Seeking Behavior
ISP	:	Information Seeking Process
PBL	:	Problem-Based Learning
RA	:	Research Assistant
RED	:	Recognition of assumptions, Evaluation of arguments, Draw conclusions
SPSS	:	Statistical Package for the Social Sciences
SUMI	:	Software Usability Measurement Inventory
WGCTA	:	Watson-Galser Critical Thinking Appraisal Test
WGCTA-UK edition	:	Watson-Galser Critical Thinking Appraisal Test-UK edition

CHAPTER 1: **INTRODUCTION**

1.1 Introduction

This chapter provides an overview of the study by presenting the background of the study, the problem statement, the research objectives, and the research questions. The chapter also states the scope of the study and the research methodology. It then provides the operational definition of terms and outline of the structure of the remaining sections of the thesis.

1.2 Background of the study

This study relies on two important concepts: critical thinking, and information seeking process, as follows:

1.2.1 Critical Thinking

Critical thinking is a significant skill in the information society to recognize false, incomplete, old, or new information. One of the main goals of higher education in the information age is to make students active in the learning process (Akyüz & Samsa, 2009). Facione (1990b) stated that teaching students to think critically is not only important to the society in general, but is also vital to the students' learning process. Most instructors claim that it is essential for students to develop critical thinking skills when they start their academic learning because these skills help students to have purposeful and self-regulatory reasoning. Critical thinking also helps students to evaluate the opinion of others, make decisions, and arrive at a reasonable conclusion when encountering complicated problems (Allegretti & Frederick, 1995).

Recently, the Internet has been known as a popular information source to meet different information needs especially during learning process of students. Due to the variety of information resources, it is an essential task for students to know how to find,

analyze, and evaluate the information. The students can find proper information while they attempt to pass the information seeking processes by leveraging the critical thinking.

Ennis (1985) defined critical thinking as “a reflective and reasonable thinking focused on deciding what to believe or not." Ennis (1987) indicated that ideal critical thinkers have a combination of abilities such as, focusing on a question; analyzing the arguments; judging the credibility of a source; making inferences; making judgments. The ideal critical thinkers can also integrate the dispositions and other abilities in making and defending a decision. They must be sensitive to the feelings, level of knowledge, and degree of sophistication of others. The critical thinkers can employ appropriate rhetorical strategies in discussion and presentation.

In addition to the characteristics of an ideal critical thinker, Ennis (1987) presented a taxonomy of critical thinking that includes: clarifying a problem; identifying a problem and formulating a question; gathering information; distinguish relevant from irrelevant information; make inference; recognizing unwarranted claims and deductive reasoning; conducting advanced clarification; determining the strength of an argument; deciding on answer, solution, or course of action; and making a judgment. In line of the taxonomy of critical thinking and the abilities of ideal critical thinkers, Ennis (1987) indicated that a critical thinker can seek information better than a person without critical thinking.

Consistent with the definition of critical thinking by Ennis (1985), several popular definitions presented by researchers such as Furedy and Furedy (1985), Pascarella, Terenzini, and Feldman (2005), and Watson and Glaser (1980). The most important components of their definitions are: identifying key issues and assumptions (interpretation), making right inferences from data (inference), deducing conclusions from the data provided (deduction), interpreting whether conclusions are warranted (recognition of assumptions), and evaluating evidence or authority (evaluation of

arguments). As a result, the RED model (Watson & Glaser, 2012a) can be a good example of common components of critical thinking, including three main skills: (1) Recognition of assumptions: recognizing structured and ill-structured assumptions, and deciding whether an assumption is really based on a defined information, (2) Evaluating of arguments: distinguishing between relevant and strong arguments and weak or irrelevant to a particular question, and (3) Drawing conclusions: it involves arriving at conclusions that logically follow from the available evidence. Drawing conclusion consists of evaluating all relevant information before drawing a conclusion, judging the credibility of different conclusions, selecting the most appropriate conclusion, and avoiding over generalization beyond the evidence. Drawing conclusion contains three sub skills, as follows: (1) Interpretation: considering evidence and deciding that the procedures of drawing conclusions are warranted, (2) Deduction: determining that the conclusions follow from given information, and (3) Inference: a conclusion that individuals can conclude from certain evidence or facts. Figure 1-1 illustrates the RED model.

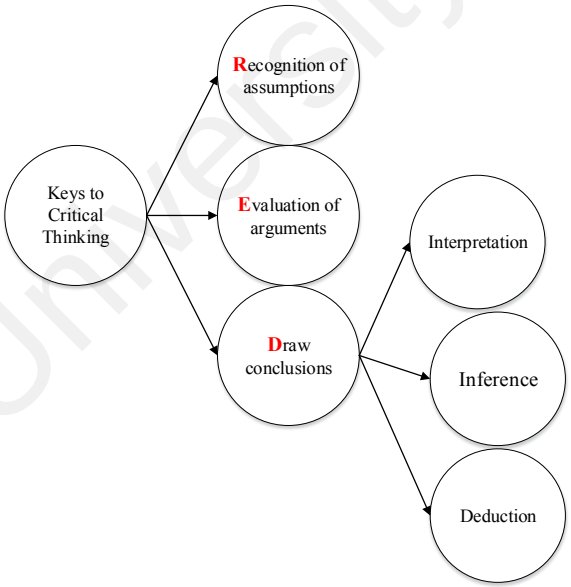

Figure 1-1: The RED model (Watson & Glaser, 2012a)

1.2.2 Information seeking process

Information seeking behavior of students and researchers is considered in several domains. Wilson (2000) described information seeking behavior as "a purposive seeking for information as a consequence of a need to satisfy some goals". In case of seeking, persons may interact with manual information systems, such as newspapers and library materials, or with computer-based systems and online systems. Keeping pace with the latest information and communication technologies (ICT) besides different information needs, are key reasons to consider information seeking behavior as a topic for all the time in different aspects. There are several models for information seeking, which are created based on different views consisting of the behavioral model for information seeking (Ellis, 1989), the information search process model (ISP) (Kuhlthau, 1991), and the problem solving model (Wilson, 1999b).

Kuhlthau (1991) proposed the information search process model in six stages based on the tasks that information seekers should do: (1) Initiation: to recognize a need for information, (2) Selection: to identify and select the general topic to be investigated or the approach to be pursued, (3) Exploration: to investigate information on the general topic in order to extend personal understanding, (4) Formulation: to form a focus from the information encountered, (5) Information collection: to gather information related to the focused topic; and (6) Presentation: to complete the search and prepare for presenting or using the findings.

The model of the information search process, representing the user's sense-making process, incorporates three main areas of human experience: the affective (feelings), the cognitive (thoughts), and the physical (actions) within each stage (Kuhlthau, 1991) that is shown in Table 1-1.

Table 1-1: Information search process (Kuhlthau, 1991)

Stage	Feelings	Thoughts	Actions	Task
Initiation	Uncertainty	General/ vague	Seeking background information	Recognize
Selection	Optimism	-	-	Identify
Exploration	Confusion / Frustration / doubt	-	Seeking relevant information	Investigate
Formulation	Clarity	Narrowed/ clearer	-	Formulate
Information collection	Sense of direction/ confidence	Increased interest	Seeking relevant or focused information	Gather
Presentation	Relief / satisfaction or disappointment	Clearer or focused	-	Complete

1.3 Problem statement

Students need to be experts in their areas of studies and in soft skills, such as critical thinking and problem-solving skills. Critical thinking composes of two important elements: (1) the ability to identify and analyze complex situations in addition to making evaluations that are justifiable, and (2) the ability to expand and improve thinking skills, and provide ideas and alternative solutions. Since the universities are responsible for training qualified student in terms of critical thinking skills, most of the higher education systems considered particular budgets to have competent postgraduates (Chai, 2011; LI & Yick-ming, 2003; Shakir, 2009; Tan & Abbas, 2009). In spite of significance of critical thinking in higher education and industry, feedback from the industry still indicates the lack of critical thinking skills among new postgraduates. For example, Flores, Matkin, Burbach, Quinn, and Harding (2012) believed that Students are graduating deficient in critical thinking skills, unprepared to think critically once in the workforce. Jackson (2010) also mentioned that some industries blames higher education institutions for

producing graduates deficient in critical thinking skills deemed essential for enhanced productivity and innovation in the workplace. In other words, the first problem of this study is the lack of critical thinking among students who postgraduates from universities in a variety of degrees and majors. Therefore, it is essential to identify an applicable strategy to cultivate critical thinking among students.

On the other hand, the well-educated persons with critical thinking skills have the capability to recognize relevant information from irrelevant information for solving problems and making decisions in today's information era. However, there is no explicitly evident from the literature about the critical thinking and any dimensions of information seeking behavior and information seeking process model (ISP). Moreover, it is required to clarify whether postgraduates use critical thinking skills while they are seeking for information.

1.4 Research objectives

The main goal of this research is to foster critical thinking among postgraduates through information seeking behavior. Therefore, the main objectives are as follows:

1. To investigate the association between critical thinking skill and information seeking process.
2. To design and develop a prototype (LeCTIS) to teach critical thinking in information seeking process.
3. To evaluate the usability and functionality of the prototype LeCTIS in facilitating critical thinking in the information seeking process model.

1.5 Research questions

The list of research questions that are answered through this study are as follows:

RQ1. What is the level of critical thinking among postgraduates?

RQ2. How do postgraduates think critically when seeking for information?

RQ3. What are the requirements for a critical thinking learning system?

RQ4. How usable is the prototype (LeCTIS) in facilitating critical thinking skill in the information seeking processes?

The first research question (1) is important in understanding the critical thinking level of postgraduates. The second research question (2) describes any relationship between critical thinking skills and the information seeking processes. The answers to the third (3) research question are useful to develop and design LeCTIS to cultivate critical thinking through the information seeking process model (ISP). The fourth (4) research question aimed to find the usability of the LeCTIS in facilitating critical thinking skills through the information seeking processes.

1.6 Scope of research

The domain of interest of this thesis is postgraduates in the University of Malaya. This is because catering to the needs and requirements of postgraduates who are at the research teams. The participants are selected from active research teams within the University of Malaya, such as Computer Science and Information Technology, Medicine, Sciences, and Engineering, Law, Education, Built environment, Dentistry, Art and Social Science, and Business and Accountancy.

In addition, this research aims to study the critical thinking skills not the other components of critical thinking such as critical thinking dispositions and metacognitions.

1.7 Theoretical lenses

The 21st century is known as the information age in which the rate of generating information is dramatically increasing in different societies. As a result, the people require to select, analyze, and evaluate the valid and reliable information properly. To achieve

this goal, critical thinking, which is one of the most important skills, can help individuals to find, select, and analyze the information to make right decisions and draw appropriate conclusions. However, as it is aforementioned in Section 1.2 and 1.3, there is a lack of critical thinking among postgraduates who have graduated from universities. Furthermore, the role of critical thinking through information seeking that results in cultivating critical thinking in information seeking process, has not been studied in the literature. This study is framed based on an appropriate theory that "critical thinkers are able to seek information as well as precision in information (Ennis, 1987, 1989). This theory was taken from Ennis's taxonomy of critical thinking dispositions and abilities (Ennis, 1987, 1989). According to the taxonomy, critical thinkers demonstrate particular attributes that distinguish them from individuals who cannot think critically, such as clarifying problem, identifying or formulating a question, gathering information, distinguishing relevant from irrelevant information, making inferences, deductive reasoning, recognizing unwarranted claims, conducting advanced clarifications, determining the strength of an argument, making judgments, dealing with components of a complex problem in an orderly manner, seeking information as well as precision in information, searching for reasons, seeking a clear statement for the problem, and looking for options. Critical thinkers generally use these skills in a proper time and place (Behar-Horenstein & Niu, 2011; Ennis, 1987, 1989).

The above theory comprises the theoretical framework, and guides the development and implementation of the LeCTIS for cultivating critical thinking in information seeking process.

1.8 Research methodology

A good research has to be conducted systematically and scientifically. The research methodology is the framework, which plans out the whole research process to ensure the

quality of the research. There are various research methodologies ranging from quantitative, qualitative, mixed method, and others that could be adopted. This study uses a quantitative method to have detailed information from postgraduates in the University of Malaya.

To address the research questions of this study, a survey questionnaire in two sections as well as two sets of interviews are prepared. The critical thinking level of postgraduates is identified based on the Watson-Glaser Critical Thinking Appraisal Test- UK edition (WGCTA-UK edition) (Watson & Glaser, 2002). To investigate the information seeking behavior of students and their usage of critical thinking during the information seeking process, this study provides a survey based on the information seeking process model (Kuhlthau, 1991) and the critical thinking skills in the RED model (Watson & Glaser, 2012a).

Afterward, to grab further information on the relationship between critical thinking and the information seeking process interview questions is provided. The interview also helps to identify the criteria that the students consider for evaluating the information. The second interview question is also provided to gather more information about the critical thinking of postgraduates and identify the influenced factors on the critical thinking. The results of the analysis of survey and interviews are used to design and develop a learning system for cultivating critical thinking of postgraduates in information seeking (LeCTIS). Finally, a sample of postgraduates who participated in the surveys are selected to evaluate the proposed LeCTIS and show its effect on the critical thinking level of students.

1.9 Delimitations

Limitations are necessary for the study to provide a direction for researchers and determine the scope of the study as well as guiding readers to the right path (Creswell,

Plano Clark, Gutmann, & Hanson, 2003). In this study, the following factors has identified as limitations:

The researcher conducted the study as a research-intensive university in Kuala Lumpur, Malaysia. The results of the study may not be generalizable to the entire population of postgraduates in Malaysia. Students are self-reporting their gender, age, degree, and field of study, which may imply inaccurate or flawed information. In the interview, the study involved only a small number of postgraduates. It would not be prudent to generalize the interview findings rather the study itself is crucial to provide ideas and ways for researchers to gain some insights for future implementations. Gathering data from postgraduates was too time-consuming because of their involvement with their own businesses and research. As a result, the procedures of this study take too much time. The researcher provides a calm and appropriate environment to get data especially to the interview and working with the LeCTIS. In addition, the researcher asked postgraduates to participate voluntarily without any tension with good mood. However, the findings may reflect unwanted results.

1.10 Research assumptions

The following assumptions are made regarding the conduct of this study:

1. It is assumed that all participants responded to the survey honestly.
2. It is assumed that participant's responses reflected their actual feelings and concerns about the information seeking part of their research.
3. It is assumed that the sample of the study are representative of the entire postgraduates.
4. It is assumed that the participants conducted the interview in an appropriate environment and their responses are satisfactory.

5. It is assumed that participants in the interview session are representatives of all postgraduates.

1.11 Significance of study

The importance of critical thinking as an outcome of the higher education system is enough reason for instructors and higher learning institutes to allocate particular programs and budget to teach and develop critical thinking among students. For instance, Singapore's vision statement from Ministry of Education (Tan & Abbas, 2009) stated that "we should help the students to ask more searching questions, encourage curiosity and critical thinking, and not only to follow prescribed answers". In the UK, the National Curriculum provided opportunities to enable students to thinking critically (Stapleton, 2011). In Hong Kong, critical thinking is mentioned as "learning goals" and has been introduced as a key feature of in "liberal studies" (Chai, 2011; Stapleton, 2011). Ministry of Higher Education of Malaysia announced that public universities in Malaysia must introduce soft skills such as critical thinking attached to the undergraduate syllabus (Shakir, 2009).

Lack of critical thinking becomes a universal concern and it is not restricted to one country. For example, the American Association of Colleges and Universities (2005) reported that test results revealed that only six percent of students could get the proficient score in critical thinking. Similarly, when a critical thinking test was conducted among college entrants in Scotland and Australia, score revealed a lack of critical thinking development between degree and non-degree holding students even in tertiary students (Pithers & Soden, 1999). Moreover, lack of critical thinking among workers in different levels caused many difficulties for their companies. For example, 3400 of the highest paid employees of the Circuit City were fired due to lack of critical thinking and making proper

decisions (D. T. Jones, 2001), or deficient critical thinking among employers in the Tesco U.S. branch caused to fail to launch Tesco in U.S. (Mui, 2007).

On the other hand, emerging the Internet as the most applicable information source to meet information needs among a huge amount of information makes individuals to decide on the quality of the information. Therefore, the seeker's behavior may change during the information seeking process. The seekers should have several skills to find, analyze, and evaluate the information, which originates from critical thinking. As a result, this belief is strengthened that critical thinkers are able to seek information better than persons without critical thinking.

To sum, it can be seen that critical thinking is helpful for persons who concern with lack of critical thinking in higher learning institutes such as students, instructors, and educational activists. Moreover, it is important for industries to have skilled employers with academic qualification besides critical thinking skills. Critical thinking helps students to analyze and evaluate the information while they are seeking for information. It is one of the aims of this study that makes it important. Furthermore, this study proposes a simple and applicable prototype (LeCTIS) to cultivate critical thinking among postgraduates through the information seeking process model. The LeCTIS is based on the relationship between critical thinking skills and the information seeking process model, which there is no explicitly evident from the literature about this relationship.

1.12 Operational definitions

There are a few terms, which are essential to this research. This section provides their definitions to provide a basic understanding of these important terms.

Critical thinking: A purposeful and self-regulatory judgment which encompasses the interpretation, analysis, evaluation, and inference as well as explanations of different

types of arguments based on logical judgment (Facione, 1990b). Critical thinking contains critical thinking skills, critical thinking dispositions, and metacognitions.

Critical thinking skills: The abilities to help thinking in a critical way (Facione, 1990b). Critical thinking skills are a combination of abilities, which are different in researchers' viewpoints. This study uses the RED model as critical thinking skills that includes recognition of assumptions, evaluation of arguments, and draw conclusions (interpretation, deduction, and inference).

Critical thinking dispositions: Habits of mind that characterize a person (E. A. Jones, 1995). Critical thinking dispositions are varied, for example, open-mindedness, truth-seeking, and self-regulation are the most important critical thinking dispositions.

Inference: Distinguish between false and true information. Defining a problem consists of selecting the most proper information piece leading to the solution. Making decisions regarding the validity of assumptions based on the information provided within a text is an inference process (Sendag & Odabasi, 2009).

Interpretation: Understanding the topic, what the topic is by meaning and similar keywords. Actually, interpretation is meaning the topic in an easy way to understand better.

Recognition of assumptions: Forming a hypothesis about the topic, finding the information gaps, and listing the facts about the topic. Indeed, recognizing structured and ill-structured assumptions, and deciding that the assumption is the given information or not.

Assumption: Is a statement that is assumed to be true when there is no proof (Watson & Glaser, 2012a).

Evaluation of arguments: Evaluating the information for final decision and concluding. In fact, distinguishing the relevant and true information from irrelevant and false information related to the given topic or issue.

Argument: Is a claim that is intended to persuade someone to believe or act a certain way.

Deduction: Justifying the previous procedures to have initial results. In other words, deduction is drawing valid conclusion and deciding about the relationship among hypotheses on a specific situation.

Information seeking process: Is a famous model in information seeking behavior area, which was presented by Kuhlthau (1991). Due to describing the search process, this model is known as the "information search process", however, several researchers worked on it with the name of "information seeking process". In this research, we also called it information seeking process rather than the information search process. To illustrate the information search process, the author proposed this model in six stages: initiation, selection, exploration, formulation, information collection, and presentation.

Initiation: Is the first stage of the information seeking process model when a person first becomes aware of a lack of knowledge or understanding (Kuhlthau, 1991). Initiation is the beginning point of search activity for researchers.

Selection: The second stage of the information seeking process model is selection. The main task in this stage is to identify and select the general topic to be investigated or the approach to be pursued (Kuhlthau, 1991). In this study, selection refers to select information related to the topic.

Exploration: Is the third stage of the information seeking process model. It is characterized by feelings of confusion, uncertainty, and doubt, which frequently increase during this time (Kuhlthau, 1991). Exploration refers to the expanding of information about the topic by doing search activity.

Formulation: Is the turning point of the ISP when feelings of uncertainty diminish and confidence increases (Kuhlthau, 1991). In this stage, information seekers concentrate on the topic and try to find the very specific information related to the topic.

Information collection: Is the fifth stage of the information seeking process model when interaction between the user and the information system functions most effectively and efficiently (Kuhlthau, 1991). Information seekers gather the information and organize them based on their needs to present in the final stage.

Presentation: Is the last stage of the information seeking process model that feelings of relief are common with a sense of satisfaction if the search has gone well or disappointed if it has not (Kuhlthau, 1991). In this stage, information seekers present their outcome of the search activities in different formats such as oral presentation, essay, completing a project or task, or writing a paper.

Postgraduates: In this study, postgraduates are someone who has completed the first degree and they are master student or Ph.D. students.

1.13 Thesis organization

This thesis comprises six (6) chapters, as follows:

Chapter 1 presents the background of the study, the problem statement, the objectives, the research questions, the theoretical lens, and operational definition of terms. Chapter 2 provides a review of the literature pertinent to the study. This chapter also explains and

analyses the state-of-the-art methods to cultivate critical thinking. The second part of Chapter 2 is about information seeking behavior and its famous models by focusing on the information seeking process model. It also describes the details of sample systems for cultivating critical thinking. Chapter 3 describes the methodology of the study, including the instruments for data collection, validity and reliability of the instruments, and the procedures of development and design of the LeCTIS to cultivate critical thinking among postgraduates. Chapter 4 provides an analysis of the surveys as well as presenting the findings of data gathered from interviews. Chapter 5 provides the details of the implemented prototype (LeCTIS) to foster critical thinking. This chapter also includes the evaluation part and explanation about how the proposed prototype (LeCTIS) work. Chapter 6 consists of conclusion and discussion as well as future work and limitations of the study.

CHAPTER 2: **LITERATURE REVIEW**

2.1 Introduction

This chapter provides a comprehensive literature review pertinent to this study to address the extent of the literature available on critical thinking and information seeking process. The purposes of this literature review are to (a) explore the ways in which critical thinking has been defined by researchers as well as its components; (b) review the best instruments in assessing critical thinking; (c) investigate how critical thinking has been developed with emphasis on educational strategies; and (d) review the nature of information seeking, information seeking behavior (ISB), and the existing famous models in information seeking by focusing on the information seeking process (ISP) model.

2.2 Critical thinking

This section describes the concept of the critical thinking along with its components and assessment tools. Finally, it reviews the instructional strategies, which have been used to cultivate critical thinking.

2.2.1 Definitions

Recently, some researchers have disputed the importance of critical thinking in learning. The Common Core State Standards mentioned that critical thinking is one of the vital cross-disciplinary skills for education and in the workplace (Association, 2009). In the 21st century, students must not only be highly competent but must also be equipped with soft skills, which include critical thinking skills, problem solving, communication, collaboration, and creativity (Ledward & Hirata, 2011). These skills prepare students for post-secondary education, employment, and to become competent members of society.

There are several definitions for critical thinking depending on different viewpoints of researchers such as philosophical, cognitive psychological, and educational views (Lewis & Smith, 1993; Sternberg, 1986), as follows:

Philosophical view is supported by Socrates, Plato, Aristotle, and more recently, Matthew Lipman and Richard Paul (Lai, 2011; Lipman, 1988; Paul, 1992). In this approach, the hypothetical critical thinker, the number of qualities and characteristics that critical thinkers may have are more important than how critical thinkers behave (Lewis & Smith, 1993; Thayer-Bacon, 2000). Philosophical view considers an ideal critical thinker rather than a real critical thinker (Sternberg, 1986). Therefore, researchers may have less tendency to talk about philosophical view during their discussion. Table 2-1 is an outline of definitions related to critical thinking in philosophical view.

Table 2-1: Definitions of critical thinking in philosophical view

Researchers	**Definitions**
McPeck (1990)	"The propensity and skill to engage in an activity with reflective skepticism".
Ennis (1985)	"Reflective and reasonable thinking that is focused on deciding what to believe or do".
Lipman (1988)	"Skillful, responsible thinking that facilitates good judgment because it 1) relies upon criteria, 2) is self-correcting, and 3) is sensitive to context".
Facione (1990b)	"Purposeful, self-regulatory judgment which results in interpretation, analysis, evaluation, and inference, as well as explanation of the evidential, conceptual, methodological, criteriological, or conceptual considerations upon which that judgment is based".
Paul (1992)	"Disciplined, self-directed thinking that exemplifies the perfections of thinking appropriate to a particular mode or domain of thought".
Bailin, Case, Coombs, and Daniels (1999)	"Thinking that is goal-directed and purposive, "thinking aimed at forming a judgment," where the thinking itself meets standards of adequacy and accuracy.
Facione (2000)	"judging in a reflective way what to do or what to believe"

The next definition of critical thinking presented based on the cognitive psychological view. There are two main differences between cognitive psychologists and philosophers: (1) The cognitive psychologist shows their tendency to focus on how people actually think against how they could or should think under ideal conditions (Sternberg, 1986), and (2) The second difference emphasizes on defining critical thinking by types of actions or

behaviors which critical thinkers can do. As a result, there is a list of skills or procedures that critical thinkers can perform (Lewis & Smith, 1993). Table 2-2 provides several definitions of critical thinking in cognitive psychological view.

Table 2-2: Definitions of critical thinking in cognitive psychological view

Researchers	Definitions
Sternberg (1986)	"The mental processes, strategies, and representations people use to solve problems, make decisions, and learn new concepts".
Halpern (1998)	"The use of those cognitive skills or strategies that increase the probability of a desirable outcome".
Willingham (2008)	"Seeing both sides of an issue, being open to new evidence that disconfirms your ideas, reasoning dispassionately, demanding that claims be backed by evidence, deducing and inferring conclusions from available facts, solving problems, and so forth".

The last definition of critical thinking relies on the educational view, which is famous due to Bloom and his associates. The taxonomy of information processing skills is one of the most applicable sources when educational practitioners want to teach and assess higher-order thinking skills. The Bloom's taxonomy has hierarchical structure with six key components, including evaluation, synthesis, analysis, application, comprehension, and knowledge (Bloom, 1956).

The strong point of the educational approach is that it is based on years of classroom experience and observations of student learning, while the philosophical and cognitive psychological view are old (Sternberg, 1986). However, some researchers believed that educational approach is vague and the concepts within the taxonomy are not clear enough for instruction and assessment in an appropriate way (Ennis, 1985; Sternberg, 1986). Furthermore, the frameworks developed in education have not been tested as hard as those developed within philosophy or psychology views (Sternberg, 1986).

2.2.2 Critical thinking components

Critical thinking is a combination of critical thinking skills, critical thinking dispositions, and metacognitions. For instance, the Delphi Committee (Facione, 1990b)

identified six skills (interpretation, analysis, evaluation, inference, explanation, and self-regulation), 16 sub skills, and 19 dispositions (inquisitiveness, open-mindedness, understanding others, and so on) that they are bound up with critical thinking. These skills and dispositions form a framework to understand and assess the qualities of human thought (Abrami et al., 2008). The other researchers introduced metacognitions as the third components of critical thinking (Ku, 2009; Nieto & Sainz, 2010; Phan, 2010). As a result, this section explains critical thinking skills, critical thinking dispositions, and metacognitions.

2.2.2.1 **Critical thinking skills**

Although there are differences in three views on the critical thinking definition, there are common elements in several definitions (Ennis, 1985; Facione, 1990b; Furedy & Furedy, 1985; Pascarella et al., 2005; Watson & Glaser, 1980; Willingham, 2008): identifying issues and assumptions, making inferences from data, deducing conclusions from data provided, interpreting whether conclusions are warranted, and evaluating evidence or authority. Other elements of critical thinking are as follows: making a statement or argument supported with evidence (Beyer, 1987; Paul, 1992), recognizing important relationships (Ennis, 1985; Furedy & Furedy, 1985; Pascarella et al., 2005), defining a problem, and forming relevant hypotheses (Ennis, 1985; Mayhew & Dressel, 1954). As a result, Facione (1998) provided a list of core critical thinking skills, which are confirmed by researchers, including: interpretation, analysis, evaluation, inference, explanation, and self-regulation (Figure 2-1).

Watson and Glaser (2012a) introduced a new category for critical thinking skills, which is called RED model. They presented this model based on a definition of critical thinking in (E. M. Glaser, 1942; Watson & Glaser, 1994), including: (1) Attitudes of inquiry that involve recognition of assumptions and interpretation, (2) Knowledge of the nature of valid inferences, abstractions, and generalizations, and (3) Skills in employing

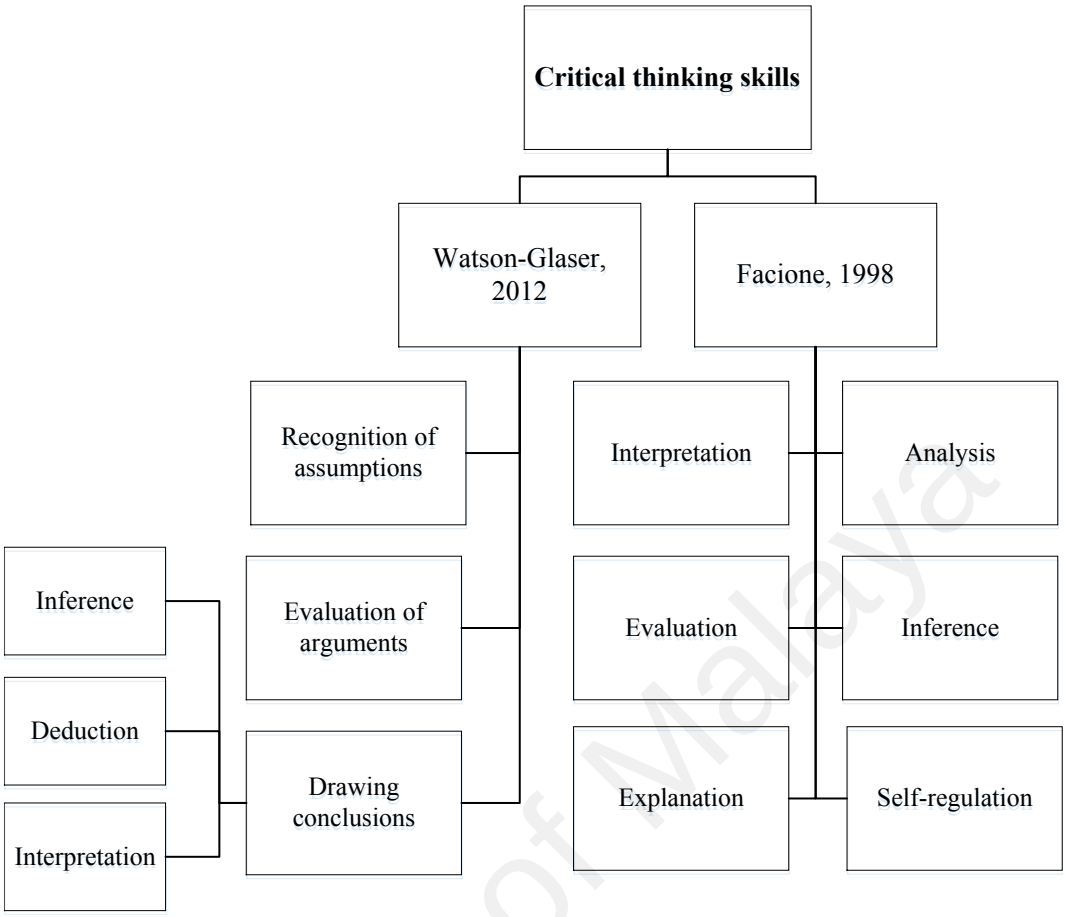

Figure 2-1: critical thinking skills (Facione, 1998; Watson & Glaser, 2012a)

and applying the above attitudes and knowledge. The RED model consists of three elements, as follows (Figure 2-1):

i. Recognition of assumptions: Recognizing structured and ill-structured assumptions, and deciding that the assumption is based on the given information or not. Recognition of assumptions is a key element in critical thinking while someone presents an idea or a plan. Indeed, it helps to evaluate the benefits of a proposal, policy, or practice (Watson & Glaser, 2002; Watson & Glaser, 2012a).

ii. Evaluation of arguments: Distinguishing between strong and relevant arguments and weak and irrelevant arguments to the given question. Analyzing arguments helps individuals in determining to believe arguments or not.

Actually, this ability is useful for someone who likes to look at the issues from all sides without bias (Watson & Glaser, 2002; Watson & Glaser, 2012a).

iii. Draw conclusions: Drawing conclusion is arriving at conclusions, which follow from the available evidence. It includes evaluating all relevant information before concluding, judging the credibility of different conclusions, selecting the most appropriate conclusion, avoiding simplicity, and generalization too much beyond the evidence (Watson & Glaser, 2012a).

2.2.2.2 **Critical thinking dispositions**

Most researchers agree that critical thinking involves dispositions as well as skills (Facione, 1990b). From the beginning of 1985, several scholars were working on critical thinking to recognize whether the ability to think critically is separated from the dispositions towards critical thinking (Ennis, 1985). As a result, researchers could find some empirical evidence to confirm that critical thinking skills and dispositions are two separate entities (Facione, 2000). In fact, the dispositions are attitudes or habits of mind. In other words, critical thinking dispositions are as "consistent internal motivations to act toward or respond to persons, events, or circumstances in habitual, yet potentially malleable ways"(Facione, 2000). The role of critical thinking dispositions in the teaching of critical thinking is important since Facione (1990b) believed that without being open-mindedness and considerate of other people and their perspectives, critical thinking will not improve.

The disposition of critical thinking is composed of different components, which some of them is similar in the list of most researchers, as follows: open-mindedness regarding various views, fair-mindedness in evaluating of arguments, prudence in suspending, making judgments, inquisitiveness regarding to a huge number of issues, the desire to be well-informed, flexibility in facing with different opinions, and willingness to modify views when it needs changes (Ennis, 1985; Facione, 1990b, 2000; Halpern, 1998; Paul,

1992). The other important components of critical thinking dispositions are: honesty regarding one's own biases, prejudices, stereotypes, or egocentric tendencies, being aware of opportunities to use critical thinking, trust in the processes of reasoned inquiry, self-confidence in one's own abilities to reason, clarity in stating the question or concern, orderliness in working with complexity, diligence in seeking relevant information, reasonableness in selecting and applying criteria, care in focusing attention on the concern at hand, persistence though difficulties are encountered, precision to the degree permitted by the subject and the circumstances. Figure 2-2 shows common cited critical thinking dispositions (Facione, 1998).

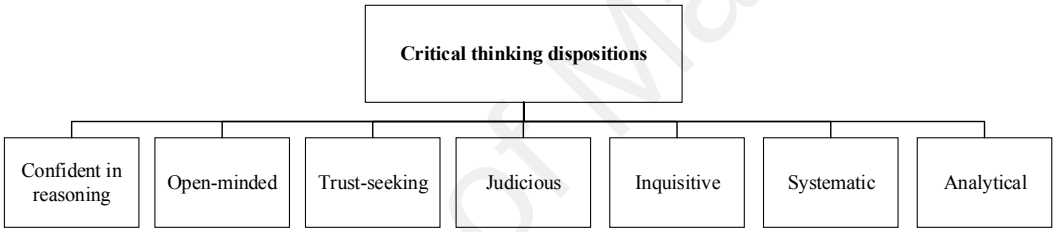

Figure 2-2: Common critical thinking dispositions (Facione, 1998)

2.2.2.3 Critical thinking metacognition

The third element of critical thinking is metacognitions that include consciousness, knowledge and regulation. If individuals want to think critically, they need to be aware of the cognitive process that must be activated in a short time, which is called consciousness. They also should know what process is and what steps should be passed that is called knowledge. Finally, individuals require to review the essential moments of the action entitled self-regulation (Kuhn, 1999; Lizarraga, 2010). It is difficult to think critically about everything because this needs to have a large amount knowledge of all subjects, but most people have a few knowledge to meet their requirements (VanderStoep & Pintrich 2007). Self-regulation of the mind plays an important role during judgments, reactions and adaptations. It is happened step-by-step at the time that cognitive activities,

affects, and goal-oriented behaviors occurred. This consists of making decisions to put effort, attention, and time into doing task(s). Self-regulation is applied into three phases with the particular aim: (1) planning (before activity), (2) execution (during the activity), (3) and evaluation (after activity) (Leung & Kember, 2003; Zimmerman, 2008).

2.2.3 Assessing the critical thinking skills

Assessment is an important part in teaching and improving critical thinking (Duron, Limbach, & Waugh, 2006). Different purposes exist to study the assessment tools such as: investigating the levels of students' critical thinking; giving students' feedback about their critical thinking abilities; motivating students to be better at critical thinking; informing teachers about the success of their efforts to teach students to think critically; doing research about critical thinking instructional questions and issues; providing help in deciding whether a student should enter an educational program; and providing information for schools and teachers to measure students based on their critical thinking skills (Ennis, 1993).

There are numerous assessment tools for critical thinking. Jacobs (1995) and Fawkes (2001) believed that the most widely cited assessment tools are the Watson-Glaser Critical Thinking Appraisal (WGCTA) (Watson & Glaser, 1980), the Cornell Critical Thinking Test (CCTT) (Ennis, Millman, & Tomko, 2005) , and the California Critical Thinking Skills Test (CCTST) (Facione, 1990a). Therefore, this section describes the assessment tools of critical thinking.

2.2.3.1 Cornell Critical Thinking Test (CCTT)

Cornell Critical Thinking Test was in two formats, X and Z (Ennis et al., 2005). Form X was prepared for students in grade 4-14 and Form Z is useful for advanced and gifted high school students, undergraduates, postgraduates and adults. There are 52 items in Form Z which are induction, deduction, evaluation, observation, credibility of statements, identification of assumptions, and the ability to discern meaning. The estimate time to

complete it is about 50 minutes (Jacobs, 1995; Perry, 2014). Reliability of Form Z ranges from 0.49 to 0.87, which is computed among 42 groups. Moreover, the validity of Form Z was calculated based on standard conditions (Behar-Horenstein & Niu, 2011). However, since there is no equivalent forms and technical data in CCTT, the researchers prefer to use WGCTA compare with CCTT (Jacobs, 1995).

2.2.3.2 Watson-Glaser Critical Thinking Appraisal (WGCTA)

WGCTA was prepared in three formats: the standard Form (Forms A and B) and the short form (WGCTA-FS) (Ku, 2009). Forms A and B have 80 items while WGCTA-FS is an inventory with 40 items (Burbach, Matkin, & Fritz, 2004). These forms can be used to study five skills: (a) inference: "the ability to determine the degrees of truth or falsity"; (b) recognition of assumptions: "the ability to recognize structured and ill-structured assumptions"; (c) deduction: "the ability to make a decision that the collected information is based on the given information or not"; (d) interpretation: "the ability to consider existing evidence and determine that the data are generalized or not"; and (e) evaluation of arguments: "the ability to distinguish weak and irrelevant arguments from strong and relevant arguments". Internal consistency and test-retest reliability for the WGCTA-FS is 0.81. Due to the old background of the WGCTA with good reliability and validity, this tool is capable of using for larger sample with easy administration (Abrami et al., 2008; Gadzella, Ginther, & Bryant, 1996; Watson & Glaser, 2012a).

2.2.3.3 California Critical Thinking Skills Test (CCTST)

CCTST is the premier test for critical thinking skills in the world today (Facione & Facione, 1994; Facione, Facione, Blohm, & Giancarlo, 2002). The audiences of the CCTST is college students, advanced, and gifted high school students (Ennis, 1993). The CCTST aims at predicting the strength of critical thinking skills as well as providing an objective measure of critical thinking skills. It was also presented in two formats: Form A and Form B. Items on Forms A and B are used parallel. Consequently, the forms can

be used for a pretest posttest design and for groups of more than 100. Both forms are useful for college level and post-baccalaureate student populations. These forms consist of 34 multiple-choice items, which cover different levels of difficulties that test-takers can answer them in a 50-minute period. There are five sub scales for CCTST, including analysis, evaluation, inference, deductive reasoning, and inductive reasoning and finally a total critical thinking skills score is computed. The latest version of CCTST is formed in 2000 that its reliability based on the testing context, KR-20 alphas ranges from 0.78 to 0.84 (Facione, 2000).

2.2.4 Instructional approaches

In analysis of critical thinking instructional approaches, Ennis's critical thinking typology (Ennis, 1989) is considered, as follows:

(1) General approach: the general approach focuses on teaching critical thinking components separately from the course content.

(2) Infusion approach: the infusion approach needs in-depth instruction as well as understanding the content and the subject matter. In fact, in this approach, critical thinking components are embedded in the curriculum and it is explicit.

(3) Immersion approach: In the immersion approach, critical thinking components are immersed in the subject matter, but it is implicit. In other words, students are not aware of being trained to think critically.

(4) Mixed approach: the mixed approach is a combination of the general approach with the infusion or immersion approach. Therefore, students are involved in the subject and critical thinking components in general.

2.2.5 Instructional strategies to cultivate critical thinking

There are several studies showing that critical thinking skills can be taught (Abrami et al., 2008; Bensley & Spero, 2014; Halpern, 2003; Moseley, 2005; Pithers & Soden, 2000; Sternberg, Roediger III, & Halpern, 2007). However, there are different views in the

teaching and development of critical thinking skills. These various views have put the researchers and teachers in a dilemma with regard to the essential components of good critical thinking (Abrami et al., 2008; Alvarez-Ortiz, 2007; Gadzella et al., 1996; Hitchcock, 2003; Solon, 2007). In spite of the various views in teaching and improving critical thinking (Ennis, 1987; Facione, 1990b; Halpern, 2003; Paul, 1993), courses on critical thinking have been only developed and taught in a few academic fields such as law, philosophy, sociology, and nursing (Dwyer, Hogan, & Stewart, 2014).

Several education methods have been recommended to teach and develop critical thinking among different participants to meet various needs. For instance, problem-based learning (Yuan, Williams, & Fan, 2008), and concept mapping (Maneval, Filburn, Deringer, & Lum, 2011) have been considered as teaching methods to improve nursing students' critical thinking. Socratic questioning has been also cited as one of the earliest teaching methods to stimulate students in active learning and cultivate critical thinking (Paul, Elder, & Bartell, 1997). Concept mapping is another effective tool with the aim of illustrating formal relationships between ideas and the constructs in a linear or structured format. As a result, concept mapping has been known as an effective learning tool in cultivating critical thinking among students (Cook, Dover, Dickson, & Colton, 2012; Eppler, 2006). Information and communication technology as well as web-based learning are common learning tools in the 21st century, which are used by instructors to transfer various contents of a course and develop critical thinking. For example, blogging is a web 2.0 tool to enhance critical thinking and problem solving skills (Ocker & Yaverbaum, 2001; Zhang, 2009). Reflective writing provides an opportunity for students to simplify the observations to see the situation that the student is a part of it. In practice, reflective writing is a learning tool, which students feel free to express their opinions and get feedback that helps students to think critically (Jamshed & Shamsudin, 2013; Lamont, Brunero, & Russell, 2010).

2.2.5.1 **Socratic questioning**

Socratic questioning is defined as an instructional strategy, which uses cross examination of individual's claims and statements to reveal inconsistencies among them (Çimer & Timuçin, 2010). Byrne (2011) stated that Socratic questioning was originated from Socrates. Socratic questioning is a format that encourages students to use existing knowledge to promote a deeper understanding. In practice, students arrange in a circle to discuss, which enhance listening, critical thinking, active learning, and team-working (Byrne, 2011).

Khoshneshin (2011) determined the factors affected student's participation and critical thinking skills through online discussion. Therefore, the author used collaborative critical thinking as an instruction method (Gokhale, 1995) besides Socratic Questioning Prompts (SQP). The results showed that collaborative environment and Socratic questioning help students to cultivate critical thinking.

In the other study, Jacob and Sam (2010) examined the effect of online forum discussion by using Socratic questioning and reflection scaffolds as the most appropriate and effective techniques. The researchers designed 14 weeks for participants to work with online discussion forum and Socratic questioning. The findings revealed that the calculated critical thinking scores had improved from the first session to the second session.

Hajhosseiny (2012) identified the effect of group discussion and Socratic questioning as two main teaching methods on students' critical thinking dispositions and social interaction. The results revealed the effectiveness of Socratic questioning and group discussion in improving critical thinking dispositions, including analyticity, cognitive maturity, critical thinking self-confidence, self-evaluation, open-mindedness, and truth-seeking. Moreover, the authors showed a tangible effect of group discussion and Socratic questioning on the seven elements of social interaction that are: knowing each other,

friendship and intimacy, tendency to dialogue, responsibility, class dynamism, interaction with teacher, and intimacy with the instructor.

Etemadzadeh, Seifi, and Far (2013) investigated the impact of Socratic questioning on critical thinking and writing skills among secondary students. They designed a 2-week program for 60 students. Finally, the researchers found that Socratic questioning has a positive effect on critical thinking of students because the post-test score of students was higher than their pre-test scores. Although, the students have though that, their writing skill is more powerful than the other skills, such as speaking, listening, and reading skills, the results showed that the pre-test score in writing skills was weak. It can be seen that the Socratic questioning could improve the writing skill of students due to the enhancement of their post-test score in writing.

Salam and Hew (2010) examined the effect of a combination of blog casts and Socratic questioning on critical thinking in evaluation of the social issues. The researchers conducted their research among 27 students in social studies from a public school in Singapore. After analyzing the think-aloud findings of students, the positive impact of blog cast and Socratic questioning revealed.

2.2.5.2 **Concept mapping**

Concept maps are graphical tools created by Joseph D. Novak and his team at Cornell University in the 1970's. Concept maps are graphic display of topics, ideas, and their relationships. Concept maps make learning concept meaningful to represent the knowledge, experience of individuals and teams in education, management, science, and medical course (Katagall, Dadde, Goudar, & Rao, 2015). Concept maps allow students to represent their thoughts and it can also be used as an evaluation method for faculty members (All, Huycke, & Fisher, 2003). Moreover, concept map provides an opportunity for students and teachers to see the current knowledge from the beginning to end point (Maria, Dimitris, Garifallos, Athanasios, & Roumeliotis, 2015). In addition, concept

mapping is an effective method to improve critical thinking and learning process by increasing the participation of students in the organization and interpretation of data, the comparison and correlation of relevant information, and the synthesis of ideas (Hussain & Shamsuar, 2013).

S. L. Chen, Liang, Lee, and Liao (2011) conducted a systematic study on the effects of concept mapping on critical thinking and learning among nursing students. The researchers applied concept maps to examine case studies and course content. They divided participants into two groups: one group received concept map instruction and the second group was under traditional instruction. To measure critical thinking the researchers used the critical thinking scale proposed by Y. Chen, Cheng, Liu, and Tsai (2009), which included five sub-scales: inference, recognition of assumptions, deduction, interpretation, and evaluation of arguments. The findings reported that the concept mapping improved the critical thinking and learning among nursing students.

W. Lee et al. (2013) investigated the influence of concept mapping as a useful teaching strategy on critical thinking for nursing students. After a 15-week program, the findings revealed that there was a significant difference between pre-test score and post-test score of critical thinking of students. Therefore, the researchers concluded that the concept mapping is an effective teaching method to cultivate critical thinking among nursing students.

Atay and Karabacak (2012) analyzed the effects of care plans on the critical thinking of nursing students by using the concept maps. They prepared three sessions in 3 to 4 hours for two groups of fresh and sophomore nursing students. The findings revealed that the students under concept mapping instruction could progress in critical thinking dispositions. Therefore, the researchers argued that the concept mapping can be recommended as a useful strategy in improving critical thinking dispositions.

2.2.5.3 **Reflective writing**

Olson (2009) described reflective writing as a practice of reinforcement and strengthening the process of reflection. With regard to the benefits of reflective writing, Levin and Wagner (2005) and Gorlewski and Greene (2011) believed that reflective writing can transform learning when students start to incorporate meta-cognition, or thinking about their thinking (critical thinking) into their writing process. As a result, reflective writing is a proper strategy to develop critical thinking, which some researchers use it to foster critical thinking among students.

Naber and Wyatt (2014) applied CCTDI and CCTST as two main instruments for measuring critical thinking skills and critical thinking dispositions among 70 nursing students. In fact, they wanted to test the effectiveness of novel reflective writing intervention based on Paul (1993) model of critical thinking. Therefore, the researchers provided a program in 8 weeks. The results showed significance increase in truth-seeking and four skills belong to CCTST. As a result, reflective writing is an effective teaching method to improve critical thinking among students.

2.2.5.4 **Problem based learning**

Problem-based learning (PBL) is one of the most applied approaches for teaching students in any education system that emphasizes on the students' role in learning (Barrows, 1988; Milter & Stinson, 1995; Savery & Duffy, 1995). In PBL, students also have to deal with ill-structured problems as a context for them to learn problem-solving skills and to become more knowledgeable in the basic and clinical sciences (Albanese & Mitchell, 1993). The PBL approach is a learning model that can foster critical thinking and hence, it is widely used by educators and researchers as follows:

Carriger (2016) attempted to assess the various effects of PBL and lecture-based instruction on knowledge acquisition and problem-solving skills especially critical thinking skills. To reach this goal, the study was conducted among three different

semester medical students to compare lecture-based instruction, PBL, and hybrid learning. The results revealed that PBL is more effective than lecture-based and hybrid learning. Therefore, the researcher found that problem-based learning can be the best way to develop critical thinking and knowledge acquisition.

Idrus, Mohd Dahan, and Abdullah (2010) discussed the teaching approaches used in private universities, and the perceptions of the lecturers and students pertaining to embedding critical thinking skills in the technical courses. They found that the democratic nature of PBL and project oriented problem-based approach (POPBL) encourages students to solve their real-life problems, and this increases students' knowledge in the learning process. It was also found that by increasing the usage of the PBL approach, critical thinking and problem-solving skills also were improving.

In another study, Choi, Lindquist, and Song (2014) examined the outcome of PBL and traditional lecture. To achieve this goal, the researchers designed a quasi-experimental non-equivalent group pretest–posttest among Korean nursing students for 16 weeks. The findings of the research revealed that students who participated in PBL class could improve in problem solving, self-directed learning abilities and critical thinking.

Similarly, Yu, Zhang, Xu, Wu, and Wang (2013) examined the effect of PBL on the development of critical thinking dispositions among Chinese nursing students by using a crossover-experimental study. This study was conducted among two groups: one group was under PBL and the second group was receiving lecture-based learning. After the first learning process, the researchers found that critical thinking dispositions including truth seeking, systematicity, and self-confidence were improved in the control group whom under problem-based learning.

Martyn, Terwijn, Kek, and Huijser (2014) conducted their study with the aim of exploring the relationships between nursing students' individual characteristics and perceptions of learning environments, teaching in PBL mode, approaches to learning, and

critical thinking skill readiness. The researchers adapted a conceptual framework by Kek and Huijser (2011) and the survey questionnaire. The findings implied that the PBL as an effective teaching approach has an essential role in improving critical thinking skills among nursing students.

2.2.5.5 **Web-based learning**

Using the newest information and communication technologies in education and learning process has become popular. Web-based learning is one of the aspects of ICT progression. Garrison and Cleveland-Innes (2005) believed that web-based learning can be most effective to increase students' critical thinking skills when discussion in web-based learning is well planned and well structured. As a result, several researchers applied web-based learning strategy to cultivate critical thinking.

Salleh, Tasir, and Shukor (2012) developed a web-based simulation learning framework to enhance critical thinking among students based on iterative simulation features social constructivist theory by Honebein (1996) and critical thinking skills (Facione, 1990b). To find the effectiveness of the framework in developing critical thinking, a web-based simulation was used. The results stated that critical thinking of students was improved due to the collaborative nature of the web-based learning environments.

Petchtone and Chaijaroen (2012) designed a web-based learning environment model to enhance cognitive skills and critical thinking. The results revealed that the web-based learning environment has nine elements, consisting of: (1) Problem base (2) Data bank (3) Related case (4) Scaffolding (5) Enhancing in cognitive skills center 6) Enhancing critical thinking center 7) Chat room and web board foster in collaboration (8) Cognitive tools (9) Coaching. In sum, it was indicated that web-based learning environment is a useful model in development of critical thinking and cognitive skills.

In another study, Sirisopon and Sopeerak (2013) constructed the web-based instruction model by using constructionism approach for development of critical thinking among undergraduate students. Also, the researchers tested the student's satisfaction toward the web-based instruction model. Indeed, the researchers attempted to teach "Personal and Community Health" course through the web-based learning. The findings of analysis showed that the score of students after learning from the web-based instruction model was higher than before learning. The satisfaction toward the web-based instruction model was also at high level.

2.2.5.6 **Information communication technology (ICT) based learning**

ICT provides a new opportunity for teachers to engage students in critical thinking by using problem solving techniques, analytical thinking, and collaboration skills (Wiseman & Anderson, 2012). Instructors use ICT in various formats during learning processes such as blogging, wikies, and online discussion forums. Cabiness, Donovan, and Green (2013) believed that wikies are able to motivate and help students to develop critical thinking. Along with the advantages of ICT, several researchers applied ICT to develop and improve critical thinking in the education system.

Yang, Chuang, Li, and Tseng (2013) investigated the influence of ICT-based learning by using an online individualized English, which was implemented using Moodle for CT-integrated English language instruction for English listening and speaking skills. In the study, students participated in the online English listening and speaking courses delivered via Moodle. The students' perception of critical thinking skills and dispositions were also assessed in the virtual environment. It was found that the English listening and speaking proficiency besides critical thinking skills and dispositions were improved especially on open-mindedness.

González-González, Gallardo-Gallardo, and Jiménez-Zarco (2014) provided a teaching innovation project in order to develop and assess one of the fundamental

students' competencies from any business administration degree, such as critical thinking. Therefore, the researchers adapted an audio-visual case methodology with short films and real stories. In fact, the researchers aimed at examining the effect of ICT on comprehension of problems and stimulate learning. The results revealed that ICT is effective in development of critical thinking among students as well as improvement in understanding the problem. In addition, the role of ICT during learning process is positively impressive.

Pucer, Trobec, and Zvanut (2014) designed and tested an ICT-based approach to acquire nursing students with critical thinking skills. The researchers prepared a discussion board analysis tool to identify key elements of critical thinking as defined by Facione (1990b). They found that there is a significant improvement in the percentage of posts where students' opinions and conclusions were justified with valid arguments. Moreover, the findings showed that the ICT-based approach was effective in improvement of critical thinking skills among nursing students.

The main objectives in (Y. C. Yeh, 2012) are: developing a blended Knowledge Management training program to foster the students' critical thinking skills, implementing an educational framework based on blended Knowledge Management model to develop students' critical thinking skills, investigating the attribute-treatment interaction, and exploring the fundamental mechanisms of this program. This research emphasized the essential role of critical thinking and knowledge management skills as the two key skills for generating, sharing, and using knowledge (Y.-C. Yeh, 2009). The findings of this study revealed that several factors such as the formation of a learning community, online communication and discussion, and observational learning can affect the knowledge management process. Therefore, the students' critical thinking skills - directly or indirectly- will improve the co-creation knowledge management model, and this will have a positive impact on both students and instructors.

Yang, Gamble, Hung, and Lin (2014) examined the effectiveness of critical thinking-infused adaptive English literacy instruction by using Moodle system. To achieve this goal, the researchers provided 10-week course entitled "English language learning and thinking training" by taking advantages of Moodle system. In practice, the critical thinking-infused adaptive English literacy instruction facilitates the collaboration among students and content delivery, which helps students to think deeply and critically. The results revealed that Moodle system and infusing critical thinking with English language have a positive impact on students' critical thinking and their English learning.

Wannapiroon (2014) developed a research-based blended learning (RBBL) model and examined the effectiveness of this model on students' critical thinking and research competency. The researcher developed the model by using 8 components, such as (1) Virtual Learning Environment (VLE), (2) Cloud Learning Management System (CLMS), 3) learning courseware, (4) learning resources, (5) scaffolding, (6) communication, (7) learning assessment, and (8) RBBL activity in four phases. The study was conducted among 10 experts during the development of model and 28 postgraduates for examining the effectiveness of the model in critical thinking and research competency. The research findings showed that there is a significant difference between pre-test score and posttest score in critical thinking and research competency. Furthermore, the participants agreed with high satisfaction toward the model. According to the experts' comments, the proposed model was revised and proposed for further implications.

2.2.5.7 **Socratic questioning and web-based learning**

To reach the goal of developing critical thinking among students, some researchers attempted to use a combination of instructional strategies such as Socratic questioning and web-based learning. For example, M. Lee, Kim, and Kim (2014) found a gap, which indicates that online learning environment is an effective tool in solving problems, but they wanted to find a very effective tool in students' learning skills. Therefore, the

researchers provided a program by using Socratic questioning in web-based collaborative learning to examine the impact of it on pre-service teachers' critical thinking skills. The study was conducted among undergraduate students under the pre-service teacher program, into two non-equivalent groups: one group under the Socratic questioning instruction and the other group without the Socratic questioning instructions. The participants required to discuss about three topics by using the web-based bulletin. Comparison of two groups revealed that Socratic questioning was effective on students who received Socratic questioning instruction, and their score in critical thinking was higher than the control group without Socratic questioning instruction.

2.2.5.8 **Problem-based learning and web-based learning**

The advantages of PBL and web-based learning to deliver material contents are not ignorable. Therefore, some scholars have taken such advantages of to develop critical thinking among students in learning institutes. For instance, Sinprakob and Songkram (2015) proposed a model of PBL on social media to enhance critical thinking among undergraduate students based on search techniques. This research was conducted in two phases consists of: (1) theories, research, and expert opinions, (2) and evaluation of the proposed model. The authors developed the model by reviewing the literature, interviewing the experts, and evaluating the system with the help of 5 experts. In fact, the researchers aimed at utilizing the advantages of PBL is to stimulate a critical thinking and a new ICT to facilitate the learning process. The findings recommended the proposed model as a useful model for improving the students' critical thinking, and the experts also agreed with high satisfaction toward the proposed model.

2.3 Sample systems to cultivate critical thinking skills

In addition to the instructional approaches for cultivating critical thinking, some researchers attempted to propose different frameworks and systems. Computerized Training in Critical Thinking $(CT)^2$ (Fischer, Spiker, Harris, McPeters, & Riedel, 2008)

for U.S. army and a critical thinking framework for any discipline (Duron et al., 2006) are explained as follows:

2.3.1 Computerized Training in Critical Thinking (CT) [2]

The United States military is one of the first organizations to promote critical thinking due to the role of critical thinking military in making complicated decision while military leaders are in stressful situations, where knowledge is not enough and certain (Cohen, Thompson, Adelman, & Bresnick, 1999; Lynch & Wolcott, 2001; Paullin, Ingerick, Trippe, & Wasko, 2011; Riedel, Morath, & McGonigle, 2001). Hence, military situations require new and insightful solutions, which can originate from sharp mind and proper thinking skills. As a result, it is required to establish a training program with the purpose of developing thinking skills.

Fischer, Spiker, Harris, et al. (2008) presented an easy and well-accessed training system in critical thinking skills entitled "Computerized Training in Critical Thinking $(CT)^2$ ". $(CT)^2$ system is a modular, web-based, self-administered, and interactive training system. It consists of several training and assessment components, including pretests, training modules, and posttests for each of eight critical thinking skills. Four of the critical thinking skills have been taught in the extended training version in addition to the standard shorter version. The pretests and training modules are interactive, involve different exercises with feedback, and utilize multi-media presentations. The main purposes of designing all components are to improve critical thinking skills and to increase self-awareness of user's thinking (Fischer, Spiker, Harris, et al., 2008; Fischer, Spiker, & Riedel, 2008, 2009a, 2009b; Tucker et al., 2010). To design the $(CT)^2$ system, the authors, firstly, developed a model of critical thinking and checked its applicability by using the initial empirical testing (Fischer et al., 2009b). Then, some reasonable and appropriate pedagogical principles were used for implementing the $(CT)^2$ system.

Fischer, Spiker, Harris, et al. (2008) completed the $(CT)^2$ system in three phases: preparatory research, prototype development and evaluation, and Development and evaluation of $(CT)^2$.

2.3.1.1 Description of $(CT)^2$ modules

$(CT)^2$ consists of several components, which training and assessments are the most noticeable modules (Fischer, Spiker, Harris, et al., 2008; Fischer et al., 2009a). Training system has two modules: standard training and extended training modules. The assessment system module involves three modules: pre-test, post-test, and evaluation. The pretests and training modules have interaction with each other. The pretest includes several exercises with corresponding feedbacks, and utilizes multimedia presentations. The explanations of these modules are as follows:

i. ***Training system module***

The training module of this prototype was provided in two modules: standard training modules and extended training modules. (1) *Standard training modules:* focus on each of the eight critical thinking skills: frame the message; recognize gist in materials; develop an explanation that ties information elements together in a plausible way; generalize from specific instances to broader classes; use mental imagery; challenge one's bias; examine other people's perspective; decide when to seek information based on its value and costs. The modules were developed to meet army training needs and to support the four themes and 18 pedagogical principles (Fischer et al., 2008c). To complete each module, users require approximately two hours. (2) *Extended training modules:* were provided for the fundamental skills of critical thinking, including, (a) frame the message; (b) recognize gist in material; (c) develop an explanation and (d) generalize from specific instances to broader classes. Each extended training module has an introduction and five training elements (Fischer, Spiker, Harris, et al., 2008; Fischer et al., 2009a).

ii. ***Assessment system module***

The assessment system has three different modules: pretest, posttest, and evaluation modules.

iii. ***Pretest module***

It was designed to (1) enable student self-assessment of critical thinking ability, (2) increase student sensitivity to their own errors and problems associated with lack of or improper skill application, (3) increase student self-awareness of critical thinking ability, and (4) present feedback to begin the learning process. Completing the pretest for each skill lasts about 20 minutes (Fischer, Spiker, Harris, et al., 2008).

iv. ***Posttest module***

It is to assess student comprehension of critical thinking concepts and evaluate student's ability. Posttest has various formats from module to module based on the types of test technique to meet the assessment objectives. In practice, posttest is conducted to evaluate student progression and to identify the weak points of the training system. The structure of posttest is based on multiple-choice questions with operational scenarios and sample materials for each skill of critical thinking. There are several formats for students, such as classification, matching, ranking, and rating by means of dragging-and dropping items. Analytical responses are also made by selecting items from lists by checking boxes, selecting YES or NO, or selecting TRUE or FALSE.

v. ***Evaluation module***

There are two evaluation formats, as follows: (a) Formative evaluation: was conducted on a sample of training components. Therefore, user's comments and suggestions on any subset of pretest, training modules, and posttest will use for the whole set. The results of the usability tests help the other tests and modules (Fischer, Spiker, Harris, et al., 2008). (b) Summative evaluation: two summative evaluations were conducted to evaluate whether (CT) 2 increases critical thinking skills. The first evaluation aimed at assessing

the learning achieved through one training module compared to a control group. The second investigation was designed to assess the extended version of the training system based on obtained skills through the standard training module (Fischer, Spiker, Harris, et al., 2008).

2.3.1.2 **Software development**

In order to develop an easy and interactive system, several technologies were used, such as the browser-based technologies of HTML, CSS (Cascading Style Sheets), and JavaScript manipulation of the DOM (Document Object Model). These three technologies have together come to be known as dynamic HTML (DHTML), and make the software for the training purposes. In addition to DHTML, various software tools were applied to build the $(CT)^2$ training environment, including, (1) Macromedia Flash™ to create animations and synchronize audio; (2) Adobe Photoshop™ to manipulate and compress graphic files; (3) Macromedia Dreamweaver™ to create HTML source code; (4) IBServer (a Sourceforge project distributed under the GPL license) as a Windows™-based testing; and (5) Sapien's PrimalScript™ integrated development environment for Windows™ scripting languages. In the viewpoint of users, a host of functional abilities and visual formats were created to support the functional characteristics required for the eight skills. In some cases, the capabilities were developed by hiring the services offered by DHTML and supported by the Internet Explorer browser. Other times, new tools and display formats were designed (Fischer, Spiker, Harris, et al., 2008).

2.3.1.3 **Time**

Users who want to complete all the training modules $(CT)^2$, need approximately two hours to work through each of the eight critical thinking skills. As a result, the completion procedures take about 16 hours for a total.

2.3.1.4 **Utilizations**

The $(CT)^2$ is available for use by any army organizations who concern about the lack of critical thinking among soldiers and seek for a solution to improve critical thinking skills. Since the $(CT)^2$ training system is a web-based system, everyone can work on it stand-alone and self-taught. This research had two main results for future researchers, (a) a testable model of critical thinking was presented, and (b) the development of $(CT)^2$ as a complete training package and a model to develop critical thinking.

2.3.1.5 **Characteristics of $(CT)^2$**

In spite of designing the $(CT)^2$ for individuals, the investigations were done among a group of soldiers. In practice, the results showed that training in a group to have several feedbacks, and discussion with instructors and peers facilitate students' learning process. Therefore, the designers of the $(CT)^2$ had to consider group learning as a precious educational tool (Fischer, Spiker, Harris, et al., 2008).

The $(CT)^2$ is a web-based program and all soldiers are able to access the system whenever they want. The informational content of the $(CT)^2$ is also unlimited to deliver. However, these features can impose restriction for learners (Fischer, Spiker, Harris, et al., 2008; Fischer et al., 2009a). The greatest limitation of the $(CT)^2$ is that it has a limitation in delivering feedback to soldiers' responses. Specially, for critical thinking, limited quality and amount of feedback might play a barrier role during the learning process. However, the results of evaluations have shown that $(CT)^2$ is useful in learning process and enhance critical thinking skills, which shows the effective role of feedback in critical thinking (Fischer, Spiker, Harris, et al., 2008).

To design the $(CT)^2$, the Socratic method was used as a classic pedagogy with high efficiency at generating clear thinking (J. M. Jones & Safrit, 1994). The weakness of learners during learning process is that, the learners ask improper questions and they

prefer not to ask any questions. Therefore, asking repeated and pointed questions is a very helpful method (Fischer, Spiker, Harris, et al., 2008).

The $(CT)^2$ was designed on the basis of the assumption that increasing self-awareness of one's own critical thinking will result in improving it (Paul & Elder, 2001). This research attempted to show the relationship between critical thinking and metacognitions likewise self-awareness (Fischer, Spiker, Harris, et al., 2008; Paullin et al., 2011). Table 2-3 provides an overview on Computerized Training in Critical thinking $(CT)^2$.

Table 2-3: An overview on Computerized Training in Critical Thinking $(CT)^2$

Audience	Features	Limitations
U.S. army forces	• Web-based programs delivery unlimited information • Two main modules and sub-modules: a. Training module, including standard training system and extended training system b. Assessment module, including pre-test, posttest, and evaluation in two formats	• 12 hours for implementation • Difficult to implement and work for audiences • Limited quality and amount of feedbacks

2.3.2 Interdisciplinary model for cultivating critical thinking

Duron et al. (2006) presented an interdisciplinary model for cultivating critical thinking among students in a variety of disciplines. The reason for developing this model was passive students and teacher's problem in making classrooms enjoyable with good outcomes in critical thinking. To propose the interdisciplinary model, Duron et al. (2006) applied the existing theory, which was taken from Bloom's taxonomy (Bloom, 1956), as well as best practices in cognitive development, effective learning environments, and outcome-based assessments.

2.3.2.1 The theory behind the interdisciplinary model

Bloom (1956) proposed a taxonomy with six levels in the cognitive domain, which related to different cognitive abilities, as follows: knowledge refers to remembering and

reciting the information, comprehension refers to relating and organizing learned information, application refers to applying information based on the rules in a specific situation, analysis was defined as critical thinking, which refers to parts and their functionality in total, synthesis was defined critical thinking, which refer to put parts together to form a new thing, and evaluation was defined as critical thinking, which refers to value and judge based on the information. Duron et al. (2006) supposed that critical thinking is required when students are in analysis, synthesis, and evaluation levels of Bloom's taxonomy.

2.3.2.2 **Features of the interdisciplinary model**

Duron et al. (2006) presents the interdisciplinary model in 5 steps, as follows:

i. ***Determine learning objectives (Step1)***

To promote critical thinking, teachers should provide learning objectives with all activities and the assessments based on the first level of Bloom's taxonomy (Bloom, 1956) that is called "knowledge". The learning objectives should meet all levels of Bloom's taxonomy. For example, in "knowledge" level, students answer the questions, such as who and what, and to describe, state, or list something. Indeed, students need to answer simple questions on facts. In "comprehension" level, students need to answer the questions about their understanding the information, such as summarizing, explaining, paraphrasing, comparing, and contrasting. In "application" level, students require to answer the questions about their ability in using information, concepts, and theories, such as constructing, solving, applying, discovering, and showing. In "analysis" level students should answer to questions about seeing patterns and classifying information, such as examining, classifying, recognizing, and analyzing. In "synthesis" level, students need to answer questions about their ability to make a relationship between their knowledge to create a new work, such as combining, constructing, and creating. In "evaluation" level,

students should answer the questions about their ability to judge evidence based on reasonable arguments, such as assessing, criticizing, evaluating, and recommending.

In the first step, teachers should provide the objective learning to identify student's behavior when they exit classrooms and allow students to practice.

ii. ***Teach through questions (Step 2)***

In this step, teachers need to provide different questions with the aim of giving an opportunity to think and answer in a proper way. Therefore, teachers are able to take advantage from simple questions in "knowledge, comprehension, and application" levels of Bloom's taxonomy, while they can ask complex questions in "analysis, synthesis, and evaluation" levels. Teachers are responsible to provide an opportunity for all students to ask more thoughtful questions and make them to think about thinking.

iii. ***Practice before you assess (Step 3)***

In this step, teachers need to use some kind of experiential learning and opportunities for reflective dialogue to provide an active learning environment. In practice, teachers should prepare the different kind of activities for students to acquire them with the topic or question as well as their feedbacks towards activities. This step helps students to answer several questions, such as "what am I learning? What is the value of what I am learning? How am I learning? What else do I need to learn?"

iv. ***Review, refine, and improve (Step 4)***

In this step, teachers are responsible for refining their courses to see the effectiveness of them. Therefore, teachers should have a close relationship with their students and ask them to talk about their outcome of the classrooms and courses. In addition, teachers need to have a diary notebook to monitor their own works. The assessment tools are also helpful in determining whether the courses and activities cause progression of students. This step helps students to be monitored and improved better in the courses.

v. ***Provide feedback and assessment of learning (Step 5)***

In the last step, teachers should collect feedbacks from students through assessment tools by using defined criteria and standards to evaluate the quality of the courses. These feedbacks allow students and teachers to engage in reflective dialogue to distinguish the successful from unsuccessful performance. Teachers require to provide an opportunity for students to practice and test whatever they expect. The feedbacks should be informational rather than controlling, and they have to be positive, standard-based, constructive, frequent, and different.

2.3.3 Drawbacks of the interdisciplinary model

Although Duron et al. (2006) claimed that their interdisciplinary model was applicable for any discipline with the purpose of cultivating critical thinking, specific disciplines may have difficulties to work on it. For instance, Physical scientists and Mathematicians prefer traditional educational methods, such as lecture-based learning. Furthermore, involvements of students in activities to make them active learners prevent them to listen to the instructions. Despite the benefits of the interdisciplinary model for cultivating critical thinking among students, sometimes it needs some fundamental changes in instructional techniques. The proposed model can be implemented in small class size, and it needs too much time to engage students in classroom activities. Therefore, time constraints and class size are the other influenced factors in implementation that teachers should consider. Table 2-4 reviews on the interdisciplinary model.

Table 2-4: An overview on the interdisciplinary model

Audiences	Features	Limitations
Students in all disciplines	• Based on the theory taken from Bloom's taxonomy • 5-step framework: a. Determine learning objectives b. Teach through questioning c. Practice before you assess d. Review, refine, and improve e. Provide feedback and assessment of learning	• Class size • Time constraints • Required fundamental changes in instructional techniques

2.4 Comparison of samples

In comparison, the $(CT)^2$ (Fischer, Spiker, Harris, et al., 2008) is an interactive training system (see Chapter 5), which consists of training system module, pretest, posttest, and evaluation. The $(CT)^2$ is a complex system to improve critical thinking among army forces, but the proposed prototype in this research has a user-friendly and flexible for each category of students to meet their needs. The $(CT)^2$ supported all features of a training system, but it could be applied in the scope of military due to the specific definition of critical thinking skills and its own critical thinking model (Fischer et al., 2009b). Moreover, Duron et al. (2006) claimed that the interdisciplinary model was applicable to all disciplines, but it practically needs fundamental verifications to match with the required disciplines.

2.5 Information seeking behavior

This Section describes the information seeking behavior and its historical background. It also provides an overview on the existing information seeking models.

2.5.1 Definitions and historical background

Information seeking as an aspect of information behavior has been getting attention by a large number of researchers, which more than 10000 research papers have been published on it as well as the other aspects such as information needs and information use (Case, 2012). Wilson (2000) defined information behavior as "the totality of human behavior in relation to sources and channels of information, consisting of both active and passive information seeking, and information use". Therefore, it includes face-to-face communication with others, and the receiving information without intention, for example, watching TV advertisements, without any purpose to get information.

Wilson (1999b) also defined information seeking behavior (ISB) as the purposive seeking for information because of emerging information needs to reach some goals. To meet the information needs, individuals may refer to manual information systems (i.e.,

newspapers or libraries), or interact with computer-based systems (i.e., the World Wide Web). Meanwhile, Marchionini (1997) defined the information seeking behavior as a process that persons intentionally involve in changing their state of knowledge. In comparison, Wilson's definition focuses on fulfilling information needs, while Marchionini insists on learning and problem solving. As a result, information seeking can be defined as a process of finding information to fulfill specific information needs, in order to improve the level of understanding or knowledge related to a problem or a question (Shuib, 2013).

2.5.2 Information seeking models

There are several models for information seeking behavior, such as Wilson's model of information seeking behavior (Wilson, 1981); Dervin's Sense-Making theory (B. Dervin, 1983); Ellis's behavioral model of information seeking strategies (Ellis, 1989; Ellis, Cox, & Hall, 1993; Wilson, 1981); Kuhlthau's model of the stages of information-seeking behavior (Kuhlthau, 1991); Wilson's model (Wilson, 1997), which expands his 1981 model through an analysis of the literature in different fields (Wilson, 1999b); Krikelas' linear model (Krikelas, 1983); Eisenberg and Berkowitz's model (Eisenberg & Berkowitz, 1992); and Marchionini's model for electronic environment (Marchionini, 1997).

Krikelas (1983) was the first to develop a model for ISB in the general population. This model consisted of four steps as follows: (1) perceiving a need, (2) perceiving the search itself, (3) finding the information, and (4) using the information. The author indicated that the results of this ISB model can be satisfaction or dissatisfaction. Krikelas stated that ''information seeking begins when someone understands that the current state of knowledge is less than that needed to deal with some problems. The process ends when that perception no longer exists." His model is constructed based on needs. It is a linear model and is complex enough in addressing the topic, but it is not flexible.

To address the complexity and flexibility of (Krikelas, 1983), Eisenberg and Berkowitz (1992) proposed a model by using the concept of "Big Six Skills", which includes task definition, information seeking, implementation, use, synthesis, and evaluation. The authors believed that these skills are appropriate with the learning theories and cognitive development theories. The presented model is based on cognitive skills that are complex and flexible enough in different areas like hypertext. This model facilitates the seeking process by going back and forwarding to refine and identify the information needs more and more to implement new strategies.

Ellis (1989) provided a model for information seeking process based on information seeking activities by employing Glaser and Strauss's grounded theory approach (B. G. Glaser, Strauss, & Strutzel, 1968). Ellis (1989) used the term *features* rather than *stages*. These features and definition are: (1) Starting: using the reading list to understand the required information; (2) Browsing: reviewing the given information and probable results; (3) Chaining: using the references and the related topics to the main question; (4) Differentiation: making different between collected information to select needed information (5) Monitoring: reading and considering the related findings to make an initial result; and (6) Extracting: drawing conclusions with deep thinking. This model was extended and fitted with behavior in physicists and chemists with a little change, then verifying and ending were added to the original model (Kakai, Ikoja-Odongo, & Kigongo-Bukenya, 2004) (7) Verifying: evaluating the results and be sure about them to find a good conclusion; and (8) Ending: the final step of the information process in which seekers make a decision (Ellis, 1993; Ellis et al., 1993).

Kuhlthau presented a new model to complement the Ellis' model by attaching the feelings, thoughts, and actions to the stages of the information search process (Kuhlthau, 1991, 2004). In practice, the proposed model is one of the few models based on actual research. This model looks at the action of seeking information in a real environment

along with the consideration to the thoughts, feelings, and actions of seekers. The Kuhlthau's model consists of cognitive issues and feelings, which increase during the information-seeking process, likewise: confusion, anxiety, doubt, and confidence. The Kuhlthau' model has 6 stages, as follows: (1) Initiation: users feel uncertainty and vague about the problem area and then try to recognize the need for information and interpret the topic or problem; (2) Selection: users should identify and select the general information or approach and they feel optimism rather than uncertainty; (3) Exploration: users should expand their understanding by investigating information on general topic, therefore, their feelings are certainty, confusion, and doubt; (4) Formulation: users form a focus from the information encountered and their uncertainty replaced by confidence; (5) Collection: users should gather information related to the topic with increasing confidence besides uncertainty; (6) Presentation: users complete their task and they have to present their outcome with relief (Kuhlthau, 1991).

Kuhlthau's model is more general than the Ellis's model in grabbing attention to the feelings attached to the different stages and activities. The strength of Kuhlthau's and Ellis's models is that they are based on actual research and have been tested in the future studies (Wilson, 1999b). Kuhlthau's and Ellis's models can be used in any domain; however, they cannot claim that their models consider many of the factors and variables. These models were generally considered in information seeking research, such as the type of need and sort of information, or the availability of sources and their characteristics (Case, 2012).

Marchionini believed that information searching is a normal and vital mechanism of human existence (Marchionini, 1997, 2006). Fundamentally, Marchionini defined information searching as "an interactive process within an information environment" (Knight & Spink, 2008). Marchionini (1997) developed the information seeking process model, which was so integrated and specifies for information search process in the

electronic environment. The generic construct of Marchionini's model as well as its attention to the users in electronic environment and their actual seeking activities make this model suitable for electronic environment. Marchionini (1997) divided the information seeking process into three sub-processes: 1) understanding; 2) planning and execution; and 3) evaluation and use. Marchionini (1997) described information search models as directed, semi-directed and undirected (i.e., browsing). The Marchionini's information seeking model includes eight steps: (1) recognition and acceptance of a problem; (2) definition and understanding of the problem; (3) choice of a search system; (4) formulation of the query; (5) execution of the search; (6) examination of results; (7) extraction of useful information; (8) reflection and iteration as necessary or conclusion of the search.

Wilson (1981) proposed a model based on the information needs of users. Indeed, the model shows if users could meet the information needs and find a proper answer for the question, the users may use the found information. However, if the users fail to find the desire information, the searching activities may repeat. This model is weak in providing a map of the area and draw attention to the research gap. Therefore, it cannot suggest the causative factors in information behavior and the defined hypotheses are not testable (Wilson, 1999b).

Wilson also proposed a second model based on two propositions, including the information need and the efforts to find information for fulfilling the information need (Wilson, 1999b). The author noted that the context of individuals' needs can be different from their personality to the environments. Moreover, several limitations can appear during search for information to fulfil these needs (Wilson, 1997). Indeed, Wilson's model can be defined as a macro-model or a model of the gross information-seeking behavior. This model suggests how information needs arise and what may prevent the actual search for information. The proposed model also represents a set of hypotheses

about information behavior that are testable, but these hypotheses are only implicit. The other weakness of this model is the lack of certain elements to motivate thinking about some sort of elements for completing a good model (Wilson, 1997).

Sense-making theory is the next model presented by (B. Dervin, 1983). It is not a simple model of information seeking behavior because it consists of a set of assumptions, a theoretic perspective, a methodological approach, a set of research methods, and a practice' designed to cope with information perceived. Sense-making theory model was designed as a human tool to make sense of a reality assumed orderly and disorderly (B. Dervin, 1983). The authors developed the sense-making theory model based on four components: (1) Situation in time and space, refers to the context in which information problems arise, (2) Gap, which indicates the difference between the contextual situation and the desired situation (e.g. uncertainty), (3) Outcome, that is the results of the Sense-Making process, and (4) Bridge, that means of closing the gap between situation and outcome. Therefore, the author presented these components in terms of a triangle: situation, gap/bridge, and outcome. The strength of the proposed model is in its methodological consequences, related to information behavior. In fact, the consequences originated from the way of questioning, and they reveal the nature of problems and outcomes as well as the extent to the provided information as a bridge to full the information gap (Brenda Dervin, 1992; B. Dervin & Dewdney, 1986).

2.6 Factors influence ISB

Initial research on ISB has focused on key factors, which influenced information seeking behavior, such as prior knowledge, position and information needs, information literacy, and demographic variables, including, education level, discipline, gender, and personal traits. Korobili, Malliari, and Zapounidou (2011) discovered some factors, which impact on the information seeking behavior of students. The results of analysis revealed that information needs, information literacy, prior knowledge, age, and degree are

effective factors towards information seeking behavior, but, discipline did not play an important role during seeking for information (Korobili et al., 2011).

Information seeking behavior is a purposive behavior to seek for information, which human use different sources to meet their information needs (Wilson, 2000). Information seeking process is a famous model (Kuhlthau, 1991) of ISB, which consists of six stages of seeking for information and shows several stages of seeking for information that an individual should pass. Although this study is based on the ISP model, to have a comprehensive view of the studies around the ISB, Section 2.6 summarizes the influenced factors on ISB and then, Section 2.7 describes the effective factors on ISP. The influenced factors on ISB are described as follows:

i. ***Positions :*** Niu and Hemminger (2012) conducted the study among faculty members, research staffs, and postgraduates in natural science, engineering, and medical science departments to investigate the influenced factors on information seeking behavior. The results showed that the academic positions besides the information needs affect the information seeking patterns.

ii. ***Discipline and education level:*** In terms of discipline and education level, Catalano (2013) reported that doctoral students in the social science use library more than other disciplines, which revealed the impact of discipline on the information seeking behavior of students. Madden (2014) in another study claimed that information needs of humanities PhD is completely varied, and they have many difficulties in the first year of the doctoral period. Furthermore, Wu and Chen (2014) found that science and technology postgraduate students have different behavior in seeking for information rather than their peers in humanities and social sciences. Jamali, Nicholas, Clark, and Rowlands (2009) revealed that life science researchers tended to use e-journals rather than the other disciplines, which displays the different behavior among different disciplines. In another study, Jamali and Nicholas (2007) reported that doctoral

students in physics and astronomy work heavily with electronic journals that showed a distinctive information seeking pattern than their counterparts in applied physics and astronomy.

iii. ***Prior knowledge :*** In the case of prior knowledge and information seeking behavior, Khosrowjerdi and Iranshahi (2011) found a statically relationship between past experience in information resource usage and relevance judgment and put effort into seeking for information. In the other word, having prior knowledge had a positive effect on the information seeking behavior of students.

iv. ***Gender:*** Studied about the relationship between gender differences and information seeking behavior revealed interesting results. For example, Zhou (2014) stated that male students involve in search activities more than female students. Therefore, male students use different search strategies to find desired information, which shows the different information seeking behavior among genders. In another study, Jansen, Moore, and Carman (2013) found that gender is an important factor in information seeking behavior. Rowlands and Nicholas (2008) also studied the impact of gender on information seeking behavior of students. The authors showed that gender has a key role in describing the information seeking behavior. Urquhart and Yeoman (2010) examined the effect of gender or sex on information behavior seeking by conducting a meta-synthesis approach. The findings showed that gender can be an important variable during seeking for information, although the targeted population for this research was women.

v. ***Information need:*** Information need is another determinant for information seeking behavior. Hence, several researchers worked on the effect of the information need on information seeking behavior. Korobili et al. (2011) emphasized on the role of information needs of students during seeking for information. Spezi (2016) stated that information need is the first step of information seeking that can clarify the future steps

during seeking for information. Weiler (2005) also explained that information need is a critical factor in information seeking behavior, because different seekers with different needs may behave different in seeking for information.

vi. ***Personal traits:*** In viewpoint of some researchers, personal traits are effective on information seeking behavior of individuals. For instance, Heinstrom (2010) explored the relationship between personal traits and information seeking behavior. The author has found that information seeking behavior was closely related to a combination of personality traits that distinguish each individual. Actually, different personal traits may form different information seeking behaviors, which are specified to individuals. Asghar (2015) studied the factors influenced on information seeking behavior of students through Facebook. The results revealed that personality trait was an important factor which is related to the information seeking behavior of students.

vii. ***Information literacy:*** There are many studies about a direct correlation between student's success and student's ability in seeking, finding, and using information (Rose et al., 1998), which are called the information literacy. Sophos (2003) defined information literacy as "the ability to access, evaluate and use information from a variety of source". Wahoush and Banfield (2014) described the information seeking behavior of nursing students. This research was conducted among nursing students and graduate nurses to know the difference between their information literacy capabilities. The results revealed that graduate students tended to use scholarly sources rather than nursing students due to their experience in information literacy. Holscher and Strube (2000) showed that successful search requires a combination of web experience and domain knowledge. In fact, it is believed that information seekers need to have information literacy as well as background knowledge. In the other study, Madden (2014) who surveyed humanities PhD students, found that the role of information literacy is so remarkable, particularly for the first month of doctoral studies. In fact,

the results indicated that if PhD students were information literate, they could easily go forward with little difficulties.

2.7 Factors associated with ISP

There are several factors, which impact on ISP, including information need, information literacy, personal factors, uncertainty, anxiety, and critical thinking as follows:

i. ***Information need:*** Clark (2014) applied a theoretical framework in order to consider the groups' user behavior and needs by inspiring Kuhlthau (1991) model. She applied the framework to two mature students' experiences in a semester-long information searching task. Finally, the author found that "the affective domain of information seeking could be an especially powerful help or hindrance to mature students".

ii. ***Information literacy:*** Fainburg (2009) used the ISP model to examine the relationship between information literacy of bachelor students, doctoral students and researchers and the information needs. The author pointed to the differences between the information needs of bachelor students; doctoral students; and researchers, and their seeking behavior. For example, some of the researchers may prefer to ask colleagues instead of seeking help from the librarians. Therefore, the freshmen researchers are not motivated towards information literacy training programs (Fainburg, 2009). In other words, the results mentioned that students with lower degrees and freshmen researchers had lower tendency in the information literacy program rather than doctoral students and experienced researchers.

iii. ***Personal factors:*** Hyldegård (2006) has also investigated how Kuhlthau's ISP model may apply to the information behavior of group members in an academic setting. The author found differences between the individual information seeker in Kuhlthau's model and group members' information seeking behavior. These differences turned out to be related to contextual, social and personal factors.

iv.Uncertainty: Uncertainty is an important concept within human information behavior. Researchers generally suggest that information seeking process starts with uncertainty, but it is decreased by progression in seeking for information (Chowdhury, Gibb, & Landoni, 2011). Moreover, uncertainty is an important feeling during the information seeking process model (ISP), which was introduced by Kuhlthau (1991). Kuhlthau (1993) defined uncertainty as "a cognitive state which commonly causes affective symptoms of anxiety and lack of confidence". Due to the significant influence of uncertainty on seekers during information seeking process, several studies have been presented about it (Blummer & Kenton, 2014; Guo, 2011; Savolainen, 2013). Wilson (1999a) also explained that each individual experience uncertainty during seeking for information and resolution stages where uncertainty replaced by certainty since the problem was solved. Chowdhury et al. (2011) worked on uncertainty and information seeking in a digital environment. The researchers found different types of uncertainty during each stage of the information seeking process model (Kuhlthau, 1991). The findings showed that there is a large number of information seeking activities and information seeking problems that caused uncertainty among users regardless age, gender, discipline, and ICT skills. Furthermore, uncertainty continues during the information seeking process in various types with respect the information resources and background knowledge. Brashers and Hogan (2013) designed an information retrieval system reflected uncertainty as a multifaceted and dynamic experience, which individuals may have during information seeking process and retrieval. The ISP model was used to design an information retrieval system by focusing on the role of uncertainty and considering a theory that uncertainty is a negative factor, and it may be vanished during information seeking process.

v.Anxiety: There are several studied around the role of anxiety during information seeking process. For example, Soane, Schubert, Lunn, and Pollard (2015) examined

the relationship between information processing style and information seeking, and its moderation by anxiety and information utility. The findings of the research showed that low level of anxiety positively affects the information seeking in spite of knowing that anxiety reduces the tendency to seek for information. In contrast, Lopatovska and Arapakis (2011) investigated the role of emotions in information seeking and found that anxiety is a negative emotion in leading users during information seeking process. Similarly, Savolainen (2014) found that anxiety and fear had negative influence during information seeking process among information scientists while joy as a positive emotion motivated users to continue the seeking for information. In practice, these findings were supported by Kuhlthau (1991)' ISP model to demonstrate the role of common feelings such as anxiety, frustration, and uncertainty at the early stages of the information seeking process model.

vi. ***Critical thinking:*** There are a few studies on relationship between critical thinking skills and ISP, which is the main concern of this study: Bentley (2014) implemented the "Inquiry Guided Learning Projects" to develop critical thinking among a college-level human anatomy and physiology course. Bentley (2014) used scientific inquiry as a means of developing critical thinking among students. The "Inquiry Guided Learning Projects" was loosely designed based on the Information Search Process model (ISP) (Kuhlthau, 1991) as a framework with emphasis on three of the six stages of the ISP: question selection, scientific research, and presentation of results. The study was conducted among 29 medical students in one semester. The qualitative and quantitative results revealed that the "Inquiry Guided Learning Projects" was useful in development of critical thinking among students as well as helping them in completing the task. In addition, the qualitative results about the "Inquiry Guided Learning Projects" assessment, were satisfactory. Therefore, it can be recommended for real study if it will be improved.

In another study, Haghparast, Hanum, and Abdullah (2013) presented a conceptual framework to show that there is a relationship between critical thinking and information seeking behavior. The researchers cultivated critical thinking by using the big six skills model (Eisenberg & Berkowitz, 1992) and critical thinking skills (Facione, 1990c). Indeed, the researchers illustrated that during research activities, information seekers need to think critically and if their critical thinking skills are improved, they can seek for information in a proper way.

A summary of the findings related to the factors associated with ISP is tabulated as follows (Table 2-5):

Table 2-5: A summary of studies on factors related associated with ISP

No.	Authors	Purpose	Methods	Outcome
Information needs				
1	Clark (2014)	To consider the groups' user behavior and needs by inspiring Kuhlthau (1991) model	Applying a theoretical framework	Information needs can be effective on information seeking of students.
Information literacy				
2	Fainburg (2009)	To examine the relationship between information literacy of bachelor students, doctoral students and researchers and the information needs	Using the ISP model	Students with lower degrees and freshmen researchers had lower tendency in the information literacy program rather than doctoral students and experienced researchers.
Personal factors				
3	Hyldegård (2006)	To investigate how Kuhlthau's ISP model may apply to the information behavior of group members in an academic setting	Using the ISP model among members in an academic setting	There are differences between the individual information seeker in Kuhlthau's model and group members' information seeking behavior. These differences are related to contextual, social and personal factors.

Uncertainty				
4	Chowdhury et al. (2011)	To investigate the impact of uncertainty during information seeking processes	Using the ISP model among different users	There are different types of uncertainty during each stage of the ISP model among users regardless age, gender, discipline, and ICT skills
5	Brashers and Hogan (2013)	To study the role of uncertainty as a dynamic or negative factor during each process of the ISP model.	Using the ISP model to design an information retrieval system	Everybody may experience uncertainty as a negative factor while they are seeking for information.
Anxiety				
6	Soane et al. (2015)	To examine the relationship between information processing style and information seeking, and its moderation by anxiety and information utility		Low level of anxiety positively affects the information seeking in spite of knowing that anxiety reduces the tendency to seek for information.
7	Lopatovska and Arapakis (2011)	To investigate the role of emotions in information seeking		Anxiety is a negative emotion in leading users during information seeking process
8	Savolainen (2014)	To compare the role of anxiety and joy as emotions during seeking for information		Anxiety and fear had negative influence during information seeking process among information scientists while joy as positive emotion motivated users to continue the seeking for information.
Critical thinking				
9	Bentley (2014)	To develop critical thinking among a college-level human anatomy and physiology course	Using scientific inquiry method to design "Inquiry Guided Learning Projects" based on the ISP model but it was loosely.	The "Inquiry Guided Learning Projects" was useful in development of critical thinking among students as well as helping them in completing the task
10	Haghparast et al. (2013)	To show whether there is a	Using the big six skills model	During research activities,

		relationship between critical thinking skills and information seeking processes.	(Eisenberg & Berkowitz, 1992) and critical thinking skills (Facione, 1990c).	information seekers need to think critically and if their critical thinking skills are improved, they can seek for information in a proper way.

2.8 Summary

Information seeking and its dimensions have been analyzed and measured in different disciplines and contexts. The relationships between information seeking and other variables, such as gender, age, task, knowledge, personality traits, motivation, learning style, experience, information literacy, computer use and expertise have been measured by some scholars (Khosrowjerdi & Iranshahi, 2011; Korobili et al., 2011; Weiler, 2005). Due to the rapid growth in creation of new information (Barron & Darling-Hammond, 2008; Jukes & McCain, 2002), critical thinking is more required to help individuals to become more adaptable and flexible against various information (Dwyer et al., 2014). Furthermore, regarding to our information society and the role of the Internet as an open medium with all types of information, critical thinking is helpful to recognize false, incomplete, obsolete and some sort of information (Saade, Morin, & Thomas, 2012).

On the other hand, the literature revealed that some of the studies (9 out of 25) were conducted among medical students and nursing students due to the significant role of critical thinking to complete nursing actions that directly affect patient outcomes (Naber & Wyatt, 2014). Furthermore, most of the participants in these studies (23 out of 25) were undergraduate students rather than postgraduates, though postgraduates also required to think critically and make crucial decisions.

Although critical thinking is an essential factor in learning process, cognitive development, and effective information seeking, it is not explicitly evident from the

literature that there is no study on the relationship between critical thinking and information seeking process.

This chapter provided a comprehensive literature review in two sections: one section is about the critical thinking and its components, which are skills, dispositions, and metacognitions. Critical thinking assessments as one of the most important parts of literature review on critical thinking were also presented by emphasis on Watson-Glaser Critical Thinking Appraisal (WGCTA). The instructional strategies to cultivate critical thinking in various contexts were described as well as two systems for cultivating critical as samples. The second section is about the information seeking behavior, the famous model in information seeking behavior by focusing on the information seeking process model (ISP) that is the target model for the current study. Furthermore, the studies about the presence of critical thinking in information seeking behavior and the information seeking process are explained.

CHAPTER 3: **RESEARCH METHODOLOGY**

3.1 Introduction

Chapter 3 describes the research design and the methodology used in this study. It justifies the data gathering approaches employed to examine the key research questions. This chapter consists of the following sections: research design, including surveys, interviews, and the related population and sampling, as well as the validity and reliability of the instruments, the design and development of the LeCTIS, evaluation of the LeCTIS, and treatment of data.

3.2 Research design

This study was conducted to address the following research objectives: to investigate the association between critical thinking skill and information seeking process, to design and develop a prototype (LeCTIS) to teach critical thinking in information seeking process, to evaluate the usability and functionality of the prototype (LeCTIS) in facilitating critical thinking in the information seeking process model. Therefore, the scope of this research was determined postgraduates in the University of Malaya because of their more knowledge in research and fluency in English language rather than undergraduate students. To conduct this study, a mixed method research approach by means of a survey and interviews was used. To address the research question 1 which is about the level of critical thinking among postgraduates, the first section of the survey (WGCTA-UK edition) was used. To answer the research question 2, which is about the critical thinking skills of postgraduates during seeking for information, the second section of the survey and the first interview were applied. In order to answer the research question 3, about the user's requirements for designing the LeCTIS prototype, the second interview was used. Research question 4 was answered by using SUMI survey, open-ended questions and acceptance testing as one of system testing method. Figure 3-1 illustrates the research flow of this study.

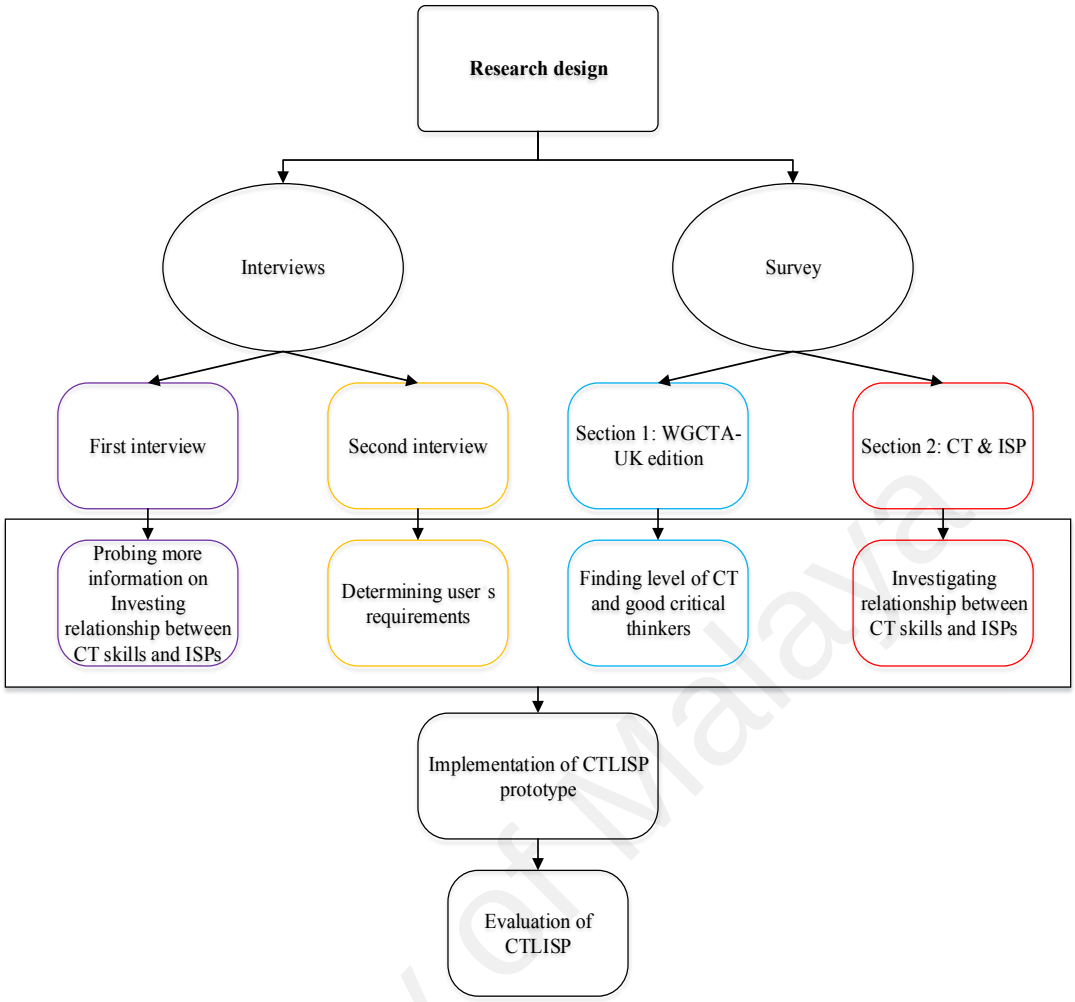

Figure 3-1: Research design

3.3 Survey

In this research, one survey in two sections were applied to address the research questions about critical thinking and information seeking, as follows:

1. What is the level of critical thinking among postgraduates?
2. How do postgraduates think critically when seeking for information?

3.3.1 First section of the survey: A survey on critical thinking

The Watson-Glaser Critical Thinking Appraisal (WGCTA) has been distinguished with its long history of development and used in distinctive countries and diversified settings. Out of this history, WGCTA has been presented in two different versions of English: US (Watson & Glaser, 1980) and UK (Watson & Glaser, 2002; Watson & Glaser, 1991). To examine the level of critical thinking of postgraduates, WGCTA-UK

edition (Watson & Glaser, 2002) was used in this study because it is newer and has more recent norms. More importantly, the UK version, offered a correction for guessing measure that enables test administrators and scorers to reduce the effect of guessing at the answers. Furthermore, the WGCTA-UK edition has been known as a reliable and valid assessment tool (Hassan & Madhum, 2007; Silvester & Dykes, 2007). The WGCTA-UK edition (Watson & Glaser, 2002) was prepared into two sections: (1) the first section is for demographic characteristics and (2) the second section consists of five parts based on five critical thinking skills, including inference, recognition of assumptions, deduction, interpretation, and evaluation of arguments with separate scenarios (Appendix D). Table 3-1 show the structure of the WGCTA-UK edition for this study.

Table 3-1: WGCTA-UK edition items

Part	Items	Remarks
1	1, 2, 3, 4, 5	Demographic characteristics
2	6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22	To examine the level of critical thinking skills

3.3.2 Second section of the survey: A survey on the relationship between critical thinking skills and the information seeking process model

The second section of the survey, which is aimed at investigating the relationship between critical thinking skills and the information seeking process was provided by the researcher. This section was constructed based on the RED model for critical thinking skills (Watson & Glaser, 2012b) and the information seeking process (ISP) model, which was presented in Kuhlthau (1991). According to the definition of critical thinking (Watson & Glaser, 1980) and the RED model (Watson & Glaser, 2012b), critical thinking skills include interpretation, recognition of assumptions, inference, deduction, and evaluation of arguments. In addition, Kuhlthau (1991) introduced the information seeking process (ISP) model in six stages, which are initiation, selection, exploration, formulation,

information collection, and presentation. As a result, the second section of the survey was prepared into one part, in which the respondents had to answer the questions about the critical thinking skills in each stage of the information seeking process model. In other words, on the basis of the RED model, five critical thinking skills were embedded into six stages of the information seeking process model. In each stage, the respondents needed to read a scenario before answering the question. After that, the respondents could select the critical thinking skills, which they use during the information seeking process (Appendix E). The structure of the second section of the survey is shown in Table 3-2.

Table 3-2: Items of the second section of the survey

Part	Items	Remarks
1	1, 2, 3, 4, 5, 6	To investigate the relationship between critical thinking skills in each stage of the information seeking process model

3.3.3 Population and sampling for the survey

This study is conducted among postgraduates in the University of Malaya, Malaysia. As such, it involves PhD students, master students, and research assistants (RAs). The number of postgraduates in the University of Malaya is around 11000 and the sample size of this study based on (Krejcie & Morgan, 1970) is 370 because simple random sampling was applied in this study. A simple random sample is meant to be an unbiased representation of a group. It is considered a fair way to select a sample from a larger population, since every member of the population has an equal chance of getting selected (Fowler & Floyd, 2013). Therefore, the survey questionnaire was distributed among the target population (all UM postgraduate students) and 367 accepted in response.

3.3.4 Data collection procedures

To collect data from postgraduates in University of Malaya, the survey questionnaire was distributed among them at the same time. To avoid waste of time, the survey was provided in two formats: online and paper-based. In the online format, an invitation email

(Appendix C) with the purpose of the study as well as the questionnaires were sent through the email service of the University of Malaya and their related the Research Gate addresses. In the paper-based format, the survey was presented in the university campus and the postgraduates were asked to complete the survey. As attached to the survey, the respondents received the consent letter and the information sheet. In the both formats, the respondents were assured that all their information will be confidential and the information will be used only for the study (Appendix D and E). It is important to mention that all respondents voluntarily participated in the study and they were free to leave the study.

3.3.5 Validity and reliability of the survey

Ensuring validity and reliability in the qualitative and quantitative research involves conducting the investigation in an ethical manner. For instance, the survey questions have to be scrutinized and validated before distributing. In the following, the results of reliability and validity tests of the survey are presented:

3.3.5.1 Validity

Content validity is defined as the attempt made to judge the consistency of the content of the questionnaire with the skills, or objectives of the study (Popham, 2000). The survey questions were developed based on the constructs in established literature. It is remarkable to mention that the validity of the WGCTA-UK edition has already been demonstrated (Hassan & Madhum, 2007; Silvester & Dykes, 2007) and it is good for actual research (Watson & Glaser, 2002). Although the validity of the WGCTA-UK edition has been demonstrated, to avoid some sort of problems during conducting the study such as cultural differences and English languages and grammars, the validity of the WGCTA-UK edition was calculated. The amount of the Cronbach's α range from 0 to 1, and the items with Cronbach's alpha close to or above 0.7 are acceptable (Table 3-3).

Table 3-3: validity results for WGCTA-UK edition survey (n=30)

No.	Items	Cronbach's α
	Inference	
1	The easiest way to eliminate heart disease in England would be to raise the general standard of living.	0.759
2	People in high income brackets are in a better position to avoid developing heart disease than people in low income brackets.	0.755
3	There is a lower rate of heart disease among northerners with relatively high incomes than among northerners with much lower incomes.	0.709
4	Whether northerners have high incomes or low incomes makes no difference to the likelihood of their developing heart disease.	0.728
	Recognition of assumptions	
5	People who have been educated in a free society will not make unwise decisions.	0.701
6	Some education systems in our society do not have the proper aim.	0.750
7	Some kinds of education can help individuals make wise decisions.	0.768
8	In a society that is not free, the individual cannot make any decisions.	0.743
	Deduction	
9	Some difficult decisions are distasteful to some people.	0.771
10	Irresponsible leaders avoid things they dislike.	0.692
11	Some responsible leaders do things they dislike doing.	0.744
	Interpretation	
12	In 1970, most adults had not entered the sixth form.	0.753
13	If the trend toward more education continues at the rate indicated by the above figures, then by 2000 more than 25% of adults will have completed three or more years of university.	0.699
14	In 1990, for every adult who had completed three or more years of university, there were more than five adults who had completed not more than 11 years of schooling.	0.784
	Presentation	
15	Yes; many families who cannot now afford it would then provide better childcare, and this would greatly improve the general health of the nation.	0.753
16	No; such grants would seriously undermine parents' sense of personal responsibility for their own families.	0.699
17	No; government provision of 'baby grants' would involve additional public expenditure of money.	0.784

To assess the validity of the second section of the survey, the Cronbach's α was calculated. The amount of the Cronbach's α range from 0 to 1, and the items with Cronbach's alpha close to or above 0.7 are acceptable (Table 3-4). Moreover, the research supervisors and five experts in the information seeking process and critical thinking area

from Iran, UK, and the US as the panel of expert reviewed the second survey. They were chosen based on their knowledge in these fields, and were considered to possess the insight to evaluate the instruments of this study.

All experts were contacted personally by email and were asked to participate in the study for the purpose of giving comments and validating the items of the instrument. The instrument as well as a cover letter to explain the purpose of the study were sent to experts to extract their opinions and comments on each items of the instrument. The aforementioned experts were requested to provide their inputs and suggestions as they felt necessary for accuracy and content validity of the instruments. All of experts provided the comments of items on the instruments.

The experts' comments were received during one week. According to the experts' opinion, the instrument was applicable in general view, but the language needed to be concise and more understandable. As a result, the language of the instrument was checked again and some difficult terms were replaced by clearer terms (Appendix E). The researcher believed that the input of ideas from the experts significantly contributed to the success of the instrument design based on their comments.

Table 3-4: Validity results for the second section of the survey (n=30)

Items		**Cronbach's α**
Initiation		
1.	Understanding the topic	0.818
2.	Creating a list of keywords about the topic	0.811
3.	Evaluating all publications about the topic	0.816
4.	Reading papers and rejecting them	0.809
5.	Completing my search activities	0.815
Selection		
6.	Concluding and finishing research activities	0.826
7.	Doing preliminary search to form a hypothesis about the topic	0.821
8.	Finding the information gaps	0.809
9.	Evaluating all information about the topic	0.809
10.	Organizing and writing the body of my research	0.805
Exploration		
11.	Forming a hypothesis about the topic	0.813

Items	Cronbach's α
12. Distinguishing between the false and true information	0.814
13. Listing the facts about the topic	0.811
14. Ending the search activities	0.823
15. Drawing the conclusion	0.818
Formulation	
16. Distinguish between false and true information	0.803
17. Forming a hypothesis about the topic	0.825
18. Understanding the topic	0.814
19. Going to the library to use resources	0.814
20. Completing the research activities	0.826
Information collection	
21. Understanding and interpreting the topic	0.822
22. Distinguishing between the false and true information about the topic	0.814
23. Justifying the previous procedures to have initial results	0.805
24. Organizing the information	0.813
25. Completing the information seeking	0.821
Presentation	
26. Organizing the information	0.807
27. Evaluating the information for final decision and conclusion	0.819
28. Distinguishing between the false and true information about the topic	0.814
29. Collecting the information	0.822
30. Interpreting the topic	0.817

Note: the scales used: 0=No; 1=Yes

3.3.5.2 **Reliability**

The survey process and the questionnaire need to be tested for reliability purpose because reliability merely reflects the consistency of the measuring device (Popham, 2000). Although the WGCTA-UK edition is a standard instrument, the reliability of this test also was measured to prevent any cultural differences and ensure that this questionnaire is reliable for the current study. Therefore, considering the formative structure of the items in the WGCTA-UK edition, a pilot study by using test and retest method was applied to evaluate reliability of this instrument. The researcher personally distributed 30 questionnaires among postgraduates in the University of Malaya to have their comments and suggestions and be sure about their answers. After one week, the

researcher conducted the Re-test. Moreover, due to the qualitative nature of the items, the Spearman correlation coefficient was applied to evaluate the agreement between the test and the retest observation for all variables. According to the result, it can be concluded that all variables in the WGCTA-UK edition questionnaire were reliable due to the strong relationship between the critical thinking score in test and re-test($p < 0.001, r = 0.841$).

At the same time, the second section of the survey, which was about the relationship between critical thinking and information seeking process, also was distributed to the same sample size (30 postgraduates) to find the reliability of the questionnaire. Table 3-5 shows the results of the correlation coefficient test. It is clear that all variables were reliable due to the strong relationship between test and re-test data, which were above 0.8.

Table 3-5: Reliability of the second section of the survey (n=30)

Variables	R	p
Score	.841**	<0.001
Initiation	.830**	<0.001
Selection	.841**	<0.001
Exploration	.846**	<0.001
Formulation	.924**	<0.001
Information collection	.894**	<0.001
Presentation	.804**	<0.001

3.3.6 Pilot study

The pilot study was conducted in August 2014 at the University of Malaya. The aim of this pilot study was to evaluate the readability and comprehension of the statements in the second section of the survey. The WGCTA-UK edition as the first section of the survey is a standard assessment tool with high validity and reliability (Hassan & Madhum, 2007; Silvester & Dykes, 2007). The pilot study helped the researcher in identifying statements in the instrument, which needed modification as well as recognizing the problems in the process of data collection. Participants were thirty (30) postgraduates in different areas of study who were selected by random sampling method. The instrument

was self-administered to each participant. The students were informed that their participation was voluntary and their information would be used only for research purpose. They were asked to respond the pilot instrument, which consisted of thirty-six (36) items. A consent form was also attached to the instrument, which described the aim of the study. Some students sought clarifications of several items in the instrument while they found a few items overlap with other items or were considered vague.

Of thirty participants, 43.3% were male and 56.7% were female. The age of participants was ranged from 20 years old to over 41 years old in five categories, which the most participants were in 20-25 years old (43.3%) and only one participant were over 41 years old (3.3%). In terms of the degree, 14 participants were master students (46.7%), 7 participants were PhD students (23.3%), and 9 participants were research assistants (30.0%). The participants were from different fields of study include, art and social science (3.3%), business and accountancy (6.7%), computer science and information technology (6.7%), economics and administration (13.3%), education (6.7%), engineering (10.0%), languages and linguistics (6.7%), law (3.3%), medicine (10.0%), science (26.7%), and built environment (6.7%). Table 3-6 shows the demographic details of participants in pilot study.

In order to assess the quality of the instrument and identify the problematic items, the scale items in the instrument were subjected to factor analysis test and reliability analysis. For the factor analysis to be considered appropriate, Bartlett's test of Sphericity should be significant at $p < .05$, and values of the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy should be between 0.6 and 1.0 as shown in Table 3-7. For this study, scale items that recorded factor loading of less than 0.4 were not accepted. The internal consistency of each scale was measured using Cronbach's alpha. Measures of reliability range from 0 to 1, and each scale should exhibit adequate reliability with Cronbach's alpha close to or above the recommended 0.7 level as shown in Table 3-8.

Table 3-6: Demographic details of study in pilot study (n=30)

Characteristics		Frequency	Percentage
Gender	Male	13	43.3
	Female	17	56.7
Age	20-25	13	43.3
	26-30	5	16.7
	31-35	7	23.3
	36-40	4	13.3
	Over 41	1	3.3
Field	Art and social science	1	3.3
	Business and accountancy	2	6.7
	Computer science and information technology	2	6.7
	Dentistry	0	0.0
	Economics and administration	4	13.3
	Education	2	6.7
	Engineering	3	10.0
	Languages and linguistics	2	6.7
	Law	1	3.3
	Medicine	3	10.0
	Science	8	26.7
	Built environment	2	6.7
Degree	Master's	14	46.7
	PhD	7	23.3
	Other	9	30.0

Table 3-7: Bartlett's test and KMO measure

Constructs of ISP	KMO	Bartlett's test Sig.	Percentage of Variance
Initiation	0.688	0.00	32.909
Selection	0.739	0.00	35.472
Exploration	0.714	0.00	33.874
Formulation	0.687	0.00	37.198
Information collection	0.656	0.00	39.372
Presentation	0.796	0.00	45.711

Table 3-8: Cronbach's Alpha and factor loading

ISP items	Factor loading
Initiation: Cronbach's α = 0.830	
1. Understanding the topic	0.625

ISP items	Factor loading
2. Creating a list of keywords about the topic	0.592
3. Evaluating all publications about the topic	0.435
4. Reading papers and rejecting them	0.566
5. Completing my search activities	0.769
6. Judgement on answer by appearance the topic	-
7. Distinguishing between the false and true information	-
Selection: Cronbach's α = 0.841	
8. Concluding and finishing research activities	0.651
9. Doing preliminary search to form a hypothesis about the topic	0.618
10. Finding the information gaps	0.487
11. Evaluating all information about the topic	0.690
12. Organizing and writing the body of my research	0.611
Exploration: Cronbach's α = 0.846	
13. Forming a hypothesis about the topic	0.526
14. Distinguishing between the false and true information	0.721
15. Listing the facts about the topic	0.729
16. Ending the search activities	0.402
17. Drawing the conclusion	0.484
Formulation : Cronbach's α= 0.924	
18. Distinguish between false and true information	0.569
19. Forming a hypothesis about the topic	0.722
20. Understanding the topic	0.553
21. Going to the library to use resources	0.487
22. Completing the research activities	0.567
23. Determining the strength of arguments	-
Information collection: Cronbach's α= 0.894	
24. Understanding and interpreting the topic	0.619
25. Distinguishing between the false and true information about the topic	0.622
26. Justifying the previous procedures to have initial results	0.654
27. Organizing the information	0.703
28. Completing the information seeking	0.720
29. Deciding on answer	-
Presentation: Cronbach's α= 0.804	
30. Organizing the information	0.674
31. Evaluating the information for final decision and conclusion	0.641
32. Distinguishing between the false and true information about the topic	0.509
33. Collecting the information	0.794
34. Interpreting the topic	0.570
35. Clarification of the information	-
36. Determining the types of argument	-

3.3.7 Data analysis

Each questionnaire was assigned a number for reference purpose before the information was coded and compiled using a statistical software package, Statistical

Package for the Social Sciences (SPSS) version 22.0. Every data entry was independently and repeatedly verified in order to ensure its accuracy. For data analysis of the first survey, the frequencies of the answers and total adoption for each critical thinking skill were computed. For data collected using a dichotomous scale, mean and standard deviation were also computed. The frequency of the answers to each question was computed for the second survey.

The normality test was conducted for two survey questions to find which statistical tests were compatible with them to draw suitable conclusions. Therefore, several parametric and non-parametric tests, such as McNemar, Friedman, t-test, ANOVA, and Bonferroni tests were applied for normal or non-normal data in each section.

3.4 Interviews

In order to answer research questions 2 and 3, two interviews with two main purposes among different participants were designed.

3.4.1 First interview

The first interview was conducted to probe further opinions and gather in-depth information on the relationship between critical thinking and information seeking process as well as exploring the behavior of postgraduates. It has six (6) questions based on six (6) stages in the information seeking process model (Kuhlthau, 1991), in which students need to answer questions related to critical thinking skills (Watson & Glaser, 2002). The interview questions were designed to meet the following research questions:

i. How postgraduates think critically when seeking for information?

ii. What are the requirements for a critical thinking learning system?

The interview was done until reaching the saturation point, which it means that the new data was not produced by asking questions and continuing interview with new respondents (Corbin & Strauss, 2014). Therefore, twelve (12) postgraduates were willing to participate in the interview. The demographic information of the participants are

presented in Table 3-9. During this phase, several questions were asked to grab further information about their behavior while they were seeking for information and how they think. Probing questions were also introduced to postgraduates, especially when it felt that asking more questions was necessary.

Table 3-9: Participant's details

No.	Respondents	Gender	Age	Degree	Field
1	Ali	Male	32	Ph.D.	Computer science
2	Georgia	Female	31	Ph.D.	Computer science
3	Lili	Female	29	Master	Computer science
4	Mona	Female	24	Ph.D.	Computer science
5	Perin	Female	31	Ph.D.	Computer science
6	Sarah	Female	33	Ph.D.	Computer science
7	Zara	Female	32	Ph.D.	Computer science
8	Mary	Female	29	Master	Engineering
9	Mark	Male	35	Ph.D.	Engineering
10	Shawn	Male	35	Ph.D.	Science
11	Lara	Female	32	Ph.D.	Science
12	Mariah	Female	30	Ph.D.	Education

Each interview lasted about twenty-five minutes approximately. The interviews were carried out using open-ended questions. Postgraduates accepted to answer the following questions:

i. Suppose that you don't have any knowledge about a topic and you have to write a paper on it. When you see the topic for the first time, what do you do? And do you start your search activities?

ii. In this step, how do you continue your search while you have a general view about the topic?

iii. How do you extend your information about the topic?

iv. How do you decide which information is suitable and which criteria are important for you to find the appropriate information?

v. How do you collect the information to ensure yourself about them? Which criteria do you use to gather information? Which procedures do you pass to collect your desired information? How do feel in this step?

vi. How do you justify your findings and complete your search activities?

vii. How do you describe yourself when you do research based?

viii. Which barriers do you have in your search activities?

ix. Which factors affect your search activities?

3.4.2 Second Interview

According to the role of critical thinking in seeking for information and solving problems (Ennis, 1987, 1989) and the literature about the influenced factors on critical thinking (Broadbear, 2012), the second interview was prepared. The main aim of the second interview was to determine the influenced factors on cultivating critical thinking and the user's requirements to design and develop the LeCTIS. On the basis of reaching to the saturation point (Corbin & Strauss, 2014), seven (7) postgraduates participated voluntarily in this interview. Their demographic information presented in Table 3-10.

Table 3-10: Participant's details

Respondents	Gender	Age	Degree	Field
Aria	Male	32	Ph.D.	Computer science
Joe	Female	31	Ph.D.	Computer science
Lena	Female	29	Master	Science
Mana	Female	24	Ph.D.	Education
Pary	Female	31	Ph.D.	Computer science
Spin	Male	33	Ph.D.	Social science
Zhina	Female	32	Master	Computer science

Participants were asked to answer five questions about critical thinking and the influenced factors on critical thinking. Each interview took fifteen to twenty minutes. Postgraduates answered the following questions:

i. How do you feel, when you need to solve a problem and make an urgent decision?

ii. What are the differences between persons with critical thinking skills and persons without critical thinking skills?

iii. Which factors are useful to improve critical thinking skills?

iv. Which factors can prevent improving critical thinking skills?

v. What are the users' requirements to design and develop a system for cultivating critical thinking?

3.4.3 Data collection procedures

Explanation of terms or interview questions was given whenever necessary throughout the interviews. Collecting data and doing interview were conducted in 2 weeks. Interviews were documented on paper and transcribed as extended field notes. The extended field notes were then verified by postgraduates in the process of "member checking" to check on the correct interpretations of the researcher. "Member checking" is viewed as a technique used for establishing the validity of an account. Lincoln and Guba (1985) indicated that this is the most crucial technique for establishing credibility. The process is necessary to ensure that the research has remained true to the ideas of the primary source. All errors, inaccuracies, and omissions in the extended field notes were corrected.

The sampling technique for interviews, is purposive sampling method because we need to select postgraduates with high score in CT. Therefore, to be sure about the level of critical thinking of participants, firstly we examined their critical thinking level by the WGCTA-UK edition survey to reveal their score in critical thinking. According to their score, we selected the participants with the high score in critical thinking. Then, the participants were asked to answer the interview question to reach the saturation point.

3.4.4 Pilot study

In order to ensure about the validity and reliability of the instrument, a pilot study was conducted among six (6) postgraduates. Five (5) out of seven (7) postgraduates accepted

to participate in the pilot study for the first interview. The cover letter and a copy of the interview were provided for each participant to state their opinions and comments on the questions. Most of the comments were related to the terms and the used language, which cause difficulty in understanding the questions and the purpose of the study. Therefore, the language of the instruments was checked and the problematic terms replaced by the simpler and clearer terms. Moreover, the supervisors of the study and five (5) experts in the information seeking behavior from Iran, England, and the US and the research supervisors received the interview with the cover letter and the purpose of the study. After analysis of their comments on the instrument, 9 questions out of 22 questions were remained. The experts advised me to change the initial questions, which are too long, time consuming, and boring with the more open-ended questions and flexible.

For the second interview, the procedures were as same as the first interview with a little difference. Four (4) postgraduates participated in the pilot study of the second interview. They received a cover letter and a copy of the second interview to mention their comments and suggestions about the questions. Along with them, five (5) experts in critical thinking area from the UK, the US, and Iran and the research supervisors got the interview as well as the cover letter to show the purpose of the interview. After analysis of their comments, 5 questions out of 8 were remained. Most of their comments and suggestions were about avoiding repetitions and overlapping a few questions and clarifications of some terms.

The reliability of the questions used during the interview process was achieved through asking of the same questions for each interviewer. According to Leary (2011), the higher reliability can be achieved in the interview by asking questions as they worded to all respondents.

3.4.5 Data analysis

The interviews were carried out using a set of open-ended questions that were organized into a structured questionnaire. Interview notes were taken and transcribed. The transcripts were then verified by the respondents via "member checking" process. All errors, inaccuracies, and omissions in the transcript were corrected. Analysis of the interviews, followed the pattern of open, axial, and selective coding detailed by (Corbin & Strauss, 2014). In practice, data were broken into discrete incidents, ideas, events, and acts and they are named to represent as different categories. The name can be the object that the analyst expects regarding the meaning of the data or the name may be taken from the words of respondents used. The categories were written and considered based on their dimensions, features, and characteristics. For each response, a separate memo was provided. Finally, several concepts or themes were originated from the categories (Corbin & Strauss, 2014).

3.5 Design and development of the LeCTIS

The approach used in the development was the prototype approach, which allows gradually building of the system, and in conjunction/parallel with the model building phase. In this study, the LeCTIS was developed to cultivate critical thinking through information seeking process on the basis of the theory, which indicates critical thinkers are able to seek information better than persons without critical thinking. Furthermore, the findings of the survey and the interviews are known as the basis of the LeCTIS prototype. To clarify, the first section of the survey reveals the lack of critical thinking as well as persons with different scores in CT. The second section of the survey as well as the first interview show which and how CT skills are used in each step of the ISP model. In addition to above, the second interview attempt to find the requirements for designing the LeCTIS prototype. As a result, the findings of these instruments with regards to the

literature behind this research are combined to design and develop the LeCTIS prototype to cultivate critical thinking among students.

In accordance with them and to answer the research question 4, the researcher proposed a prototype (LeCTIS) by applying Microsoft Windows Platform, Visual Studio 2014 with C#, and Microsoft SQL Server 2014.

The requirements of the LeCTIS prototype were determined by analyzing the responses to the second interview. Furthermore, reviewing the literature helped to find the requirements of the implemented systems in cultivating critical thinking. Therefore, two proposed systems $(CT)^2$ (Fischer, Spiker, Harris, et al., 2008) and the interdisciplinary framework (Duron et al., 2006) were reviewed and compared.

3.5.1 Evaluation of the prototype

To address the research question 4, which indicates that "how usable is the prototype (LeCTIS) in facilitating critical thinking skills in the information seeking process model?" the evaluation of the LeCTIS were conducted for two important features: (a) the usability of the LeCTIS and (b) the functionality of the LeCTIS.

The system evaluation part of this research was performed among 17 postgraduates in the University of Malaya. To determine the usability and functionality of the LeCTIS, an electronic questionnaire was developed by using questions in the Software Usability Measurement Inventory (SUMI) (Kirakowski & Corbett, 1993) in three parts: part A, part B, and part C (Appendix F). Part A includes twenty-two questions, which were relevant to the proposed LeCTIS, were adopted from SUMI and put together in an electronic questionnaire (Table 3-11). The main reason to use SUMI is that its validity and reliability have been established internationally. The answered electronic questionnaires were checked for completeness (i.e. all questions were answered) before conducting the analysis. Part B is about the functionality of the modules, which it was designed with Likert scale of "Very weak", "Weak", "Satisfactory", "Strong", and "Very strong" (Table

3-12). Respondents need to answer all questions and it was checked before starting analysis.

Table 3-11: An outline of survey items extracted from SUMI

No.	Survey items	Extracted from
1	I would recommend this software to my colleagues.	Q2
2	The instructions and prompts are helpful.	Q3
3	I enjoy the time I spend using this software.	Q7
4	Working with this software is satisfying.	Q12
5	The way that system information is presented is clear and understandable.	Q13
6	The software documentation is very informative.	Q15
7	Working with this software is mentally stimulating.	Q17
8	I feel in command of this software when I am using it.	Q19
9	I can understand and act on the information provided by this software.	Q23
10	There is too much to read before you can use the software.	Q25
11	Using this software is frustrating.	Q27
12	The software has helped me overcome any problems I have had in using it.	Q28
13	The speed of this software is fast enough.	Q29
14	It is obvious that user needs have been fully taken into consideration.	Q31
15	The organization of the menus seems quite logical.	Q33
16	Learning how to use new functions is difficult.	Q35
17	There are too many steps required to get something to work.	Q36
18	It is easy to make the software do exactly what you want.	Q39
19	I will never learn to use all that is offered in this software.	Q40
20	The software presents itself in a very attractive way.	Q42
21	It is relatively easy to move from one part of a task to another.	Q44
22	It is easy to see at a glance what the options are at each stage.	Q48

Table 3-12: An outline of items related to functionality of the prototype

How would you rate the overall functionality of? -	Very weak	Weak	Satisfactory	Strong	Very strong
Registration					
Pre-test					

Learning process					
Task					
Post-test					
Evaluation					
Utilities					

Part C consists of three open-ended questions about the strengths and limitations of the proposed system. Indeed, this part aims at collecting the general comments of the respondents to improve the system:

Q1. In your opinion, what are the strong points of the tool (if any)?

Q2. In your opinion, what are the weaknesses of the tool (if any)?

Q3. Please give your comments and recommendations (if any) on other issues that would help to improve your satisfaction on the use of the tool.

The second phase of system evaluation, which is called system testing, was also accomplished by 17 postgraduates in the University of Malaya during September and October at the time convenient of the participants in the beginning of second semester of academic year 2015. The LeCTIS evaluation took six (6) weeks to complete. It was arranged in such a way that one postgraduates evaluate the LeCTIS at one time. The system testing was carried out in the postgraduates' rooms or in a discussion room with the personal computer installed. The evaluation procedure consisted of twenty minutes' briefing on the purpose of the LeCTIS, twenty minutes for doing pre-test, twenty-five minutes for learning section, ten minutes for doing the task, five minutes for evaluation, and twenty minutes for doing post-test. Participants need to follow all the procedures in the implemented prototype (LeCTIS). The results of system testing show that the LeCTIS has positive impact on cultivating critical thinking skills. The researcher's role was a facilitator to guide participants and supervise the procedures carefully to take notes, avoid errors, or missing data.

3.5.2 Validity and reliability of SUMI

Although the reliability and validity of SUMI survey was demonstrated and accepted internationally (Kirakowski & Corbett, 1993) and to avoid probable problem, such as cultural differences, and the language, the reliability and validity tests were conducted. Therefore, 15 postgraduates were asked to participate in a pilot study regarding understandability of the items. The demographic details of participants in pilot study for SUMI items are tabulated in Table 3-13.

Table 3-13: Demographic details of participants in SUMI pilot study

No	Participants	Gender	Age range	degree	Feld
1	Rayan	Female	26-30	PhD	Computer science
2	Sima	Female	26-30	PhD	Computer science
3	Sana	Female	20-25	Master	Science
4	Sam	Male	31-35	PhD	Science
5	Jack	Male	26-30	PhD	Computer science
6	Melani	Female	26-30	PhD	Computer science
7	Tressa	Female	26-30	PhD	Engineering
8	Liza	Female	20-25	Master	Education
9	Anna	Female	20-25	Master	Medicine
10	Catherin	Female	31-35	PhD	Medicine
11	Joe	Male	26-30	PhD	Computer science
12	Ace	Male	20-25	Master	Engineering
13	Suzan	Female	36-40	PhD	Economic and administration
14	Natasha	Female	31-35	PhD	Computer science
15	Ester	Female	26-30	PhD	Education

The pilot study was conducted during one week. It took about 3 to 5 minutes. It was prepared in the paper format. The participants received a consent form to state the purpose of the study as well as the survey. The participants were ensured about the privacy and confidentiality of provided information and they were told that their participation was voluntary and they were free to leave the study whenever they feel. To measure the reliability of SUMI survey, the reliability analysis test was conducted. The Cronbach's α shows there is a strong relationship among items of SUMI survey ($p < 0.001, r = 0.826$).

To compute the validity of the first part of the SUMI items, the Cronbach' α was used. The amount of the Cronbach's α range from 0 to 1, and the items with Cronbach's alpha close to or above 0.7 are acceptable (Table 3-14).

Table 3-14: Validity results for SUMI items (n=15)

No.	Items	Cronbach' α
1.	I would recommend this software to my colleagues.	0.745
2.	The instructions and prompts are helpful.	0.758
3.	I enjoy the time I spend using this software.	0.788
4.	Working with this software is satisfying.	0.756
5.	The way that system information is presented is clear and understandable.	0.825
6.	The software documentation is very informative.	0.769
7.	Working with this software is mentally stimulating.	0.805
8.	I feel in command of this software when I am using it.	0.702
9.	I can understand and act on the information provided by this software.	0.914
10.	There is too much to read before you can use the software.	0.907
11.	Using this software is frustrating.	0.742
12.	The software has helped me overcome any problems I have had in using it.	0.720
13.	The speed of this software is fast enough.	0.755
14.	It is obvious that user needs have been fully taken into consideration.	0.792
15.	The organization of the menus seems quite logical.	0.712
16.	Learning how to use new functions is difficult.	0.789
17.	There are too many steps required to get something to work.	0.800
18.	It is easy to make the software do exactly what you want.	0.920
19.	I will never learn to use all that is offered in this software.	0.861
20.	The software presents itself in a very attractive way.	0.788
21.	It is relatively easy to move from one part of a task to another.	0.702
22.	It is easy to see at a glance what the options are at each stage.	0.819

Note: the scales used for SUMI items are: Disagree=1; Undecided=2; Agree=3

3.5.3 Data analysis

At the first step, the participants require to accomplish the pre-test part. After performing the learning process, the participants have to pass the post-test to identify the impact of the system on fostering critical thinking skills. To achieve this goal, the proposed system has to record the scores of the participants in the both per-test and post-test. To evaluate the system from improving the critical thinking view, the paired sample

t-test was applied. Furthermore, descriptive statistics ware done to find the usability of the system for analyzing SUMI responses.

3.6 Summary

The purpose of chapter three is to present the methodology of this study. In this study, multiple data collection techniques were employed to grab depth and breadth information on critical thinking and information seeking behavior of postgraduates. Furthermore, the chapter reports on the data collection, including the participants and activities involved. Research design shows the techniques to collect data, the procedures as well as preliminary outcomes, and the evaluation part for the proposed prototype (LeCTIS). The next chapter presents the data analysis and findings of this study.

CHAPTER 4: **DATA ANALYSIS**

4.1 Introduction

This chapter aims to present the findings of this study based on the research objectives: (a) to investigate the association between critical thinking skill and information seeking process; (b) to design and develop a prototype (LeCTIS) to teach critical thinking in information seeking process; and (c) to evaluate the usability and functionality of the prototype (LeCTIS) in facilitating critical thinking in the information seeking process model. The main focus is to understand the level of critical thinking among postgraduates as well as investigate the association between critical thinking skills and information seeking processes. This chapter also describes and discusses the findings of a survey in two sections and two interviews, which are conducted among postgraduates at the University of Malaya. The first section of the survey aims to examine the level of critical thinking among postgraduates and the main focus of the second section of the survey is to investigate the association between critical thinking skills and information seeking processes. The main purpose of the first interview is to determine the requirements for a critical thinking learning system. The second interview is conducted to grab further information to know how postgraduates evaluate their information by using critical thinking.

4.2 Survey

This section presents the findings of the survey questionnaires among participants and analyzes them to provide the responses of these research questions:

- What is the level of critical thinking among postgraduates?
- How postgraduates think critically when seeking for information?

Therefore, the demographic characteristics of participants as the first step are described. In the next steps, level of critical thinking among participants and the

association between critical thinking skills and information seeking processes are explained.

4.2.1 Demographic characteristics of respondents

The participants of this study are various in gender, age, field of study, and degree. The results of descriptive statistics show that 50.7% of the participants ware male and 49.3% were female. Moreover, 77.1% of the participants' ages were in the range of 20 years old and 35 years old while the participants between 36 and 40 years old, and more than 41 were 22.9%. Regarding to the fields of participants, the most number of them were from computer science and information technology (26.7%) and the least number of participants are from dentistry (1.1%), languages and linguistics (1.9%), and law (1.1%). Moreover, 48.2% of the participants were PhD candidate, 41.4% Master student, and 10.4% of them belongs to research, which are entitled "other". These research assistants were not students, but they had Master's or PhD degree, and they only worked on projects as researchers. Table 4-1 shows characteristics of respondents.

4.2.2 Level of critical thinking among graduate students

The first research question of this study was replied based on the Watson-Glaser critical thinking appraisal- UK edition (WGCTA-UK edition) (Watson & Glaser, 2002). In other words, to examine the level of critical thinking among postgraduates in the University of Malaya, the WGCTA-UK edition was distributed. It has five items with separate scenarios that students should decide about them and conclude. These items are inference, recognition of assumptions, deduction, interpretation, and evaluation of arguments.

Table 4-1: Frequency distribution of demographic characteristics of respondents

Characteristics		Frequency	Percentage
Gender	Male	186	50.7
	Female	181	49.3
Age	20-25	74	20.2
	26-30	113	30.8
	31-35	96	26.2
	36-40	45	12.5
	Over 41	38	10.4
Field	Art and social science	24	6.5
	Business and accountancy	18	4.9
	Computer science and information technology	98	26.7
	Dentistry	4	1.1
	Economics and administration	20	5.4
	Education	22	6.0
	Engineering	63	17.2
	Languages and linguistics	7	1.9
	Law	4	1.1
	Medicine	46	12.5
	Science	49	13.4
	Built environment	12	3.3
Degree	Master's	152	41.4
	PhD	177	48.2
	Other	38	10.4

4.2.2.1 **Critical thinking score**

Each participant can earn 17 as a total score in the WGCTA-UK edition. According to the results of critical thinking score and the guideline, which is presented by Watson and Glaser (2012a), each score of respondents can be computed based on the correct answers in the percent format. As a result, it can be seen that 74.39% of postgraduates at the University of Malaya suffer from the lack of critical thinking and only 25.61% of them have an acceptable score in critical thinking. Therefore, it is demonstrated the main problem of the study, which indicates the lack of critical thinking among postgraduates who want to enter the society as potential workforces. Table 4-2 shows the frequency and percentage of respondents to WGCTA-UK edition.

Table 4-2: Critical thinking score of respondents

Below average 0-40	Average 40-60	Above average 60-100
41	232	94
11.17%	63.22%	25.61%

4.2.2.2 Comparison of the details for mean score of critical thinking skills

To compare mean scores of critical thinking skills and finding weak and strong critical thinking skills, t-test was applied. According to the results of one sample t-test (test value= 0.5), it can be seen that the weak point of postgraduates is in the *inference* (Table 4-3). It means that the respondents are unable to discriminate the degree of true and false information. As a result, they have a problem to decide about the provided information to select the correct responses (Watson & Glaser, 2002). On the other hand, the strong points of the respondents are in *recognition of assumptions* and *deduction*. Consequently, they can recognize structured and ill-structured assumptions, which it helps them to find the information gaps. Moreover, deduction is very helpful for them to draw valid conclusions and make decisions about the relationship among premises on a specific situation.

Table 4-3: Ranking of critical thinking skills of respondents

Critical thinking skills	N	Mean	SD	SE	t	p value
Inference	367	0.269	0.231	0.012	-19.17	<0.001
Recognition	367	0.643	0.243	0.013	11.277	<0.001
Deduction	367	0.677	0.249	0.013	13.577	<0.001
Interpretation	367	0.584	0.294	0.015	5.477	<0.001
Evaluation	367	0.556	0.259	0.014	4.127	<0.001

In order to evaluate the differences in the mean scores for CT1 to CT5 (inference, recognition of assumptions, deduction, interpretation, and evaluation of arguments), a one-way repeated measure ANOVA was conducted to assess whether there were differences among these skills.

The result of Mauchly's test illustrated that the Sphericity assumption was violated($\chi^2 = 45.066, p<0.001$), therefore the degree of freedom had to be adjusted using the Greenhouse-Geisser estimation of Sphericity. The results of repeated measure ANOVA showed that there was a statistically significant difference among these five variables$F\ (3.74, 1381.14)\ = 160.781, P < 0.05, \eta 2 = 0.305$), therefore, to evaluate the details for the mean scores of critical thinking skills post hoc test (Bonferroni) was applied to compare the mean scores.

The mean score of critical thinking skills is shown in Figure 4-1. It also revealed the existence of a significant difference among all critical thinking skills ($p < 0.05$) since it was explained in Table 4-4.

Table 4-4: Comparison between mean scores of critical thinking skills

Group	Mean	SD
CT1 (inference)	0.269	0.231
CT2 (recognition)	0.643	0.243
CT3 (deduction)	0.677	0.249
CT4 (interpretation)	0.584	0.294
CT5 (evaluation)	0.556	0.259

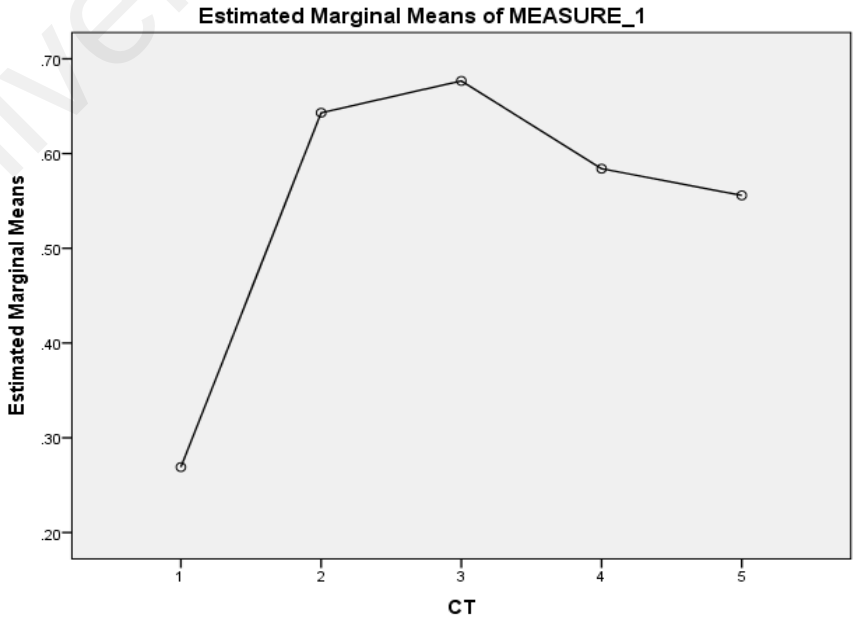

Figure 4-1: Different mean score of critical thinking skills

The results of post hoc test (Bonferroni) revealed that the difference among all components of critical thinking (inference, recognition, deduction, interpretation, and evaluation) was significant($p < 0.05$). The highest mean belongs to CT3 (deduction) and CT4 (interpretation) with 0.93 as well as there was a significant difference between CT3 and CT5($p < 0.05$). Moreover, Table 4-5 shows that there was a significant difference among CT1 (inference) and all critical thinking skills (recognition, deduction, interpretation, and evaluation), and the lowest mean score belongs to "inference". To clarify, (I) CT and (J) CT indicate the critical thinking skills as follows: 1=inference, 2=recognition of assumptions, 3=interpretation, 4=deduction, and 5=evaluation of arguments.

Table 4-5: Difference among mean score of critical thinking skills

(I) CT	(J) CT	Mean Difference (I-J)	SE	P Value
1	2	-0.374*	0.015	<0.001
1	3	-0.408*	0.017	<0.001
1	4	-0.315*	0.018	<0.001
1	5	-0.287*	0.018	<0.001
2	3	-0.034	0.017	0.525
2	4	0.59*	0.019	0.024
2	5	0.87*	0.019	<0.001
3	4	0.93*	0.018	<0.001
3	5	0.121*	0.018	<0.001
4	5	0.028	0.021	1

4.2.2.3 Frequency distribution of items related to critical thinking skills

In this section, descriptive statistics were used to find the number of respondents to each question of the critical thinking survey (WGCTA-UK edition). This section also explains the rate of familiarity of the postgraduates with critical thinking skills and their reaction towards different scenarios in WGCTA-UK edition. It is necessary to mention that **bold** numbers show the frequency of positive answers to the questions. It means that

frequency distribution of items related to critical thinking skills were computed based on these values (true=1 and false=0).

i. ***Frequency distribution of items related to inference***

In the WGCTA- UK edition, "inference" is the first part of a questionnaire, including four (4) items with one scenario. An inference is an initial conclusion that a person can draw from the observations or facts. Sometimes, the individuals need to use the existing knowledge or information that somebody may have to decide whether an inference is probably true or false.

Table 4-6 shows the rate of correct answers of respondents to the questions. For example, only 35.4% of respondents correctly answered to the inference1. In comparison with inferences, it is shown that the inference2 has a higher rate (41.7%) rather than the inference3 with 13.6% correct answers.

Table 4-6: Frequency distribution of items related to inference

Item	T	PT	ID	PF	F	Mean	SD
Inference1	16.3	32.7	**35.4**	9.0	6.5	0.35	0.479
Inference2	18.8	**41.7**	18.3	12.8	8.4	0.42	0.494
Inference3	**13.6**	22.9	43.3	9.8	10.4	0.14	0.344
Inference4	16.9	22.9	26.2	17.2	**16.9**	0.17	0.375
Total	-	-	-	-	-	0.27	-

Note: the scales used for inference are different (Watson & Glaser, 2002):

- Inference1: 0=T, PT, PF, and F; 1= ID
- Inference2: 0=T, ID, PF, and F; 1=PT
- Inference3: 0= PT, ID, PF, and F; 1=T
- Inference4: 0= T, PT, ID, and PF; 1=F

ii. ***Frequency distribution of items related to recognition of assumptions***

Recognition of assumptions is the second part of the WGCTA-UK edition with four (4) questions and one scenario. Recognition of assumptions means recognizing structured and ill-structured assumptions, and deciding about an assumption based on the existing information.

The results of descriptive statistics indicate that respondents are powerful in the recognition of assumptions3 (91.8%) due to their high ranking correct answers. The

second ranking belongs to the recognition of assumptions4 with 68.9%, and the recognition of assumptions1 (62.1%) is in the third ranking. As a result, the recognition of assumptions2 (34.3%) is the weakest point of respondents (Table 4-7).

Table 4-7: Frequency distribution of items related to recognition of assumptions

Item	Yes	No	Mean	SD
Recognition of assumptions1	37.9	**62.1**	0.62	0.486
Recognition of assumptions2	65.7	**34.3**	0.34	0.475
Recognition of assumptions3	**91.8**	8.2	0.92	0.274
Recognition of assumptions4	31.1	**68.9**	0.69	0.463
Total	-	-	0.64	-

Note: the scales used for recognition of assumptions are (Watson & Glaser, 2002):

- Recognition of assumptions1: 0=Yes; 1=No
- Recognition of assumptions2: 0=Yes; 1=No
- Recognition of assumptions3: 0=No; 1=Yes
- Recognition of assumptions4: 0=Yes; 1=No

iii. Frequency distribution of items related to deduction

The third part of the WGCTA-UK edition is deduction. It has three (3) questions with one scenario. Deduction is to determine whether the conclusions necessarily follow from information in given statements (Watson & Glaser, 2002).

Table 4-8 tabulates how respondents answer the questions on the deduction part. The deduction1 (87.7%) has the most rate of correct responses, and the deduction3 with 80.4% is in the second place, but the worst place is for the deduction2 (34.9%).

Table 4-8: Frequency distribution of items related to deduction

Item	Yes	No	Mean	SD
Deduction1	**87.7**	12.3	0.88	0.328
Deduction2	65.1	**34.9**	0.35	0.477
Deduction3	**80.4**	19.6	0.80	0.398
Total	-	-	0.67	-

Note: the scales used for deduction are (Watson & Glaser, 2002):

- Deduction1: 0=No; 1=Yes
- Deduction2: 0=Yes; 1=No
- Deduction3: 0=No; 1=Yes

iv. ***Frequency distribution of items related to interpretation***

The fourth part of the WGCTA-UK edition is interpretation, consists of three (3) questions with one scenario. Interpretation is an important skill of critical thinking, which helps students to clarify and identify a problem or an issue.

Table 4-9 shows the frequency of correct answers as well as percentages. The interpretation3with 69.5% correct answer is in the first rank rather than the interpretation1 (53.1%) and the interpretation2 (52.6%).

Table 4-9: Frequency distribution of items related to interpretation

Item	Yes	No	Mean	SD
Interpretation1	**53.1**	46.9	0.53	0.500
Interpretation2	47.4	**52.6**	0.53	0.500
Interpretation3	**69.5**	30.5	0.69	0.461
Total	-	-	0.58	-

Note: the scales used for interpretation are (Watson & Glaser, 2002):

- Interpretation1: 0=No; 1=Yes
- Interpretation2: 0=Yes; 1=No
- Interpretation3: 0=No; 1=Yes

v. ***Frequency distribution of items related to evaluation of arguments***

The last part of the WGCTA-UK edition has three (3) questions with one scenario. Evaluation of arguments indicate to distinguishing between strong and relevant arguments and weak or irrelevant arguments.

Table 4-10 shows that the evaluation of arguments1 (72.8%) has the highest rate of correct answers, in spite of the lowest rate of the evaluation of arguments2 (39.8%) and the average rate of the evaluation of arguments3 (54.2%).

Table 4-10: Frequency distribution of items related to evaluation of arguments

Item	Strong	Weak	Mean	SD
Evaluation of arguments1	**72.8**	27.2	0.73	0.446
Evaluation of arguments2	**39.8**	60.2	0.40	0.490
Evaluation of arguments3	45.8	**54.2**	0.54	0.499
Total	-	-	0.55	-

Note: the scales used for evaluation of arguments are (Watson & Glaser, 2002):

- Evaluation of arguments1: 0=Weak; 1=Strong
- Evaluation of arguments2: 0=Weak; 1=Strong

- Evaluation of arguments3: 0=Strong; 1=Weak

4.2.3 Association between critical thinking skills and information seeking processes

To address the second research question of this study about the association between critical thinking skills and information seeking processes, the second section of the survey was provided based on the RED model (Watson & Glaser, 2012a) and the information seeking process model (ISP) in (Kuhlthau, 1991). The questionnaire has six (6) main sections with separate scenarios to ask the respondents about the critical thinking skills while they are seeking for information.

4.2.3.1 Frequency distribution of items related to information seeking process

The descriptive statistics were used to find the frequency of responses to each question in the aforementioned questionnaire, which designed to identify the association between information seeking process and critical thinking,

i. ***Frequency distribution of items related to initiation***

Initiation is the first step of information seeking processes in the ISP model (Kuhlthau, 1991). In this step, the information needs create because of the lack of knowledge or understanding. As a result, students try to understand the task, contemplate the problem and discuss about the problem to overcome their uncertainty.

Initiation is divided into five (5) questions with one scenario to show, which critical thinking skills are used by respondents. It is clear that interpretation1 (92.9%) and inference (69.2%) are the most applicable critical thinking skills. Moreover, it shows that conclusion (31.1%) and recognition of assumptions (23.4%) are the least applicable critical thinking skills (Table 4-11).

Table 4-11: Frequency distribution of items related to initiation

Items	Yes	No	Mean	SD
Interpretation	**92.9**	7.1	0.93	0.257
Inference	**69.2**	30.8	0.69	0.462
Evaluation of arguments	47.4	52.6	0.47	0.500
Recognition of assumptions	23.4	76.6	0.23	0.424
Conclusion	31.1	68.9	0.31	0.463
Total	-	-	0.52	-

Note: the scales used for initiation are: 0=No; 1=Yes

ii. ***Frequency distribution of items related to selection***

During selection as the second step of the ISP model, students identify and select the general information about the task or topic. Therefore, students have to skim and scan several information resources to avoid being anxious.

Selection consists of five (5) questions with one scenario to show, which critical thinking skills are used by respondents. Table 4-12 indicates that during selection, the respondents use their recognition of assumptions (72.8%), interpretation (71.4%), and evaluation of arguments (65.7%).

Table 4-12: Frequency distribution of items related to selection

Items	Yes	No	Mean	SD
Conclusion	12.5	87.5	0.13	0.332
Recognition of assumptions	**72.8**	27.2	0.73	0.446
Interpretation	**71.4**	28.6	0.71	0.453
Evaluation of arguments	**65.7**	34.3	0.66	0.475
Deduction	31.1	68.9	0.31	0.463
Total	-	-	0.50	-

Note: the scales used for selection are: 0=No; 1=Yes

iii. ***Frequency distribution of items related to exploration***

In the third step of the ISP model, which is called exploration, students investigate information about the topic or task to extend their understanding and knowledge. Then, the students located the information and referred to information resources for finding any relationships between the new information and the existing information to have a wider view about the questions or problem (Kuhlthau, 1991).

Exploration includes five questions with one scenario to show, which critical thinking skills are used by respondents during seeking for information. Table 4-13 reveals that students prefer to use recognition (86.1%), inference (72.2%), and interpretation (58.6%) rather than the other critical thinking skills.

Table 4-13: Frequency distribution of items related to exploration

Items	Yes	No	Mean	SD
Interpretation	**58.6**	41.4	0.59	0.493
Inference	**72.2**	27.8	0.72	0.449
Recognition	**86.1**	13.9	0.86	0.346
Deduction	7.9	92.1	0.08	0.270
Conclusion	10.6	89.4	0.11	0.309
Total	-	-	0.47	-

Note: the scales used for exploration are: 0=No; 1=Yes

iv. ***Frequency distribution of items related to formulation***

Formulation is the fourth step of the ISP model, which is known as the turning point of the ISP model. Students attempt to form a focus from the information encountered and the information is more personalized and specified. In other words, some hypothesis may form in the student's mind. Therefore, students fell confidence and clarity in their research ways (Kuhlthau, 1991).

Formulation has five questions with one scenario to show, which critical thinking skills are used by students in formulation step. Table 4-14 shows that during formulation step, the most percentages of critical thinking skills belong to recognition (54.5%) and inference (51.2%). However, fewer students use the other critical thinking skills, such as conclusion (31.6%) and interpretation (32.5%).

Table 4-14: Frequency distribution of items related to formulation

Items	Yes	No	Mean	SD
Inference	**51.2**	48.8	0.51	0.501
Recognition	**54.5**	45.5	0.54	0.499
Interpretation	32.5	67.5	0.32	0.469
Evaluation	48.8	51.2	0.49	0.501
Conclusion	31.6	68.4	0.32	0.466

Items	Yes	No	Mean	SD
Total	-	-	0.43	-

Note: the scales used for formulation are: 0=No; 1=Yes

v. ***Frequency distribution of items related to information collection***

When students arrive to the information collection step of the ISP model, they focus on the relevant information about the topic or task and try to gather their information to support their probable formulated hypothesis. At this point, students collect relevant, accurate, and valid information based on their criteria. Therefore, students satisfy themselves and feel more confident than previous (Kuhlthau, 1991).

Information collection consists of five questions with one scenario to indicate, which critical thinking skills are used by students when they are in information collection step. Regarding to the students' responses to the information collection scenario, they prefer to use their deduction (75.7%) and evaluation (75.4%) in comparison with the other critical thinking skills (Table 4-15).

Table 4-15: Frequency distribution of items related to information collection

Items	Yes	No	Mean	SD
Interpretation	35.4	64.6	0.35	0.479
Inference	42.2	57.8	0.42	0.495
Deduction	**75.7**	24.3	0.76	0.429
Evaluation	**75.4**	25.6	0.74	0.437
Conclusion	36.5	63.5	0.37	0.482
Total	-	-	0.52	-

Note: the scales used for information collection are: 0=No; 1=Yes

vi. ***Frequency distribution of items related to presentation***

The last step of the ISP model is presentation, which students decide about the information and complete their search activities. Students organize their information and prepare to present all relevant information to the topic or problem. Therefore, removing redundant information and adding relevant information to the collected information is

done by students. In this step, students fell calm and satisfactory about whatever they did from the first step to the last step of the ISP model (Kuhlthau, 1991).

According to Table 4-16, presentation is divided into five questions with one scenario to show, which critical thinking skills are used by students in the last step of the ISP model. Evaluation (85.3%) and deduction (59.4%) are the most useful critical thinking skills that students applied.

Table 4-16: Frequency distribution of items related to presentation

Items	Yes	No	Mean	SD
Deduction	**59.4**	40.6	0.59	0.492
Evaluation	**85.3**	14.7	0.85	0.355
Inference	20.7	79.3	0.21	0.406
Recognition	17.7	82.3	0.18	0.382
Interpretation	26.7	73.3	0.27	0.443
Total	-	-	0.42	-

Note: the scales used for presentation are: 0=No; 1=Yes

4.2.3.2 Presence of critical thinking skills in information seeking processes

To address the second (2nd) research question about the association between critical thinking skills and information seeking processes and get deeper information, different statistical tests applied. For instance, Friedman and McNemar tests were used for all steps of the ISP model to confirm there is significant association between critical thinking skills and the information seeking processes. Friedman test evaluates the overall difference among all skills and just indicates whether there is difference or not. On the other hand, if the variables are binary or dichotomous McNemar test is better, which it is paired sample t-test (Leech, Barrett, & Morgan, 2005). According to the score of critical thinking, 94 out of 367 postgraduates could get good score in critical thinking. Therefore, to show whether the respondents think critically while they are seeking for information, this study examined the good critical thinker's score.

i. ***Initiation and critical thinking skills***

According to the Friedman test's results (Table 4-17), there was a statistically significant difference in initiation as the first step of the ISP model, depending on which critical thinking skills were used by students, $\chi 2\ (4)\ =\ 134.730,\ p\ =\ 0.001$.

Table 4-17: Initiation and critical thinking skills

Items	N	Mean	SD	Mean Rank	$\chi 2$	p value
Interpretation	94	0.98	0.145	4.16	134.730	<0.001
Inference	94	0.64	0.483	3.31		
Evaluation	94	0.47	0.502	2.88		
Recognition	94	0.19	0.396	2.19		
Conclusion	94	0.30	0.460	2.46		

Note: the scales used for initiation are: 0=No; 1=Yes

Table 4-18 shows the results of McNemar's test as follows:

There was statistically significant difference in interpretation and inference, $\chi 2 = 26.694, df = 1, p < 0.001$ (69.5% and 93.3%).

There was statistically significant difference in interpretation and evaluation, $\chi 2 = 46.021, df = 1, p < 0.001$ (47.5% and 93.5%).

There was statistically significant difference in interpretation and recognition, $\chi 2 = 72.014, df = 1, p < 0.001$ (25.2% and 100.0%).

There was statistically significant difference in interpretation and conclusion, $\chi 2 = 62.016, df = 1, p < 0.001$ (32.3% and 96.5%).

There was statistically significant difference in inference and evaluation, $\chi 2 = 4.327, df = 1, p < 0.001$ (47.6% and 69.5%).

There was statistically significant difference in inference and recognition, $\chi 2 = 33.620, df = 1, p < 0.001$ (30.7% and 90.7%).

There was statistically significant difference in inference and conclusion, $\chi 2 = 20.021, df = 1, p < 0.001$ (31.5% and 70.2%).

There was statistically significant difference in evaluation and recognition, $\chi 2 = 14.881, df = 1, p < 0.001$ (32.2% and 65.1%).

There was statistically significant difference in evaluation and conclusion, $\chi 2 = 3.750, df = 1, p < 0.001$ (32.2% and 49.1%).

There was statistically significant difference in recognition and conclusion, $\chi 2 = 2.700, df = 1, p = 0.013$ (41.9% and 31.6%).

Table 4-18: McNemar results for initiation and critical thinking skills

(I) CT	(J) CT	Frequency		χ^2	P
		(I) Yes	(J) Yes		
Interpretation	**Inference**	69.5%	93.3%	26.694	<0.001
Interpretation	**Evaluation**	47.5%	93.1%	46.021	<0.001
Interpretation	**Recognition**	25.2%	100.0%	72.014	<0.001
Interpretation	**Conclusion**	32.3%	96.5%	62.016	<0.001
Inference	**Evaluation**	47.6%	69.5%	4.327	<0.001
Inference	**Recognition**	30.7%	90.7%	33.620	<0.001
Inference	**Conclusion**	31.5%	70.2%	20.021	<0.001
Evaluation	**Recognition**	32.2%	65.1%	14.881	<0.001
Evaluation	**Conclusion**	32.2%	49.1%	3.750	<0.001
Recognition	**Conclusion**	41.9%	31.6%	2.700	0.013

Note: the scales used for initiation are: 0=No; 1=Yes

ii. ***Selection and critical thinking skills***

There was a significant difference in selection as the second step of ISP, depending on which critical thinking skills were used by students, $\chi 2\ (4) = 148.092,\ p = 0.001$. Table 4-19 shows the results of Friedman's test.

Table 4-19: Selection and critical thinking skills

Items	N	Mean	SD	Mean Rank	χ^2	p value
Conclusion	94	0.04	0.203	1.83		
Recognition	94	0.72	0.450	3.53		
Interpretation	94	0.74	0.438	3.59		
Evaluation	94	0.77	0.426	3.64	148.092	<0.001
Deduction	94	0.28	0.420	2.41		

Note: the scales used for selection are: 0=No; 1=Yes

Table 4-20 shows the results of McNamara's test as follows:

There was statistically significant difference in conclusion and recognition, $\chi 2 = 55.125, df = 1, p < 0.001$ (52.2% and 9.0%).

There was statistically significant difference in conclusion and interpretation, $\chi 2 = 57.095, df = 1, p < 0.001$ (62.5% and 11.5%).

There was statistically significant difference in conclusion and evaluation, $\chi 2 = 62.347, df = 1, p < 0.001$ (63.0% and 12.0%).

There was statistically significant difference in conclusion and deduction, $\chi 2 = 14.700, df = 1, p < 0.001$ (50.0% and 20.2%).

There was not statistically significant difference in recognition and interpretation, $\chi 2 = 0.029, df = 1, p = 0.734$ (73.0% and 74.4%).

There was not statistically significant difference in recognition and evaluation, $\chi 2 = 5.695, df = 1, p = 0.225$ (64.0% and 71.0%).

There was statistically significant difference in recognition and deduction, $\chi 2 = 35.558, df = 1, p < 0.001$ (29.2% and 68.4%).

There was not statistically significant difference in interpretation and evaluation, $\chi 2 = 2.759, df = 1, p < 0.097$ (68.3% and 74.3%).

There was statistically significant difference in interpretation and deduction, $\chi 2 = 74.348, df = 1, p < 0.001$ (37.0% and 85.1%).

There was statistically significant difference in interpretation and deduction, $\chi 2 = 34., df = 1, p < 0.001$ (37.8% and 79.8%).

Table 4-20: McNemar results for selection and critical thinking skills

(I) CT	(J) CT	Frequency		χ^2	P
		(I) Yes	(J) Yes		
Conclusion	**Recognition**	52.2%	9.0%	55.125	<0.001
Conclusion	**Interpretation**	65.2%	11.5%	57.095	<0.001
Conclusion	**Evaluation**	63.0%	12.0%	62.347	<0.001
Conclusion	**Deduction**	50.0%	20.2%	14.700	<0.001

(I) CT	(J) CT	Frequency		χ^2	P
		(I) Yes	(J) Yes		
Recognition	**Interpretation**	73.0%	74.4%	0.029	0.734
Recognition	**Evaluation**	64.0%	71.0%	0.225	0.052
Recognition	**Deduction**	29.2%	68.4%	35.558	<0.001
Interpretation	**Evaluation**	68.3%	74.3%	2.759	0.097
Interpretation	**Deduction**	37.0%	85.1%	74.348	<0.001
Evaluation	**Deduction**	37.8%	79.8%	34.914	<0.001

Note: the scales used for selection are: 0=No; 1=Yes

iii. ***Exploration and critical thinking skills***

There was a significant difference in exploration as the third step of the ISP model, depending on which critical thinking skills were used by students, $\chi 2\,(4) = 234.406,\ p = 0.001$. The results of Friedman's test are shown in Table 4-21.

Table 4-21: Exploration and critical thinking skills

Items	N	Mean	SD	Mean Rank	χ^2	p value
Interpretation	94	0.66	0.476	3.47	234.406	<0.001
Inference	94	0.77	0.426	3.73		
Recognition	94	0.89	0.310	4.05		
Deduction	94	0.02	0.145	1.87		
Conclusion	94	0.02	0.145	1.87		

Note: the scales used for exploration are: 0=No; 1=Yes

Table 4-22 shows the McNemar's test results as follows:

There was statistically significant difference in interpretation and inference, $\chi 2 = 1.029, df = 1, p < 0.001$ (75.8% and 61.5%).

There was statistically significant difference in interpretation and recognition, $\chi 2 = 15.402, df = 1, p < 0.001$ (87.4% and 59.5%).

There was statistically significant difference in interpretation and deduction, $\chi 2 = 74.141, df = 1, p < 0.001$ (8.8% and 65.5%).

There was statistically significant difference in interpretation and conclusion, $\chi 2 = 54.391, df = 1, p < 0.001$ (10.7% and 59.0%).

There was statistically significant difference in inference and recognition, $\chi 2 = 1.929, df = 1, p < 0.001$ (86.0% and 72.2%).

There was statistically significant difference in inference and deduction, $\chi 2 = 21.050, df = 1, p < 0.001$ (6.8% and 62.1%).

There was statistically significant difference in inference and conclusion, $\chi 2 = 68.014, df = 1, p < 0.001$ (11.3% and 76.9%).

There was statistically significant difference in recognition and deduction, $\chi 2 = 12.971, df = 1, p < 0.001$ (7.3% and 79.3%).

There was statistically significant difference in recognition and conclusion, $\chi 2 = 80.012, df = 1, p < 0.001$ (11.7% and 94.9%).

There was no statistically significant difference in deduction and conclusion, $\chi 2 = 2.250, df = 1, p = 0.134$ (55.2% and 41.0%).

Table 4-22: McNemar results for exploration and critical thinking skills

(I) CT	(J) CT	Frequency		χ^2	P
		(I) Yes	(J) Yes		
Interpretation	**Inference**	75.8%	61.5%	1.029	<0.001
Interpretation	**Recognition**	87.4%	59.5%	15.402	<0.001
Interpretation	**Deduction**	8.8%	65.5%	74.141	<0.001
Interpretation	**Conclusion**	10.7%	59.0%	54.391	<0.001
Inference	**Recognition**	86.0%	72.2%	1.929	<0.001
Inference	**Deduction**	6.8%	62.1%	21.050	<0.001
Inference	**Conclusion**	11.3%	76.9%	68.014	<0.001
Recognition	**Deduction**	7.3%	79.3%	12.971	<0.001
Recognition	**Conclusion**	11.7%	94.9%	80.012	<0.001
Deduction	**Conclusion**	55.2%	41.0%	2.250	0.134

Note: the scales used for exploration are: 0=No; 1=Yes

iv. ***Formulation and critical thinking skills***

There was a significant difference in formulation as the fourth step of the ISP model, depending on which critical thinking skills were used by students , $\chi 2\,(4) = 32.926,\ p = 0.001$. Table 4-23 shows the results of Friedman's test.

Table 4-23: Formulation and critical thinking skills

Items	N	Mean	SD	Mean Rank	χ^2	p value
Inference	94	0.51	0.493	3.35	32.916	<0.001
Recognition	94	0.54	0.497	3.30		
Interpretation	94	0.32	0.438	2.50		
Evaluation	94	0.49	0.503	3.14		
Conclusion	94	0.32	0.476	2.71		

Note: the scales used for formulation are: 0=No; 1=Yes

Table 4-24 shows the results of McNemar's test as follows:

There was no statistically significant difference in inference and recognition, $\chi 2 = 0.029, df = 1, p < 0.001$ (64.4% and 60.5%).

There was statistically significant difference in inference and interpretation, $\chi 2 = 26.694, df = 1, p < 0.001$ (45.2% and 71.4%).

There was no statistically significant difference in inference and evaluation, $\chi 2 = 1.021, df = 1, p = 0.591$ (54.3% and 57.0%).

There was statistically significant difference in inference and conclusion, $\chi 2 = 8.817, df = 1, p < 0.001$ (25.5% and 41.4%).

There was statistically significant difference in recognition and interpretation, $\chi 2 = 18.283, df = 1, p < 0.001$ (35.5% and 59.7%).

There was no statistically significant difference in recognition and evaluation, $\chi 2 = 0.413, df = 1, p = 0.173$ (41.0% and 45.8%).

There was statistically significant difference in recognition and conclusion, $\chi 2 = 8.167, df = 1, p < 0.001$ (25.0% and 43.1%).

There was statistically significant difference in interpretation and evaluation, $\chi 2 = 14.697, df = 1, p < 0.001$ (52.1% and 34.6%).

There was no statistically significant difference in interpretation and conclusion, $\chi 2 = 1.021, df = 1, p = 0.880$ (25.2% and 25.9%).

There was statistically significant difference in evaluation and conclusion, $\chi 2 = 3.516, df = 1, p < 0.001$ (23.5% and 36.2%).

Table 4-24: McNemar results for formulation and critical thinking skills

(I) CT	(J) CT	Frequency		χ^2	P
		(I) Yes	(J) Yes		
Inference	**Recognition**	64.4%	60.5%	0.029	0.323
Inference	**Interpretation**	45.2%	71.4%	26.694	<0.001
Inference	**Evaluation**	54.3%	57.0%	1.021	0.591
Inference	**Conclusion**	25.5%	41.4%	8.817	<0.001
Recognition	**Interpretation**	35.5%	59.7%	18.283	<0.001
Recognition	**Evaluation**	41.0%	45.8%	0.413	0.173
Recognition	**Conclusion**	25.0%	43.1%	8.167	<0.001
Interpretation	**Evaluation**	52.1%	34.6%	14.694	<0.001
Interpretation	**Conclusion**	25.2%	25.9%	1.021	0.880
Evaluation	**Conclusion**	23.5%	36.2%	3.516	<0.001

Note: the scales used for formulation are: 0=No; 1=Yes

v. ***Information collection and critical thinking skills***

There was a significant difference in the information collection as the fifth step of ISP, depending on which critical thinking skills were used by students, $\chi 2\,(4) = 246.594,\ p = 0.001$. The results of Friedman's test are shown in Table 4-25.

Table 4-25: Information collection and critical thinking skills

Items	N	Mean	SD	Mean Rank	χ^2	p value
Interpretation	94	0.40	0.493	2.62	67.025	<0.001
Inference	94	0.45	0.500	2.72		
Deduction	94	0.77	0.426	3.52		
Evaluation	94	0.81	0.396	3.63		
Conclusion	94	0.36	0.483	2.51		

Note: the scales used for information collection are: 0=No; 1=Yes

Table 4-26 shows the McNemar's test as follows:

There was statistically significant difference in interpretation and inference, $\chi 2 = 0.281, df = 1, p = 0.029$ (63.1% and 52.9%).

There was statistically significant difference in interpretation and deduction, $\chi 2 = 20.167, df = 1, p < 0.001$ (80.0% and 37.4%).

There was statistically significant difference in interpretation and evaluation, $\chi 2 = 23.603, df = 1, p < 0.001$ (71.5% and 34.1%).

There was no statistically significant difference in interpretation and conclusion, $\chi 2 = 0.188, df = 1, p = 0.821$ (33.8% and 32.8%).

There was statistically significant difference in inference and deduction, $\chi 2 = 20.024, df = 1, p < 0.001$ (82.6% and 46.0%).

There was statistically significant difference in inference and evaluation, $\chi 2 = 0.817, df = 1, p < 0.001$ (71.6% and 40.7%).

There was no statistically significant difference in inference and conclusion, $\chi 2 = 21.780, df = 1, p = 0.162$ (27.1% and 31.3%).

There was no statistically significant difference in deduction and evaluation, $\chi 2 = 0.321, df = 1, p = 0.707$ (78.8% and 80.2%).

There was statistically significant difference in deduction and conclusion, $\chi 2 = 25.352, df = 1, p < 0.001$ (34.5% and 71.6%).

There was statistically significant difference in evaluation and conclusion, $\chi 2 = 33.620, df = 1, p < 0.001$ (39.6% and 70.6%).

Table 4-26: McNemar results for information collection and critical thinking skills

(I) CT	(J) CT	Frequency		χ^2	P
		(I) Yes	(J) Yes		
Interpretation	Inference	63.1%	52.9%	0.281	0.029
Interpretation	Deduction	80.0%	37.4%	20.167	<0.001
Interpretation	Evaluation	71.5%	34.1%	23.603	<0.001
Interpretation	Conclusion	33.8%	32.8%	0.188	0.821
Inference	Deduction	82.6%	46.0%	20.024	<0.001
Inference	Evaluation	71.6%	40.7%	0.817	<0.001
Inference	Conclusion	27.1%	31.3%	21.780	0.162
Deduction	Evaluation	78.8%	80.2%	0.321	0.707

(I) CT	(J) CT	Frequency		χ^2	P
		(I) Yes	(J) Yes		
Deduction	Conclusion	34.5%	71.6%	25.352	<0.001
Evaluation	Conclusion	39.6%	70.6%	33.620	<0.001

Note: the scales used for information collection are: 0=No; 1=Yes

vi. ***Presentation and critical thinking skills***

There was a significant difference in the presentation as the final step of ISP, depending on which critical thinking skills were used by students, $\chi 2\,(4) = 155.447,\ p = 0.001$. The results of Friedman's test are shown in Table 4-27.

Table 4-27: Presentation and critical thinking skills

Items	N	Mean	SD	Mean Rank	χ^2	p value
Deduction	94	0.68	0.469	3.64	155.447	<0.001
Evaluation	94	0.87	0.335	4.12		
Inference	94	0.19	0.396	2.41		
Recognition	94	0.15	0.358	2.31		
Interpretation	94	0.23	0.426	2.52		

Note: the scales used for presentation are: 0=No; 1=Yes

Table 4-28 shows the results of McNemar's test as follows:

There was statistically significant difference in deduction and evaluation, $\chi 2 = 8.500, df = 1, p < 0.001$ (85.3% and 59.4%).

There was statistically significant difference in deduction and inference, $\chi 2 = 37.500, df = 1, p < 0.001$ (27.5% and 78.4%).

There was statistically significant difference in deduction and recognition, $\chi 2 = 41.397, df = 1, p < 0.001$ (20.6% and 69.2%).

There was statistically significant difference in deduction and interpretation, $\chi 2 = 33.620, df = 1, p < 0.001$ (33.5% and 74.5%).

There was statistically significant difference in evaluation and inference, $\chi 2 = 58.368, df = 1, p < 0.001$ (19.8% and 81.6%).

There was statistically significant difference in evaluation and recognition, $\chi 2 = 62.347, df = 1, p < 0.001$ (14.4% and 69.2%).

There was statistically significant difference in evaluation and interpretation, $\chi 2 = 48.347, df = 1, p < 0.001$ (24.9% and 79.6%).

There was no statistically significant difference in inference and recognition, $\chi 2 = 1.449, df = 1, p = 0.229$ (47.4% and 55.4%).

There was statistically significant difference in inference and interpretation, $\chi 2 = 0.281, df = 1, p = 0.041$ (44.7% and 34.7%).

There was statistically significant difference in recognition and interpretation, $\chi 2 = 1.531, df = 1, p < 0.001$ (50.8% and 33.7%).

Table 4-28: McNemar results for presentation and critical thinking skills

(I) CT	(J) CT	Frequency		χ^2	P
		(I) Yes	(J) Yes		
Deduction	**Evaluation**	85.3%	59.4%	8.500	<0.001
Deduction	**Inference**	27.5%	78.4%	37.500	<0.001
Deduction	**Recognition**	20.6%	69.2%	41.397	<0.001
Deduction	**Interpretation**	33.5%	74.5%	33.620	<0.001
Evaluation	**Inference**	19.8%	81.6%	58.368	<0.001
Evaluation	**Recognition**	14.4%	69.2%	62.347	<0.001
Evaluation	**Interpretation**	24.9%	79.6%	48.347	<0.001
Inference	**Recognition**	47.4%	55.4%	1.449	0.229
Inference	**Interpretation**	44.7%	34.7%	0.281	0.041
Recognition	**Interpretation**	50.8%	33.7%	1.531	<0.001

Note: the scales used for presentation are: 0=No; 1=Yes

4.3 Interviews

This study includes two series of interview questions to address the following research questions:

1. How do postgraduates think critically when seeking for information?
2. What are the requirements for a critical thinking learning system?

This section explains the findings of the results of the interviews.

4.3.1 Finding - How do postgraduates think critically when seeking for information?

This section presents findings derived from the analysis of the data obtained from interviewing twelve (12) postgraduates of the University of Malaya. The postgraduates who participated in initial surveys, expressed their level of critical thinking and their usage rate of critical thinking skills during seeking for information. Each interview took approximately twenty-five minutes. The interviews were carried out by using a set of nine open-ended questions, organized into a structured questionnaire in the research center of the University of Malaya. The researcher guaranteed the participants data and confidentialities. In order to protect their anonymity, their names have been substituted with pseudonyms.

4.3.1.1 **Preferred search engine and the information sources**

Generally, all postgraduates use the Internet as source to meet their information needs. Information sources provide information for somebody who wants to fulfil a variety of information needs. These information sources can be categorized as the primary, secondary, and tertiary sources, which are presented in printed and online formats. In this section, the postgraduates indicated their popular sources that they prefer to find their answers, such as Wikipedia, Google scholar, and specific databases, including ACM, Elsevier, and Springer. Furthermore, postgraduates mentioned that Google is the most popular search engine that they refer to it as the first step of seeking.

Regarding above, most of postgraduates talked about **Google** as the first search engine for searching as follows:

Mark said that:

> *"It's a habit for me to search everything in google. I believe google is like a huge library without any time limitation. I prefer to ask my questions from google"* (Mark, interview, June 2015).

Zara also believed that:

> *"Google is the first place where I go to ask questions. I think all of us are dependent on google and we have to appreciate it"* (Zara, interview, May 2015).

Similarly, Shawn indicated that:

> *"For me, google is a teacher, a friend, and a library. I cannot remember the time without internet and google. Google helps me to clarify everything and answer my questions"* (Shawn, interview, June 20150).

According to the above verbatim, we took important keywords to clarify the participants' aims, such as *Google, search, as question, first place,* and *clarify everything.*

8 out of 12 respondents referred to **Wikipedia** as the first information source to take a general idea and the definition of terms.

Sarah told that:

> "*First of all, I try to find a good definition about the topic, the academic one I mean, and I try to find something about the definition. For example, I look for it in Wikipedia and in general websites, I try to find some definitions and something like this"* (Sarah, interview, May 2015).

Lara also told that:

> *"Wikipedia is very helpful and it gives me a general viewpoint"* (Lara, interview, June 2015).

Similarly, Georgia told that:

> *"First of all, I need to go for the definition terms and the terms I don't know about them, the specific topic maybe I need to start from the Wikipedia"* (Georgia, interview, may 2015).

Mariah also indicated that:

> *"I search it (the unknown topic) in the google and Wikipedia to make myself familiar with it"* (Mariah, interview, June 2015).

Consistent with Mariah, Sarah also mentioned a point on **Wikipedia** and talked about **google scholar**:

> *"I try to find something about the definition. For example, I look for it in Wikipedia and in general website, I try to find some definition, and then I go through the google scholar or research gate to find some related articles"* (Sarah, interview, May 2015).

Based on the transcribed interviews, we found some keywords to direct us in answering our questions, such as *Wikipedia, Google scholar, definition about the topic, general viewpoint,* and *definition terms.*

In the next level, respondents prefer to grab deeper information. To achieve this goal, the respondents used the specific websites, such as **ACM, Springer, and Elsevier**. There are several reasons for leveraging such scientific websites: finding limitation, scope, and direction.

Ali mentioned that:

> *"After understanding the topic of the problem, I can find how I can find the data, for example, if it's related to computer, I will go to the website that is related to the computer or I will go to the library to find the computer part and try to find sources that I need"* (Ali, interview, May 2015).

Mona indicated that the quality of papers in Google is not as fine as specific websites, therefore, she prefers to search papers in the related websites to the topic.

> *"If it is relevant to my degree means I have a little bit knowledge about it, then I will just focus on it, but not focus I mean collect papers, but, from google. You know google does not provide the most of the papers just some conferences, which are helpful from 2 to 3 times and like this. It has a lot of good quality papers and if we focus on that paper, we can't go to the directions, which is*

suitable for us. That's why I will focus on other websites like google scholar little bit fine, but ACM, Springer, and this type" (Mona, interview, May 2015).

On the basis of the interviewee's responses, we could extract these keywords, which are helpful in choosing the themes, such as *ACM, Springer, and Elsevier, website that is related to the computer (means the specific one), relevant, good quality papers,* and *suitable.*

4.3.1.2 **Criteria to evaluate the information**

Postgraduates use several criteria while they were seeking information. It means that, respondents considered different criteria in each step of the information seeking process. For the first time, when respondents want to search information about the given topic, 5 out of 12 respondents looked at the author, publisher, URL, date of publication, and the number of citations, which each paper may have. One of respondents said that he preferred to cite **ISI papers** because they have better quality rather than the other papers in the other websites. In practice, we extracted some keywords, which indicate the respondents' aims and their criteria, such as *ISI-cited, number of citations, famous author, date of publication, famous publisher, URL, qualified publisher, relevant information and paper, indexed paper,* and *citations.*

Ali remarked that:

"There are some criteria for example, if you find/ need some papers, the most important thing is that is it ISI-cited or not. If the paper is ISI-cited, definitely it's better than the paper is not ISI-cited and goes to another criterion, for example, how many citations it has. When the number of citations of one paper is good, it means that this paper is better than the other one. Related to information you need, there are some criteria to assess this" (Ali, interview, May 2015).

Lara added some criteria**,** such as **URL, and famous authors** and said that:

"I used some criteria such as, famous authors, date of publication, and the number of citations as well as URL" (Lara, interview, June 2015).

Lili also indicated that:

"For me, famous author and publisher are very important. It can be clarified by the URL, and the number of citations that the paper could take" (Lili, interview, May 2015).

Georgia told that her criteria may vary based on the type of information she needs, for example, **date of publication**:

"It depends, if I'm looking for the methods, definitely I'm looking for the recent ones and the date is important. If I'm looking for the definition and the concept, maybe the oldest one helps me, so also the citation and the date" (Georgia, interview, May 2015).

Similarly, Mary said that:

"Date of publication shows how the paper is new. I prefer to search the newest publications in my area, then the authors and publishers become important for me. I try to control the visual criteria, such as the URL, date of publication, number of citations of the authors and qualified publishers" (Mary, interview, June 2015).

8 out of 12 respondents said that the **relevancy** of information that they sought is the most important criteria. Lili added relevancy as a key factor to select information.

Lili mentioned that:

"In a paper, if I want to evaluate the paper, I prefer to review the indexed paper in a valid site, I prefer to review technical papers from famous industries like IBM or something like that. After that, when I collect my papers, I review the abstracts and the conclusions. Then if I find it relevant to my research, I put it in my library to have a whole study" (Lili, interview, May 2015).

Mary also said that:

"I try to find some relevant information and papers to help me to familiar more with the topic" (Mary, interview, June 2015).

The most important criteria, which postgraduates consider deciding about the suitability of the collected information, is **relevancy**. Respondents mentioned that when they want to cite a paper, it is necessary to ensure about its relevancy to the sought information. Georgia indicated that:

"If it's related to any part of my study so it means it's related even from the methodology, even from the concept to use, even the findings and the conclusion. If it's related to my research, so I can cite it" (Georgia, interview, May 2015).

Perin also emphasized on **relevancy** of the information and told that:

"The first important criterion is relevancy. I try to collect papers, which are more relevant to the topic" (Perin, interview, May 2015).

Shawn also believed in relevancy and said that:

"I skim the research engine results to find how close they are to my search inquiry" (Shawn, interview, June 2015).

Mona indicate that:

"According to my search query and the keywords I have, I try to collect the information, which match with my keywords, otherwise I skip the irrelevant information" (Mona, interview, May 2015).

4.3.1.3 Critical thinking skills during information seeking processes

According to the results of analysis of the interviews, it can be found that all postgraduates use different critical thinking skills while they are seeking for information, but they may not be aware about it. The information seeking process consists of six steps and during these steps, postgraduates use one or more critical thinking skills. For instance, while students saw a new topic for the first time without any background knowledge, they

attempted to use "**interpretation"** and **"inference"** as the first critical thinking skills to get the definition of the topic and general view about it. To extract the above expressions, we selected some keywords, which convey similar meaning and value, such as *understand the topic, search, see the definition, find a/the definition, definition of terms,* and *understand the meaning of the topic.*

Ali indicated that:

> *"I try to understand the topic of the things that I want to search, then I go to the documents or Internet or any sources that I have to meet my information needs"* (Ali, interview, May 2015).

Similar to Ali, other respondents, such as Perin, Sarah, and Georgia also emphasized on the interpretation skill for the first step of the information seeking process.

Perin told that:

> *"First, I search in Wikipedia to see the definition of the word"* (Perin, interview, May 2015).

Sarah mentioned that:

> *"For me first of all, I try to find a good definition about the topic"* (Sarah, interview, May 2015).

Georgia also explained that:

> *"First of all, I need to go for the definition terms and the terms I don't know about them, the specific topic, maybe I need to start from the Wikipedia or somewhere else. It shouldn't be in the formal or specific journals even googling to finding the different terms and definition for them"* (Georgia, interview, May 2015).

Similarly, Mary said:

> *"I try to understand the meaning of the topic; therefore, I refer to Wikipedia and Google to find the definition"* (Mary, interview, June 2015).

In the second step of information seeking processes, which is called "selection", some postgraduates used "**recognition of assumptions"**, **"interpretation"**, and **"evaluation of arguments"** as a critical thinking skill. Therefore, we took some keywords and expressions with the same meaning, such as *go through the research keywords, abstract, identify, related, relevant article, introduction,* and *know in general.*

For example, Georgia told that:

> *"I first go through the research keywords and maybe at the second stage abstract, short abstract will help me to identify whether it's quite related to a topic I'm looking for"* (Georgia, interview, May 2015).

Lili mentioned that to select the information, she scanned the papers:

> *"First quick look to the abstract and the conclusion. Then, in the implementation I try to find some instruments that the proper use of simulation or evaluation. After that, I go to the paper"* (Lili, interview, May 2015).

Lara also said that:

> *"I look at the abstracts and their keywords to know they are related or not"* (Lara, interview, June 2015).

In accordance with the other respondents and to confirm the other answers, which reflect the recognition of assumption by them, Perin indicated that:

> *"I read different articles about the topic, maybe the abstract of the papers"* (Perin, interview, May 2015).

Sarah told that:

> *"For the second step, if I find something interesting in the first step, I follow that one a bit in a deep and find some relevant article and read them, maybe introduction, sometimes conclusion as well and get some more information to be dominated about the research area and things, which are interesting for me"* (Sarah, interview, May 2015).

Zara explained that:

> *"In the second step, I just came to know about my topic in general. After that, I have found some parameters, which are discussed in each paper. I combine that parameters"* (Zara, interview, May 2015).

Postgraduates in the "exploration" step as the third step of the information seeking process model used "**recognition of assumptions**", "**interpretation**" and "**inference**" as critical thinking skills. They have their own points of view, and sometimes prefer to search again and read more about the topic to be sure about the information that was selected and the research gap that was formed in their mind. We extracted some keywords to convey similar meaning of the critical thinking skills in this step, such as *related work, previous work, find gap, focus, research gap, search deep, critically think, hypothesis, methods, conclusion, search again, google scholar, change the search query, search more, various keywords, repeat search activities, search too much,* and *various channels*.

Mona emphasized on the research gap and existing works in her area. She told that:

> *"Actually, when I will read about related work, previous work, which is published, I will just not rely on that work. First, I will implement it myself, then I want to see it. Whether that information they have provided is ok or not. If I will find the same gap that they have written in their papers, then I will focus on that gap and I will solve that gap, which they have written that, there is a limitation or maybe it will be my PhD topic or it will be no for me the next direction"* (Mona, interview, May 2015).

Similarly, Sarah also preferred to be sure about the research gap and the previous works. She said that:

> *"Actually, when I find initial research gaps, first of all, I want to make sure is it the real research gap, so I search more in deep about the research gap and I try to find is there anyone else tackle this as research gap or it is still research*

gap and not addressed anywhere in any research paper. Then, if I find it is not addressed to anyone else, I will find the details of it" (Sarah, interview, May 2015).

Mariah emphasized on hypothesis and thinking critically:

"I will read more high-ranking articles first and critically think about their hypothesis, methods or study, and their conclusions" (Mariah, interview, June, 2015).

The other respondent, Perin, relied on searching again and assure about the procedures, which she follows:

"To find the specific question about the topic, maybe I should search again in Google scholar, for example, I want to know about one topic like cloud computing and only security of cloud computing. So, I should search again and change the search query like cloud computing and security" (Perin, interview, May 2015).

Mark said that:

"In addition to reading the abstract, depends on what I need for the topic, for example, solving a problem or doing a project, I go to the body of paper to find what they suggest and which part of the paper can help me. I also search more by various keywords to repeat search activities" (Mark, interview, June 2015).

Lara also agreed to search again and said:

"I try to know more and more by searching too much via various channels like specific website and databases, or contact with scholars to know more and details of the topic" (Lara, interview, June 2015).

In the fourth step of the information seeking process, which is known "formulation", postgraduates used "**recognition of assumptions**", and "**inference**". During this step, when respondents form a hypothesis in their minds, it means they use their recognition of

assumptions or when they refer to the previous works and read more and deeply, indeed their interpretation skill was used. It can be found from respondents' statements that the respondents focused on interpretation and recognition of assumptions. To find the respondents' opinion, we extract some keywords, such as *deeply read, relevant articles, research gap, screening, understand more, paraphrase my query, focus, relevant paper and information, information gap, read the paper, read deeply,* and *find details*. For example, Perin told that:

> *"I think I should deeply read the manuscript I search"* (Perin, interview, May 2015).

Mary also is the same as Perin and said that:

> *"I need to read deeply and search details not general information"* (Mary, interview, June 2015).

Sarah also believed in recognition of assumptions and inference. She mentioned:

> *"I try to find very relevant articles with the research gap that I have identified already. So, I try to follow them and identify the research gap, they formulate it and not just trust one article, find some of them. If it exists, I try to find some very relevant article and how they organize the work, how they do their experiment"* (Sarah, interview, May 2015).

Similarly, Shawn indicated that:

> *"Screening the provided information to understand more about the desirable topic is dependent on how consistent is that to my knowledge or to that of other websites. If the provided information is consistent I usually consider that as my answer. If not, I should be digging for more info or perhaps paraphrase my query* (Shawn, interview, May 2015).

Lara said that:

"I try to focus on the relevant papers and information, therefor, relevancy is very important for me. Information gap is revealed, when I read more and it helps me to find the right way. Therefore, I read the body of papers to find further information to conclude" (Lara, interview, June 2015).

Zara uses inference as well as recognition of assumptions and interpretation:

"When I read different papers and sometimes when I found relevant and most truthful information in the google, I make them in the different folders and after reading my paper, then I find some relevant information on some websites, then I want the URL of that, link of these websites and after that, I had noted that relevant information, even I read the papers you know after reading papers we summarize papers" (Zara, interview, May 2015).

Mark thought that specifying the scope of the topic is helpful:

"I try to specify my scope and extend my knowledge along with the topic. I mean that I try to read deeply and find some useful details around the topic, I have" (Mark, interview, June 2015).

Information collection as the fifth step of the information seeking process needs some critical thinking skills because during this step, postgraduates should organize their information and decide about whatever they collected in the last steps. As a result, they use some critical thinking skills such as "**evaluation of arguments**", and "**deduction**". To find the above critical thinking skills, we extracted some keywords to convey the same meaning of the critical thinking skills, such as *search more, organize, analyze, relevancy, divided the information, find solution, find pattern, accuracy, reviewing paper, collect the information, collect the data, previous work, extract information, survey, rad some paper,* and *categorize.*

Ali told that:

"I try to search more and find many things to find that is it close to my work or not. Does it have any relevancy or anything that related to my work, then, I try to search more. Most of the time, I try to find a pattern or something to follow. Based on my knowledge and based on the information I gather in the previous part, I try to organize and analyze the information" (Ali, interview, May 2015).

Mary also agreed with Ali on organizing the information and she said:

"I try to organize the information according to the criteria as I told that relevancy is the most important criteria for me. Therefore, according to the criteria that I have, I divided the information in some categories to feel easy to find final solution" (Mary, interview, June 2015).

Mark believed in relevant and accurate information:

"Based on the relevancy and accuracy, I decide what information is good. Also, I try to find some pattern or guideline to help me to do my work, therefore, these patterns can lead me to go forward" (Mark, interview, June 2015).

Shawn as same as Mark said:

"I divide information into three categories (relevant/neutral/not relevant). Then I need to judge the accuracy of this information in each category and try to see their point of views to the given topic. All of these give me an insight into the query" (Shawn, interview, June 2015).

Georgia concentrated on meeting the research objectives, therefore, she applied her deduction, and inference:

"As long as I reach the objectives and research questions, I think it's enough. But reviewing more paper will reveal more aspects maybe then I need to add it, but doing the review paper or at least having a review paper will help a lot" (Georgia, interview, May, 2015).

Similarly, Sarah thought that referring to the previous steps can help her to organize the information:

> *"Following the previous step that I define some criteria, guideline for my work so following the guideline that they said or the expert person in my field, I try to go in deep. For my work I will get some results in this step, I do the experiment for example, some relative area in my work they prepare a survey, and then try to collect information from the audience. For my work, exactly because I use the open source project for my work, I collect the information, I collect the data from the repositories and then through I extract some information, details information that I was through in formulated research gap or not"* (Sarah, interview, May 2015).

Lili believed that if she could prepare a thematic taxonomy based on the existing publication in her area, she could be sure about her organization of information:

> *"If I can categorize the papers that I read to thematic taxonomy, I will satisfy, but I just read some papers"* (Lili, interview, May 2015).

The final step of the information seeking process model is "presentation". During this step, like the previous steps, postgraduates use several critical thinking skills, such as "**evaluation of arguments**", and "**deduction**". These skills help respondents to draw conclusions and decide about their information to finish their search activities. Therefore, we took some keywords from the transcribed interviews, which show the critical thinking skills in this step, such as *repeat the searching, search one more time, relevancy, accuracy, find pattern or guideline, repeat the last steps, go back,* and *review all procedures.*

Georgia told that she tried to search more and find new things to decide about her seeking information:

"I try to search it one more time to find what's new in the area, actually not in one-year basis quite a few months. I will repeat the searching again to see whether what the latest is" (Georgia, interview, May 2015).

Mark indicated that being up-date is an important factor:

"Based on the relevancy and accuracy, I decide what information is good. Also, I try to find some pattern or guideline to help me to do my work, therefore, these patterns can lead me to go forward" (Mark, interview, June 2015).

Perin also emphasized on returning to the last steps and use her critical thinking skills to conclude. She indicated that:

"I try to read the papers, which I found in the last steps. Also, I may repeat the last steps to be sure about, for example, the definition of the topic. And it may happen to me more and more to conclude that I found whatever I want" (Perin, interview, May 2015).

Lara also had the same opinion with the other respondents:

"I think in this step I need to go back and see whatever I have done to be sure about my works. I may repeat searching or using some guidelines and supervisor's advice to be sure about my work. At this time, I think I have done what I need to do and I can announce I finish" (Lara, interview, June 2015).

Sarah preferred to use deduction and evaluation of arguments as the most important skills and she explained that:

"Actually, if I refer to the statistical criteria, first of all, I find in my field, how many cases evaluated, how many surveys they prepared or something like this, but you can find it by yourself as well. If you do the analysis you receive the point as much as the information you added, you will not get more information. It means you receive the point that the information is enough for you and no more things there is enough for you" (Sarah, interview, May 2015).

Similar to Perin and Georgia, Mary believed in reviewing last procedures as well as evaluating provided information by asking some questions:

> *"I try to review all procedures that I passed to be sure about the findings. Also, I may try to change keywords and search again with different keywords. Also, I may ask some questions from myself to be sure about what I found, then, I combine them and try to present them in a paper format or something I need to present"* (Mary, interview, June 2015).

4.3.1.4 **Feelings while seeking information**

In accordance with the ISP model (Kuhlthau, 1991), information seekers have different feelings during seeking for information. In the first step of the information seeking process model, users feel uncertainty because they do not know anything about the topic and it changes with optimism in the second step. In the third step, they may feel confused and doubt, which it replaced with clarity in the next step. Confidence and satisfaction are the desired feeling, which users feel while they want to decide about the information and present the outcome of their search activities. As a result, we extracted some keywords to show respondent's feelings, such as *afraid, difficult, confusion, uncertainty, happy, confident, frightening, comfortable, good, freely, interesting, boring, very tired,* and *satisfactory*.

Some postgraduates had the same feelings during the information seeking process while some of them have different feelings. For example, Ali described himself and he mentioned that:

> *"I'm afraid about it and I think this is very difficult for me to understand it in the first step. When I go through this topic and I don't have any information about it in the first step, it's difficult for me. In the next steps, when I have information about the topic, it can be easier and easier to achieve the goals"* (Ali, interview, May 2015).

Similarly, Mary said that:

> *"If I want to describe myself, I can tell you I feel confusion and uncertainty but it goes up and down as well as excitement and worry. At the end, I feel happy and confident"* (Mary, interview, June 2015).

Lara also described herself as same as Mary:

> *"First of all, I feel uncertainty and frightening and it comes with me, but sometimes I feel comfortable and confident and sometimes I feel I don't know anything and my knowledge is not enough. But at the end, I feel good and freely"* (Lara, interview, June 2015).

Lili told that when she saw the topic for the first time, it was interesting for her, but this feeling changed with boring, tiredness and difficulty.

> *"First, because it's new topic and it's new for me, it's so interesting, but after I find the problem, I should narrow down in the research sometimes it can be boring for me, because I know the gap, I know the solution that the other researchers suggested, but it is sometimes boring. I think I prefer the level that define the problem and now it's hard time to suggest a solution for this"* (Lili, interview, May 2015).

Sarah describes herself in her words:

> *"For the first step, you are like a turtle, slowly going and moving. Sometimes you feel very tired and you feel you cannot finish this work and sometimes you need someone to guide you well to go in the steps in a correct way. But when you collect your information and doing the experiment or something like this, you feel much better and with higher speed because you have something already and you want to make sure the things that you have is correct or not so you speed up. Then in the last steps you will be like a jet because you have everything and you*

want to finish as fast you can and no one before you submit it or publish it or something like this (Sarah. Interview, May 2015).

Lara said:

"First of all, I feel uncertainty and frightening and it comes with me, but sometimes I feel good and confident and sometimes I feel I don't know anything and my knowledge is not enough. But at the end, I feel satisfactory" (Lara, interview, June 2015).

In contrast the other respondents, Mark and Shawn feel confidence during seeking for information. Mark said:

"I'm an optimistic person as a whole. I may feel confused or afraid for the first step, but because I like research I think my confidence is the strongest feeling during seeking for information" (Mark, interview, June 2015).

Shawn also felt confidence:

"Usually I am confident to find my answer about the given topic using the search engines. At least it can show me a way to find my answer" (Shawn, interview, June 2015).

4.3.1.5 **Factors influenced the seeking for information**

All postgraduates complained about several barriers, which put them in trouble to seek and evaluate information, such as access to information sources, background knowledge, and English language as a communication and comprehension tool. To clarify this part, we took some keywords to show the influenced factors, such as *finding information through the Internet, information sources, some books, some papers, available online, library, English language, barrier, native researchers, research group, mood, background knowledge, scientific language, huge amount of information, trustworthy, environment, mental situation, feel well,* and *family.*

Ali talked about the **information sources** that:

"There are some limitations, for example, if is it a new topic, finding information around it through the Internet is difficult. And, how to access the information sources is harder than finding them. Because they may be published by government organizations or some institutes as their research outcomes or they may not be free of charge. Sometimes, you don't have enough sources about one topic" (Ali, interview, May 2015).

Similarly, Georgia told that:

"In some cases, I need to have access to some papers, which they were not available in full access in our library and I don't find something else, also some books were not available online or even into the library" (Georgia, interview, May 2015).

Lili indicated that **English language** is her barrier and she explained that:

"Sometimes the English language can be a barrier because sometimes understanding the paper, especially if they come from the native researchers, is not easy for us, and also communicate with the other research groups outside the university can be hard" (Lili, interview, May 2015).

Mary as same as Lili has problem with English language and said that:

"My mood, background knowledge and English language as a scientific language to understand some texts are very effective" (Mary, interview, June 2015).

Mariah mentioned **huge amount of information and the trustworthy** as the barriers to evaluate the information:

"Huge amount of information, which makes it difficult for me to separate the trustworthy information" (Mariah, interview, June 2015).

Similarly, Lara said that"

"Huge amount of task that I have to do as well as background knowledge about the topic" (Lara, interview, June 2015).

Mark emphasized on the environment and indicated that huge amount of information is another important factor:

"Mood, the environment and huge amount of information are effective" (Mark, interview, June 2015).

7 out of 12 respondents believed that their **mood and personality trait** were the key factors to influence the procedures of seeking for information. To confirm this, Perin mentioned that:

"My mood is very important because if I was in a good mood and good mental situation, I can read too much and collect much more information" (Perin, interview, May 2015).

Georgia also said that:

"Being in a good mood helps me to concentrate on the task and whatever I have to seek around the topic. Therefore, I usually try to do research when I feel well, because I can go ahead" (Georgia, interview, May 2015).

Lili by emphasizing on her mood, believed that the **environment** and the place also could influence, therefore, she claimed that:

"Control my mood is the most important factor that influence because when I was not in a good mood, I cannot analyze or research perfect. But the other thing is a supervisor and comments also can affect our research because if they give us good comments or motivated us, we can go through the research. After that, I think the environment, weather and seat, everything can be influenced" (Lili, interview, May 2015).

Mona thought that family issue was the main factor during her search activities:

"Basically, it's family, if they are far, we can't concentrate, but if they are with us, then we also can't concentrate because it's difficult to come in the morning and just go back in the evening. It's difficult to manage all the things. Other is also the weather and the third one is the supervisor. Maybe if he's conducting meeting again and again because it will affect the mood also because maybe that time we have mood to concentrate more. If we come back from the meeting, then the situation is changed" (Mona, interview, May 2015).

Although this study focuses on a very small number of postgraduates, some very interesting themes emerged. The results of the interviews are organized based the following themes:

a. preferred search engine and the information sources
b. criteria to evaluate the information
c. critical thinking skills during information seeking processes
d. feelings while seeking information
e. factors influenced the information seeking

4.3.2 Finding - Determining the user's requirements and the influenced factors on cultivating critical thinking skills

This section presents the findings of the second interview with seven (7) postgraduates in the University of Malaya due to reaching to the saturation point (Corbin & Strauss, 2014). Before starting the interview, their critical thinking skills was examined based on the WGCTA-UK edition to be sure about their score in critical thinking. The results of the WGTCA-UK edition revealed that they can be known as good critical thinkers with more that 60% correct answers (Watson & Glaser, 2002; Watson & Glaser, 2012a). These postgraduates answered the survey questionnaires voluntarily. The data from the study, will be treated in a way that assures the privacy and confidentiality of the participants. In order to preserve their anonymity, their names have been substituted with pseudonyms.

Each interview lasted fifteen to twenty minutes. The interviews were conducted in the research center of the University of Malaya. The interviews consisted of five (5) open-ended questions, organized into a structured questionnaire. Interview notes were manually taken and transcribed. The extended field notes were then verified by the postgraduates in the process of "member checking" to facilitate credibility of responses. All errors, inaccuracies and omissions in the transcripts were corrected.

4.3.2.1 **Influenced factors on critical thinking practices**

Analyzing the responses to the interview questions clarified several factors, which influence on critical thinking practices of postgraduates, such as environment, mood and personality traits, as well as different involvements including various tasks from their supervisors. These factors were taken from some keywords, such as *pressure from supervisors, limited time, a huge number of tasks, mood, mental situation, environment, weather,* and *seat.*

Knowing the influenced factors can directly or indirectly be helpful for instructors to provide opportunities in cultivating critical thinking. Moreover, it is good for designing and developing a learning system with more proficiencies and less deficiencies. Therefore, finding the influenced factors are integrated with determining user's requirements which results in development of the LeCTIS prototype.

Some of respondents mentioned that lecturer's tasks and their focusing on the given topic in a limited time without attention to the way of thinking, such as critical thinking. For example, 5 out of 7 participants emphasizes the **pressure from their supervisors**. Zhina said:

> *"The pressure from supervisors prevent them to concentrate and think well"*
>
> (Zhina, interview, May 2015).

Aria indicated that:

"I like to have enough time to work on the topic that I am interested in because I am able to look at it differently from multiple sides, but, my supervisor pushes me to do the things that he feels better" (Aria, interview, May 2015).

Similarly, Lena indicated that:

*"Limited time and my supervisor's pressure make me follow him without thinking because I feel he knows better than me, although I like to be independent in doing something" (*Lena, interview, May 2015).

Spin told that:

I am a Ph.D. student, it means that I need to think freely and I like to report my findings to my supervisor, but she makes me to do what she asks and she emphasizes on the time limitation during Ph.D. journey" (Spin, interview, May 2015).

Mana in the same tone as Zhina indicated that:

"A huge number of tasks from supervisors, which are irrelevant to main topic disturbed me. As a result, it doesn't allow me to think critically" (Mana, interview, May 2015).

6 out of 7 respondents indicated **mood and personality traits** are the most important factors, which play an important role to think critically or be a barrier to avoid thinking critically. Pary said that:

"If I was not in a good mood, I cannot think, analyze, and do research" (Pary, interview, May 2015).

Similarly, Lena said that:

"My mood is very important because if I was in a good mood and good mental situation, I can think well" (Lena, interview, May 2015).

Joe also told that:

"Everything is dependent on the mood, then, if I feel well, I can do anything. Therefore, I try not to think about anything if I am not good" (Joe, interview, May 2015).

Spin and Pary also added another factor such as **environment and place**. For instance, Spin said that:

"I think the environment, weather, and seat can influence on my thought" (Spin, interview, May 2015).

Pary also indicated that:

When I want to do a simple thing, I consider all details around me. It shows that, I cannot think and make decision in an improper situation or environment" (Pary, interview, May 2015).

In addition to the factors, which influenced critical thinking among postgraduates as they mentioned, there are four barriers in different viewpoints that often prevent individuals from thinking critically, consisting of: (1) Lack of training: teachers are not trained in critical thinking methodology (Broadbear, 2012), (2) Lack of information: few instructional materials provide critical thinking resources (Scriven & Paul, 2007), (3) Preconception: both teachers and students have preconceptions about the content that prevent them to think critically about the material. Preconception is a type of personal bias, which avoid students and teachers in critical thinking because it eliminates analytical skills, such as fair-mindedness, open-mindedness, and inquisitiveness about a topic (Kang & Howren, 2004), and (4) Time-constraints: time constraints are barriers to integrating critical thinking skills in the classroom. Instructors often have some difficulties towards content to cover in a short time period. For example, teachers focus on the content more than the student learning, simple ways, such as lectures and objective tests become a routine method in classrooms. Although the researchers insist on the project-based

learning and the subjective assessments, teachers use lecturing and objective assessments (Broadbear, 2012; Brodie & Irving, 2007).

4.3.2.2 **User's requirements for critical thinking learning system**

To understand the necessary requirements of respondents about the system for cultivating critical thinking, postgraduates answered the question "What are the users' requirements to design and develop a system for cultivating critical thinking?" In response to this question, postgraduates indicated several requirements, including the security of the system in protecting their data, a comprehensive registration process by asking different questions related to their interests and characteristics, providing useful links for users with different knowledge and English level, considering the user's time as well as various materials for learning processes, and creating an evaluation part to be aware of their progress, such as pre-test and post-test. These requirements were extracted by using some keywords in transcribed interviews, such as *high security, own ID and password, differentiate, new user, known user, administer, sure about their private data, complex registration procedures, categorize, different questions, education, field, language, favorites, topic, degree, subject, useful links, useful dictionaries, encyclopedias, meaning, definitions, take too much time, long procedures, useless, user's situations, duration of each part of the system, considering the time, simple and interesting topics, user's needs and favorites, user's requirements, user's knowledge, accessible materials, films, games, pdfs, learning materials, interactive features, different tasks, test users before taking learning processes, to know my score before learning, positive impact, different warning messages, evaluate, obtained score, passing test,* and *progress.*

All respondents believed in protecting their private data against probable manipulation, deletion, and addition. Indeed, the postgraduates focused on the **security** of the developed system. Aria said:

"I prefer to work with the system with the high security to avoid manipulation or delete my identification. Therefore, if you want to design a system, each user should have their own ID and password and the administrator should differentiate from the new user or the known user" (Aria, interview, May 2015).

Similarly, Joe said:

"The system I'm working has the capability to approve my ID and password by email service. I think it makes users be sure about their private data" (Joe, interview, May 2015).

3 out of 7 respondents indicated their opinions on the classified procedures for registering users. Practically, they talked about the **registration function** by asking some questions about their field, degree, gender, and age.

Lena mentioned that:

"A system should provide a secure environment for users who want to enter the data and work with it. Therefore, I like complex registration procedures with different questions and categorize each user based on their education, field, language, or their favorites" (Lena, interview, May 2015).

Pary said:

"If I want to use a system, I like the system ask me about my major, education level, and which topic I like to work. Then, I enter the system, because I think this system respects my knowledge and knows my favorite, therefore, my mistakes may be decreased" (Pary, interview, May 2015).

Zhina as one of the respondents indicated that:

"The system should have facilities for users to choose their education, degree, and the subject, which they like. I feel better to work with this system rather than the other systems without care about the users" (Zhina, interview, May 2015).

4 out of 7 respondents focused on the English language and they told that the systems should consider all users with different English knowledge. Therefore, they tend to work with the system with **useful links**, such as wikies, dictionaries, and some papers to define the required terms. Mana told that:

> *"When I want to work with a system with specific topics, I prefer to know something about it. Particularly, I like to have any facilities, such as useful links, some useful dictionaries, or encyclopedias to know their meanings and the definitions"* (Mana, interview, May 2015).

Spin also expressed that:

> *"English language is my common problem and I suffer from it, especially when I need to use specific tools. Therefore, I like to have helpful things without wasting time to search"* (Spin, interview, May 2015).

Aria also told that:

> *"Because I'm not Englishman, I have many problems to understand specific things. Now you can imagine that I want to work with the specific system. Therefore, I have to access to good dictionaries or use some hints or links to know more about the given topic in the system"* (Aria, interview, May 2015).

Mana also believed that:

> *"Overcoming on English problem is very necessary for me by using some help from dictionaries or useful links"* (Mana, interview, May 2015).

All of the respondents agreed with the time issue of systems. They mentioned that the system should consider our time and avoid frustrating. The system should be able to manage the **user's time** by providing simple tasks in small parts.

Spin said:

"Sometimes I have to work with different systems to learn something but because they take too much time, I cancel it or I may finish working with it without positive outcome" (Spin. Interview, May 2015).

Pary also told that:

"The system with the long procedures is useless and I think it's better to consider the user's situations such as their mood, their time, and their extra activities" (Pary, interview, May 2015).

Joe also thought that:

"System designers should mention the duration of each part of system as well as considering the time. If it takes a long time to become familiar with the system as well as passing related procedures, nobody likes to work with it" (Joe, interview, May 2015).

Mana said that:

"Some systems take too much times to work, but if the system uses some simple and interesting topics, it is easy to work" (Mana, interview, May 2015).

Lena also indicated that:

"The system should consider the users' needs and favorites based on their major, degree, or background knowledge" (Lena, interview, May 2015).

5 out of 7 respondents indicated that the systems should provide simple useful materials to teach new things. To clarify, the systems should have **various learning processes** to reach their goals. Indeed, users emphasized on the learning function in different and interesting parts regarding to the user's needs and favorites.

Aria mentioned that:

"If the system wants to teach a new thing, I think the developers need to consider the users' requirements before starting to develop the system. I think

users can help developers better than several research manuscripts" (Aria, interview, May 20150).

Mana believed that:

"By considering users' knowledge about the given topic, I think the system is able to work and the outcome of the system can be positive" (Mana, interview, May 2015).

Joe told that:

"The system should have accessible materials for learning. In addition, the system should use some simple topics and present them in an interesting way such as, films, games, or pdfs to avoid tiredness" (Joe, interview, May 2015).

Spin also believed that:

"I like to work with a system with some learning materials to teach me and different tasks to ask relevant questions. I think this system has an interactive feature without needing of instructor (Spin, interview, May 2015).

6 out of 7 respondents mentioned that the learning systems should be able to test the users before working with the system and after it to find the progress of users. **Pre-test** and **post-test functions** are very important for users, because they make users aware of their progress or any changes. The users are able to see and compare their results before and after learning processes.

Joe talked about the pre-test and he said that:

"The system should test users before taking learning processes" (Joe, interview, May 2015).

Aria also agreed with Joe and mentioned that:

"I like to know my score before learning, because it is amazing for me to know my knowledge about the given topic or something else, which it depends on the type of the system" (Aria, interview, May 2015).

Lena said that:

> *"A system should prepare some tests to show the positive impact of the system. Also, I think the system should have different warning messages to inform the users' progress or mistakes"* (Lena, interview, May 2015).

Pary also indicated that:

"The administrator should put some simple tests to evaluate the users and categorize them based on their obtained scores to continue their work" (Pary, interview, May 2015).

Spin also agreed with Pary and Lena. He told that:

> *"Although passing test is stressed out and boring for me, I think it is necessary to know our progress and score"* (Spin, interview, May 2015).

Similarly, Mana said that:

> *"I think it is important for instructors and students even for administrator of the system to know how a learning system affect the users' ability. I mean, knowing scores before and after learning is an applicable function of the system*" (Mana, interview, May 2015).

According to the user's interviews, we found there are some functional and non-functional requirements for the system. For instance, all systems should be secured and attempt to provide high security in different modules of systems to avoid manipulation of the user's data. Security is integrated in the registration module of the system as users indicated. Also, the system has a complex registration module based on the user's interviews. In designing and development of the system, some useful links, including papers and websites with simple and interesting definitions and information about the topics are given in order to make users familiar with the aim of the system and whatever a user like to know. Users emphasized on the learning process as well as user's time. Therefore, in this system, a very user-friendly learning system by considering user's knowledge and needs using some films is provided. Moreover, some users indicated some

points about testing them before and after learning processes to know the impact of the system on their knowledge as well as the functionality of the system in system designer's view. As a result, the pre-test, and post-test module are prepared in this system and at the end the users and the administrator are able to see their scores and their progress during the learning processes by using evaluation and result modules.

Although this study focuses on a very small number of postgraduates, a very interesting theme emerged. These are the main themes extracted from the analysis of this interview:

a) Influenced factors on critical thinking practices

b) User's requirements for critical thinking learning system

4.4 Foundation of system design

The results of the second section of the survey and the first interview revealed that there are several associations between critical thinking skills and the information seeking processes. Participants indicated that they used different critical thinking skills while they were seeking for information. For example, participants used "interpretation" and "inference" in the first step of the information seeking process model, which is called "initiation". In "selection" step, participants preferred to use "recognition of assumptions", "interpretation", and "evaluation of arguments". In "exploration" as the third step of the information seeking process model, the most applicable critical thinking skills are "interpretation", "inference", and "recognition of assumptions". Participants mentioned that they used "inference" and "recognition of assumptions" in "formulation" step as the fourth step of the information seeking process model. When participants wanted to collect their information in the fifth step of the information seeking process, they used "deduction" and "evaluation of arguments" skills. Finally, participants used their "deduction" and "evaluation of arguments" to draw conclusions and present their outcome of seeking for information. In addition, the findings of the second interview

revealed the influenced factors on critical thinking as well as the findings of the first interview, which shows the influenced factors during seeking for information. As a result, Figure 4-2 is designed on the basis of the above findings.

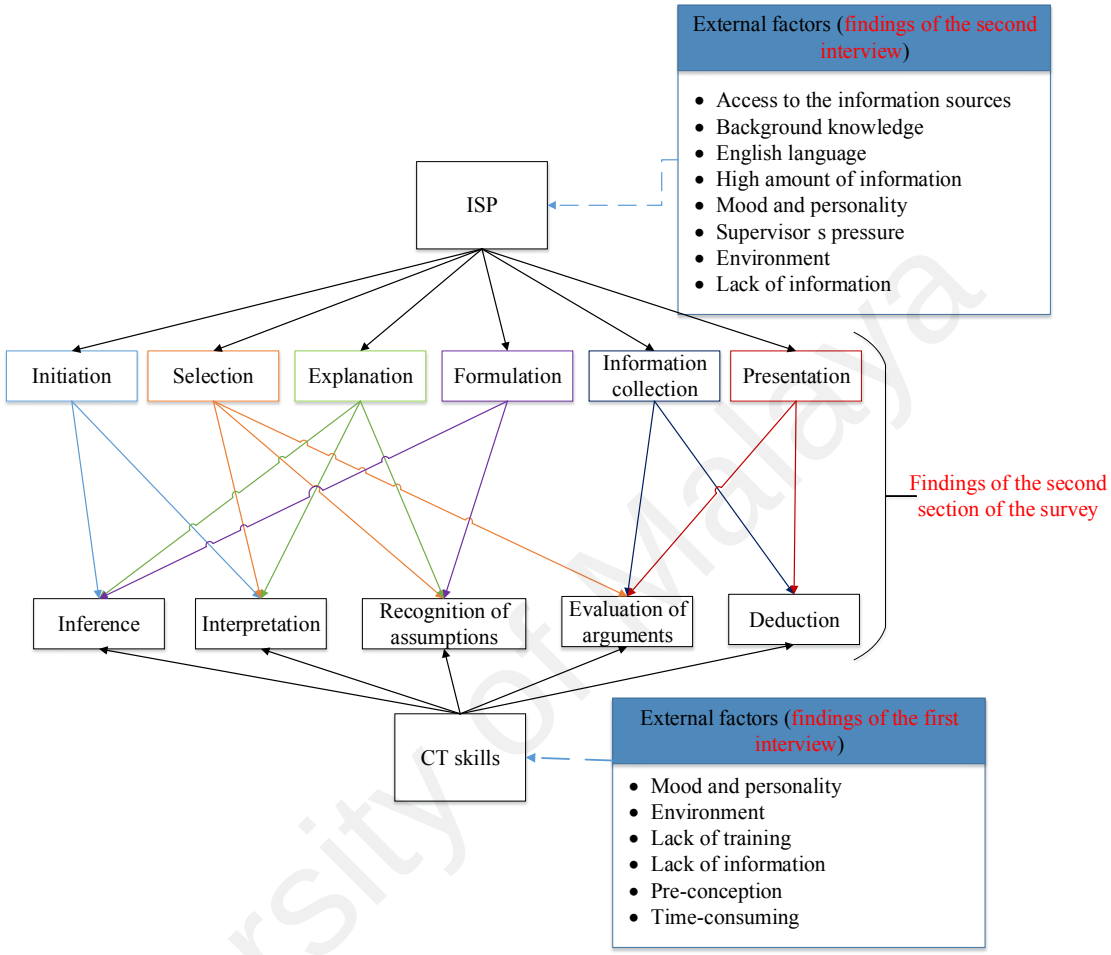

Figure 4-2: Foundation of the system design

4.5 Summary

This chapter discusses results of the survey in two sections and 3 interviews. The first section of the survey revealed the level of critical thinking among postgraduates in the University of Malaya as well as their strong and weak points in each critical thinking skills. The second section of the survey was to investigate the relationship between critical thinking skills and information seeking processes.

The finding of the first interview showed that how postgraduates think critically while seeking for information. Furthermore, the second interview was designed to take deeper

information about the influenced factors on critical thinking skills and determining user's requirements for critical thinking learning system. According to these findings, a diagram was illustrated as the foundation of the development of the LeCTIS prototype in chapter five.

Chapter five presents the development of the LeCTIS prototype for cultivating critical thinking and its evaluation.

CHAPTER 5: **DEVELOPMENT OF LECTIS PROTOTYPE**

5.1 Introduction

This chapter aims to (a) determine the user requirements from the collected data in the first interview and the first survey, (b) present the system development of the identified requirements, (c) report on the usability and functionality of the developed tool, and (d) explain the system evaluation and the related results. Research questions 4 is addressed in this chapter.

5.2 Determining user requirements

In order to develop the LeCTIS, knowing the user requirements is essential. Therefore, considering related works in the literature and conducting interview are the main steps. Study of the samples on training system in cultivating critical thinking skills (Duron et al., 2006; Fischer, Spiker, Harris, et al., 2008) illustrated essential functional requirements such as, the enrollment module, the training module with different type of tasks, and the assessment module including, pre-test, post-test, and evaluation modules.

Furthermore, seven (7) postgraduates participated in the interview related to their thoughts and needs in developing the LeCTIS. The users' requirements were extracted from the second interview, which was about the critical thinking skills among postgraduates and their opinions about the influenced factors on critical thinking skills. The participants indicated several functional and non-functional requirements, which they think a training system should have. For example, the participants talked about the registration module with different options on the basis of different users with different characteristics. Furthermore, the participants discussed about the useful links for further information about the topics, idioms, expressions, and vocabularies. In addition, the participants prefer to use systems with learning modules by considering user's times as well as their weak points and strong points, which were revealed in the pre-test module. Therefore, the participants emphasized on the evaluation part in the system to see their

progress after doing some tasks and passing post-test. Table 5-1 is an overview on the user requirements, which were extracted from the first interview.

Table 5-1: User requirements extracted from the first interview

No	Extracted from interview transcripts	Prototype (LeCTIS) modules	Proposed users' requirements
1	Students needed the system to provide specific ID based on their favorites and characteristics (Verbal statement, such as *"each user should have their own ID and password and the administrator should differ from the new user or the known user"* Aria, interview, May 2015)*;* "*I like a complex registration procedure with different questions and categorize each user based on their education, field, language, or their favorites"* (Lena, interview, May 2015); *"If I want to use a system, I like to be asked me about my major, education level, and which topic I like to work. Then, I enter the system, because I think this system respects my knowledge and knows my favorite, therefore, my mistakes may be decreased"* (Pary, interview, May 2015).	Registration	The system should provide unique IDs based on the user's characteristics, such as age, gender, field, and education level.
2	Students liked to have definitions of idioms, expressions, or vocabularies (Verbal statements, such as "*When I want to work with a system with specific topics, I prefer to know something about it. Particularly, I like to have any facilities such as useful links or some useful dictionaries or encyclopedias to know their meanings and the definitions"* Mana, interview, May 2015);	Introduction	The system should provide any facilities to familiar with strange idioms, expressions, or vocabularies that are difficult for users.

No	Extracted from interview transcripts	Prototype (LeCTIS) modules	Proposed users' requirements
	"English language is his common problem and he suffers from it especially when he needs to use specific tools. Therefore, I like to have useful things to help without wasting time to search" (Spin, interview, May 2015); *"Overcoming on English problem is very necessary for me by using some help from dictionaries or useful links"* (Mana, interview, May 2015).		
3	Students preferred to work with the system in a short time (Verbal statements, such as *"some systems take too much times to work, but if the system use some simple and interesting topics, it is easy to work"* Mana, interview, May 2015); *"Sometimes I have to work with different systems to learn something but because they take too much time, I cancel it or I may finish working with it without positive outcome"* (Spin. Interview, May 2015); *"System designers should mention the duration of each part of system as well as considering the time. If it takes a long time to become familiar with the system as well as passing related procedures, nobody likes to work with it"* (Joe, interview, May 2015).	Learning module is divided into 3 short videos.	The system should consider the users' times specially for learning parts.
4	Students wanted to know their scores in each step (Verbal statements, such as *"a system should prepare some tests to show the positive impact of the system. Also, I think the system should have different warning messages to inform the users' progress or mistakes"* Lena, interview, May 2015);	Evaluation results and warning message that show who is able to go to the next step.	The system should consider scores in task and pre-test modules to allow users to continue.

No	Extracted from interview transcripts	Prototype (LeCTIS) modules	Proposed users' requirements
	"The administrator should put some simple tests to evaluate the users and categorize them based on their obtained scores to continue their work" (Pary, interview, May 2015).		
5	Students liked to work with the system based on their knowledge (Verbal statement, such as *"by considering users' knowledge about the given topic, I think the system is able to work and the outcome of the system can be positive"* Mana, interview, May 2015); *"If the system wants to teach a new thing, I think the developers need to consider the users' requirements before starting to develop the system. I think users can help developers better than several research manuscripts"* (Aria, interview, May 20150).	Task	The system should propose various topics to teach and test according to the user's knowledge and fields.
6	Students thought that the interactive system is more useful (Verbal statement, such as *"the system should have accessible materials for learning. In addition, the system should use some simple topics and present them in an interesting way such as, films, games, or pdfs to avoid tiredness"* Joe, interview, May 2015); *"I like to work with a system with some learning materials to teach me and different tasks to ask relevant questions. I think this system has an interactive feature without needing of instructor"* (Spin, interview, May 2015).	Task	The system should provide an interaction between learning materials and the users.
7	Students required to know their situation before receiving instructions (Verbal statement, such as *"the administrator should put some*	Pre-test	The system should test the users' critical thinking ability

No	Extracted from interview transcripts	Prototype (LeCTIS) modules	Proposed users' requirements
	simple tests to evaluate the users and categorize them based on their obtained scores to continue their work" Pary, interview, May 2015); *"The system should test users before taking learning processes"* (Joe, interview, May 2015); *"I like to know my score before learning, because it is amazing for me to know my knowledge about the given topic or something else, which it depends on the type of the system"* (Aria, interview, May 2015).		
8	Students liked to know their progress after passing learning section (Verbal statement, such as *"although passing test is stressed out and boring for me, I think it is necessary to know our progress and score"* Spin, interview, May 2015). *"A system should prepare some tests to show the positive impact of the system"* (Lena, interview, May 2015); *"I think it is important for instructors and students even for administrator of the system to know how a learning system affect the users' ability. I mean, knowing scores before and after learning is an applicable function of the system*" (Mana, interview, May 2015).	Post-test	The system should show any differences in critical thinking skills if it is happened.

According to the users' requirements, the main modules of the LeCTIS prototype are as follows: registration, which is provided for users to input their data and login to the system; introduction, which contains useful links for different users based on their characteristics and interests as well as some information about the nature of critical

thinking and information seeking processes; learning module with three (3) short films by considering user's time and involvements aiming at attracting the user's attention; evaluation module and its warning message to show who got acceptable score and continue or not; task module, which is prepared based on the background knowledge of users with different topics as well as an interaction between users and systems; pre-test and post-test modules, which they aimed at finding the level of critical thinking of users before learning processes and after learning and also to find the usability of the LeCTIS prototype.

5.3 The Development of the system functionality

The association between critical thinking skills and information seeking processes that was originated from the survey and interview and the user requirements as well as the considering the features of the sample models are the main foundations of the development of the system. The approach used in the development was the prototype approach, which allows gradually building of the system, and in conjunction/parallel with the model building phase. This prototype (LeCTIS) was designed to cultivate critical thinking among postgraduates through information seeking process. This section discusses the development platform and the development of the proposal system functionality.

5.3.1 Development platform

The system has been developed on the Microsoft Windows Platform, by using Visual Studio 2014 (C#) and SQL Server 2014. The core modules of the LeCTIS take several phases to develop and implement. They include registration, pre-test, learning, task, evaluation, and post-test.

The LeCTIS prototype has two (2) user access levels: system administrator and students as users. (1) The system administrator's level is delegated to the person who is responsible for managing the whole system, and monitoring the users' activities. The

system administrator can also manage the users' access control, if a user forgot his/her password, the new password will be sent to him/her since he/she requests. Moreover, the system administrator can take a report to find out the usability of the LeCTIS and update learning methods to teach critical thinking to the users. (2) User who voluntarily participates in this study and is only able to accomplish the pretest, task, evaluation, and posttest phases. Figure 5-1 illustrates the system decomposition and its details. The details of each module is explained in the relevant sections.

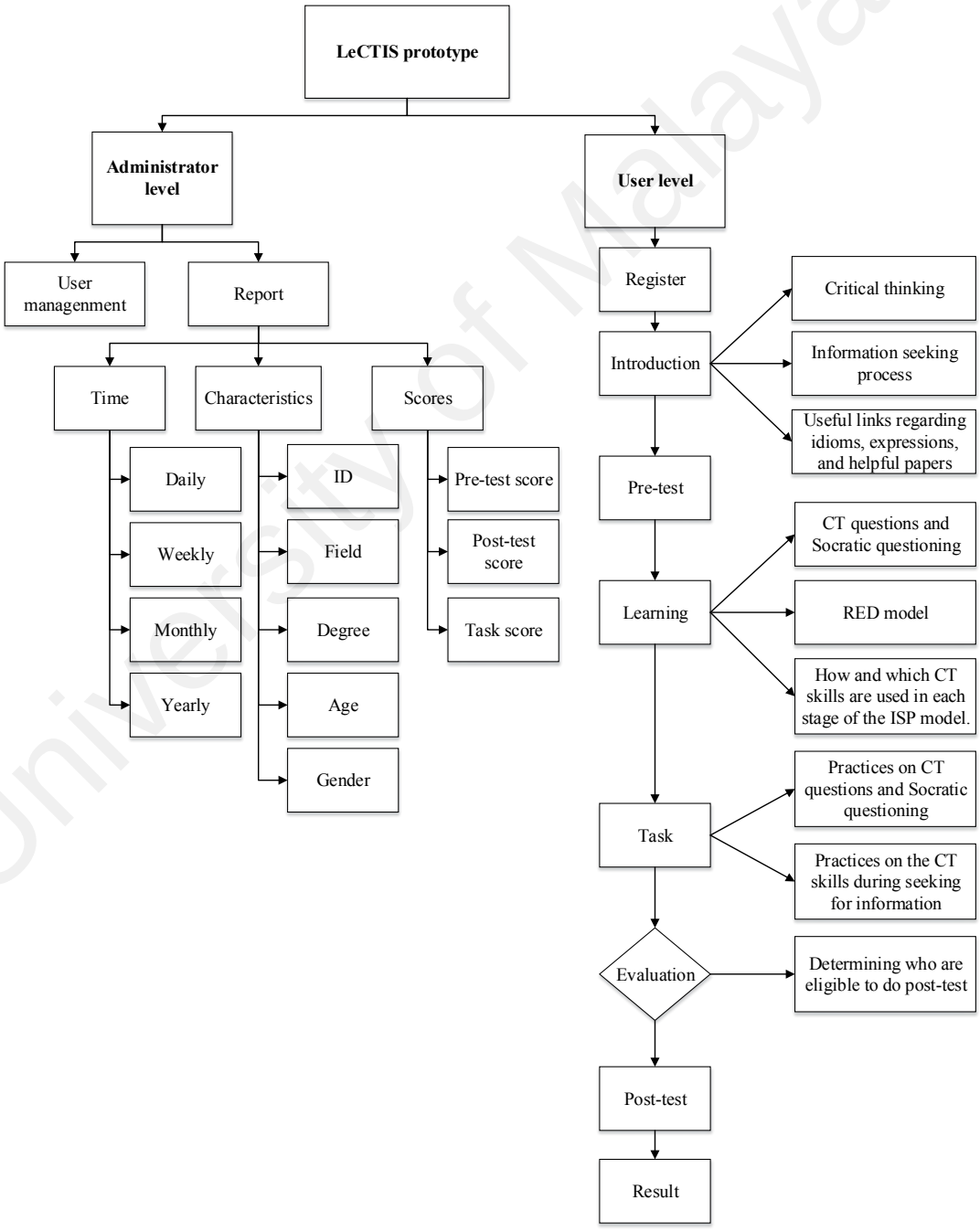

Figure 5-1: System decomposition

5.3.2 System interface design

The homepage of the system consists of the title bar, and pane task. In the title bar, the name of the system is displayed. In the task pane, several items are shown. The active items of the task pane are highlighted in bold.

5.3.3 System features

This section presents the features that the system performs under task pane. The modules supported by the system are: registration, pre-test, learning, task, evaluation, and post-test.

5.3.3.1 Registration module

Registration is the first module of the developed system, which allows a new user to register and enter into the system for participating in this study by answering the questions and performing the tasks, respectively. In other words, to log in to the system for the first time, the user requires to register in the system as a new user by filling up some personal information, including name, age, gender, major, username, password, login, and exit, in the registration windows. Indeed, to develop this module, user's requirements were considered to have a complex registration processes and recoding the user's information to provide different tasks and questions based on their requirements. The registration module permits the system to store the characteristics of a new user for further evaluations. After that, the user can log in to the system by entering his/her username and password in the log in windows.

5.3.3.2 Introduction module

The introduction module of the system presents an outline of critical thinking and information seeking processes for the users in two tabs. This section is optional for users who like to be familiar more to: (1) the nature of critical thinking and its components, including critical thinking skills and critical thinking dispositions, and (2) the information seeking process, which involves some sort of definitions of information seeking as well

as useful resources to get more information for users are provided. In each tab, a few useful links are provided for users who like to have extra information about critical thinking and information seeking process. These links were designed based on the requirements of users who worried about their English languages and background knowledge. In practice, these links were prepared to get more information and definitions on idioms, expressions, and topics. In the first interview, some users talked about their popular information sources, such as Google, Wikipedia, and google scholar. These links were taken from these information sources. After reading the introduction, the user has to return to the homepage by pressing the "Home" button located in the right down of introduction page for performing the pre-test.

5.3.3.3 **Pre-test module**

The pretest module is designed to discover the level of critical thinking of the users and identify their weaknesses and strengths in critical thinking on the basis of the WGCTA-UK edition (Watson & Glaser, 2002). The pretest module consists of five tabs based on the critical thinking model (inference, recognition of assumptions, interpretation, deduction, and evaluation). Each tab includes a short scenario along with some multi-choice questions, which the users have to reply to all of them, respectively. The main reason of this module is knowing the strength and weaknesses of the user in each skill as the users indicated in the interview as a functional requirement. The users mentioned that it is better to design a pre-test module to test user's critical thinking before starting learning process. Actually, this module encourages users to progress and helps instructors to know the level of critical thinking of users. The user can also move between the tabs by clicking on the tab bar or by using the "Forward" and "Backward" buttons in the right down of the pretest window. To avoid missing some questions or pages in the pretest module, the progress bar is used for showing that the pretest is going on or finished. Users can be sure about their answers by going back or forward to check their

responses or change them. When the pre-test is done and the user answered all questions, the user has to press the "Save" key to finalize the pretest and store the result in the database. Finally, the user can return to the home page by pressing the "Home" button and enter to the learning section. Figure 5-2 displays the pretest of the proposed system.

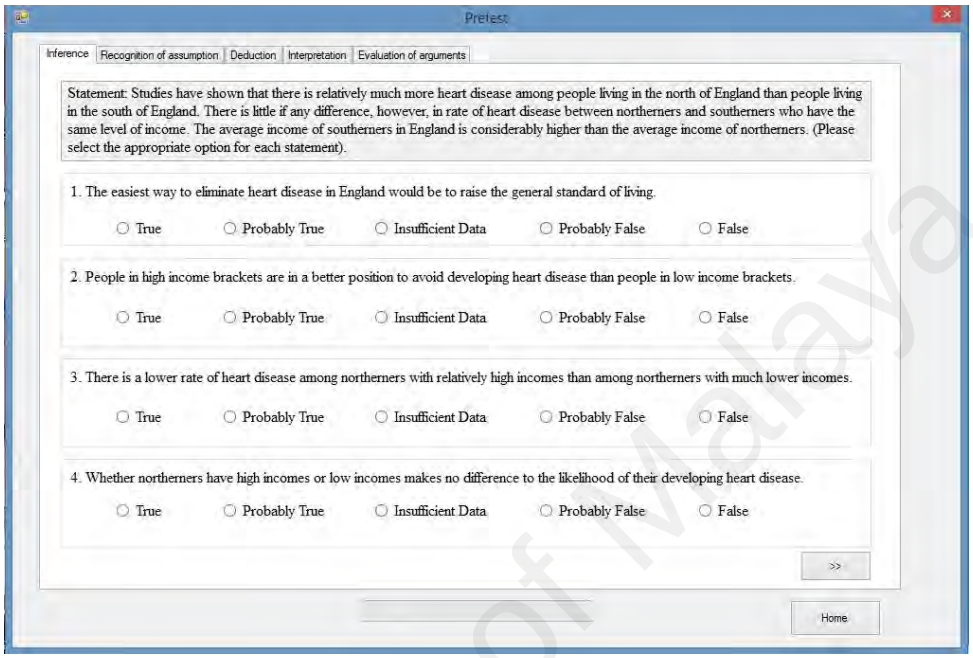

Figure 5-2: Pretest module in the proposed system

5.3.3.4 Learning module

Learning section is one of the most important sections of this system, which shows the relationship between critical thinking skills and information seeking processes based on the results of analysis of findings in the second survey (see Section 4.2.3) and the interview (see Section 4.3.1). This module aims at teaching the user on what the critical thinking is and what the ISP is. Also, the user finds the nature of critical thinking questions and he/she is able to differentiate between the deep and surficial questions. Moreover, the user is aware of the critical thinking skills, which are used in each stage of the ISP model. The learning section includes three movies about critical thinking and using critical thinking during the information seeking process, which justifies our findings in Chapter 4. These three separated movies are made by the Prezi software last 25

minutes. During playing the movies, the users can press the stop, zoom, forward, or backward buttons to be sure about whatever they want to know and take notes if it is necessary. The time of these movies is compatible with user's requirements in which they prefer to work with the system that consider the user's time. Therefore, the learning module is divided into three movies by considering the simplicity of the topics and attractiveness of the movies in a short time.

The first movie is about critical thinking questions that are taken from the Socratic questioning method to teach users. This type of questions helps students to get deeper information in different contexts, such as oral discussion, doing assignments or projects individually, and writing a paper about novel topics. This movie lasts 11 minutes and 47 seconds (Figure 5-3).

The second movie is prepared based on the RED model and its components (Watson & Glaser, 2012a). It includes simple and comprehensive definitions of critical thinking skills that users should know to answer the post-test questions as well as several examples for each critical thinking skill. It lasts about 3 minutes.

The third movie is prepared based on the foundation of system design, which was proposed in Section4.4. Actually, this movie shows how critical thinking skills are used in each step of the information seeking process (ISP) model. The movie shows six stages of the ISP model (Kuhlthau, 1991) and the relevant critical thinking skills within each step. This movie lasts about 10 minutes and 13 seconds.

It is important to mention that whenever users decide that they are ready to go to the task, they can stop watching movies and press "Home" button to return to the home page for accomplishing the task module.

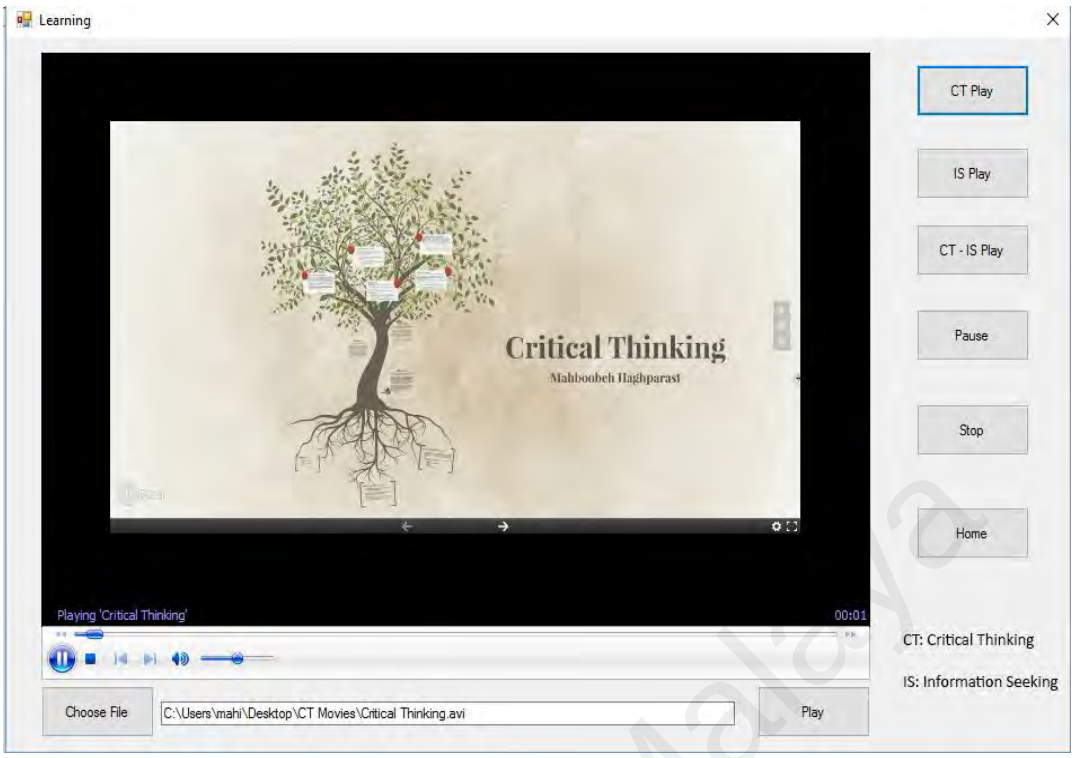

Figure 5-3: Learning process

5.3.3.5 **Task module**

The purpose of the task module is to know how the user learn about the critical thinking questions and how it is applicable if the user wants to write a paper. Therefore, task module is provided in two parts. To design the questions of task module, Socratic questioning and the ISP model were the main patterns. Therefore, the questions in the task module can be changed based on user's favorite and background in both sections. Firstly, six (6) questions were designed on the basis of the information seeking process (ISP) model (Kuhlthau, 1991). To clarify, the user should answer 18 questions, which is divided in 6 stages of the ISP model. The user needs to learn the type of questions and select the critical questions that lead the user to get more information. The questions were designed based on the Socratic questions technique proposed by Paul and Elder (2007). The respondents need to determine, which questions are helpful and which of the questions can be critical thinking questions. The users should answer the questions based

on their outcome from learning section. To show what is Socratic questioning, we can bring a few examples and their related explanations as follows:

If someone participate in a discussion about something, to understand it deeply, she/he tries to ask some questions like “why do you say that?” or “how does this relate to our discussion?” Paul and Elder (2007). Based on existing templates, the task module also used the Socratic Questioning method by providing various questions about given scenarios, such as “suppose that you participate in a discussion about endangered species such as Asian tiger, African elephant, and Iranian cheetah. Which question do you ask to grab more information about it?” then we provided four questions and the user should select one of them as a good and critical question. The questions are: what is Asian tiger? / why should we be worried about endangered species? / why do you say that there are at risk? / and what are the other endangered species? The user should pass the learning module, including types of questions to know which question is better to grab more information. If the user selects “why do you say that there are at risk?” option, it shows that the user can recognize types of questions in this part. In practice, the task module tries to help students in recognizing different kinds of questions as well as interaction between users and the systems in the second part of the task module.

They can select each question by its appropriate tab at the top of the task page or using the forward/backward buttons at the bottom of the page. Before saving the responses, the users have enough time to review them and be sure about their responses. Figure 5-4 shows the first part of the task module.

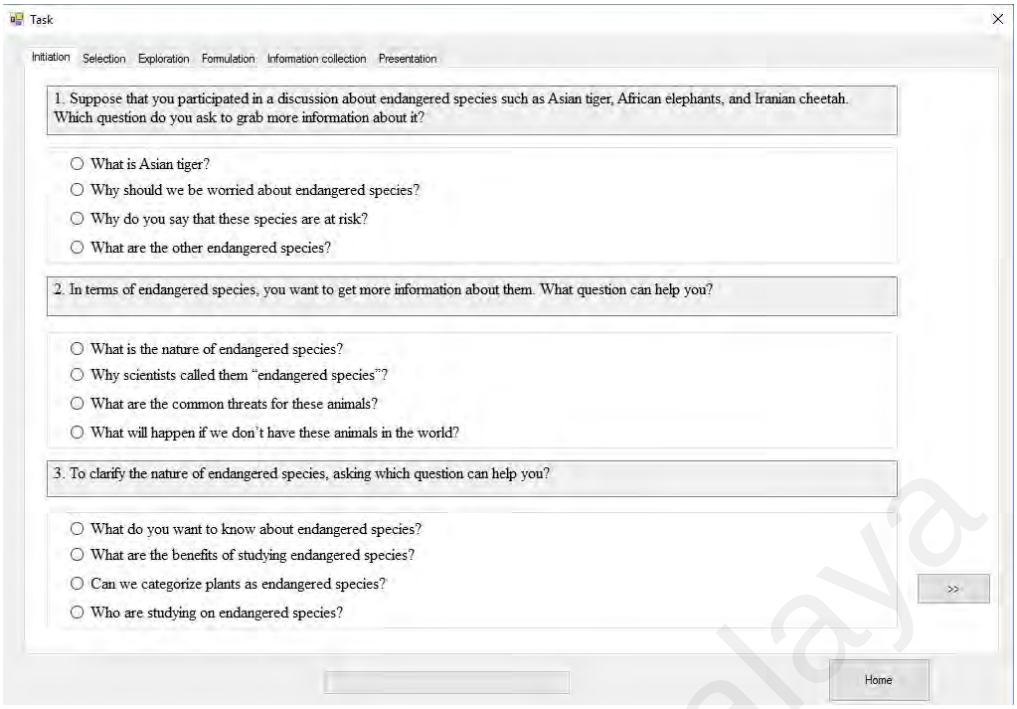

Figure 5-4: Task module (first part)

The second part of the task module explains how a researcher has to seek for information and present the outcome in a paper format. Therefore, the processes of seeking for information are described thoroughly. To have an interaction between system and the user, some questions are also provided to examine the findings of the users (Figure 5-5). The second part of the task module is an interactive part of the task module, which users watch movie on the stages of the seeking for information and doing research. Afterwards, the user needs to answer the questions based on whatever he/she learned in the learning module. The questions are good for the user to differentiate each part of a paper.

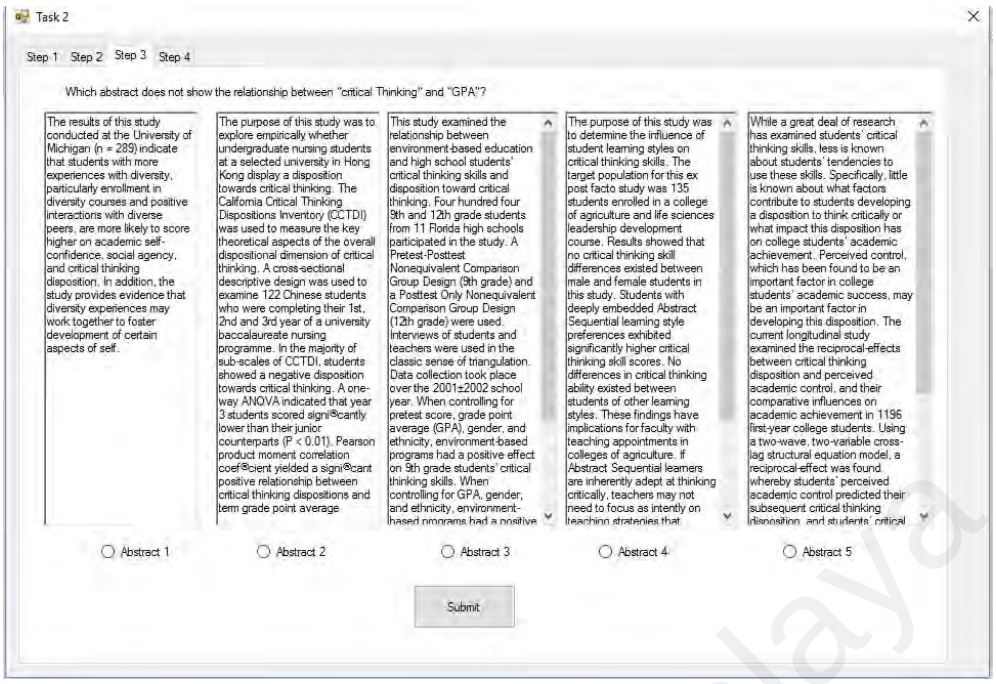

Figure 5-5: Task module (second part)

Task section as same as pretest section has progress bar to show the number of answered questions as well as remaining questions. At the end of the task section, when users feel that they answer all the questions, they have to save their responses and return to the home page by using the "Home" button to go for evaluation section.

5.3.3.6 **Evaluation module**

Evaluation module is a crucial part of this system, which determines who is eligible to go for doing post-test and who is not eligible by using the results of "task" modules, and the preliminary framework as the base of designing the system.

According to the findings of the second survey in Section 4.2.3, users applied different critical thinking skills in each stage of the ISP model. As a result, several questions were provided for each ISP stage based on the applied critical thinking skills. The users have to answer the questions to determine whether they use proper critical thinking skills. If a user is weak in answering the questions in any stage of the ISP model, the user is ineligible to go for the post-test and he/she should return to task module and pass it again. If the

user is able to answer the task questions properly, the user is eligible and he/she can go for performing the post-test.

The evaluation module consists of the following stages:

- Initiation: It indicates the first stage of the ISP model, which is in relation with interpretation and inference skills of the CT. The user is asked to answer a few questions about the mentioned critical thinking skills. 60% of answers should be correct to introduce the user as eligible user to do post-test.
- Selection: It is the second stage of the ISP model, where recognition of assumptions, interpretation, and evaluation of arguments are used. The user should answer questions related to these skills. If the user answer 60% of questions correctly, he/she can go for post-test.
- Exploration: In the third stage of the ISP model, interpretation, inference, and recognition of assumptions are mostly used. The user requires to answer the questions related to the applied critical thinking skills. To be eligible for doing post-test, the user need to answer 60% of questions correctly.
- Formulation: It is the fourth stage of the ISP model, which inference and recognition of assumptions are applicable. There are a few questions on the applied critical thinking skills, that user needs to answer 60% of questions correctly to do post-test as the next step.
- Information collection: In information collection as the fifth stage of the ISP model, deduction and evaluation of arguments are very useful. The user needs to answer a few questions in relation with used critical thinking skills. If the user wants to do post-test, 60% of answers should be correct.
- Presentation: It is the final stage of the ISP model, which deduction and evaluation of arguments are mostly used. Therefore, the user needs to answer a few questions that related to the used critical thinking skills. The user should

answer 60% of the questions correctly if he/she wants to go forward and do post-test.

Figure 5-6 shows the appearance of the evaluation module.

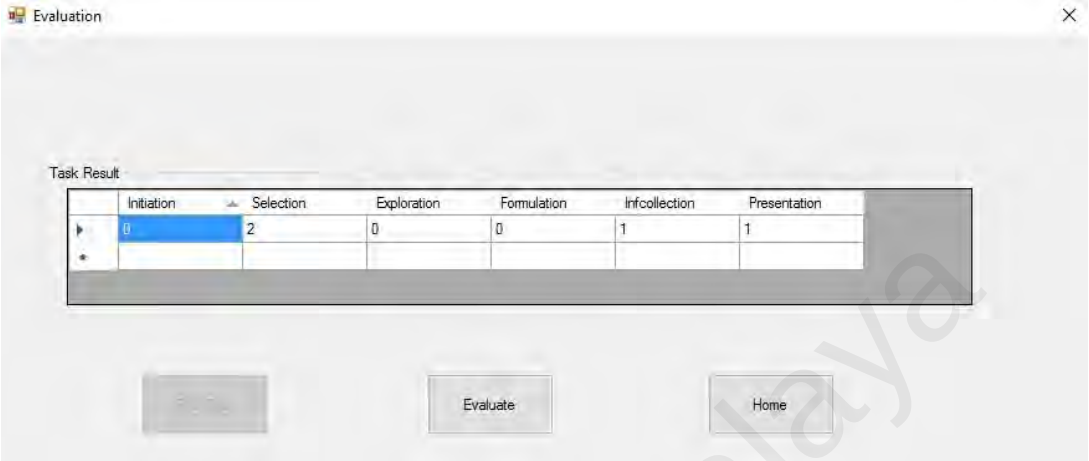

Figure 5-6: Evaluation module

5.3.3.7 Posttest module

Posttest is the final section of the proposed system for the users. This section is similar to the pretest by using WGCTA-UK edition (Watson & Glaser, 2002) to compare the results of pretest and posttest modules. Indeed, this section shows the progression of the users in critical thinking. As a result, this section is a vital part of this system to measure the users' improvement in critical thinking. It shows the role of the training system in cultivating critical thinking, and identify the users' weaknesses and strengths in each skill of critical thinking (Figure 5-7).

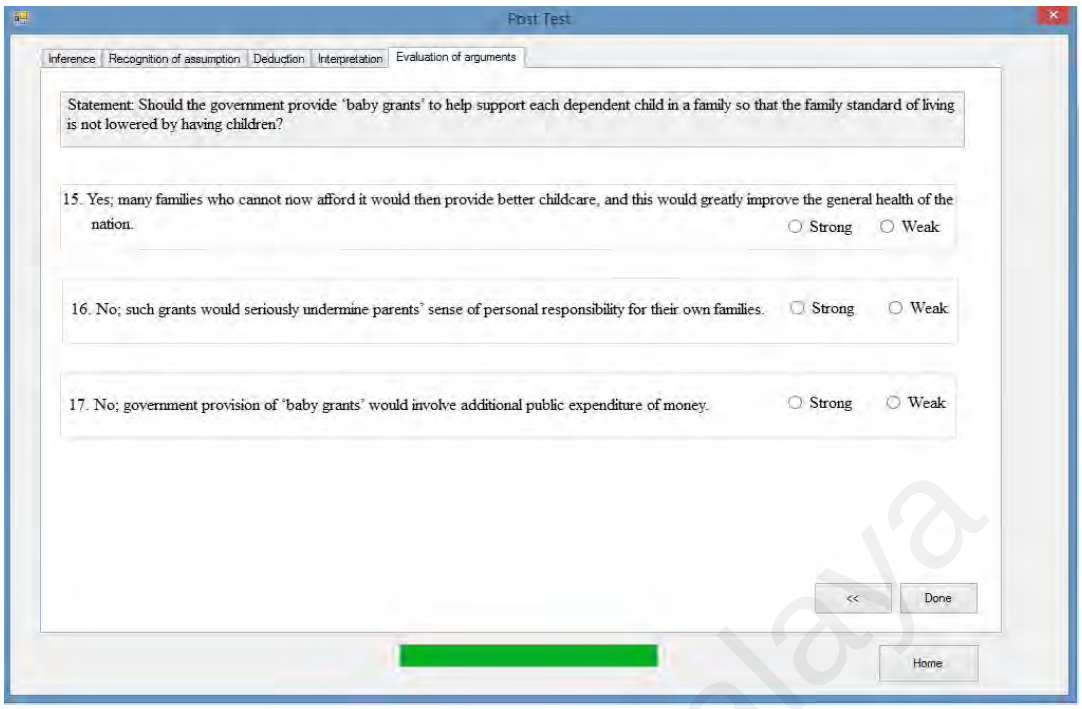

Figure 5-7: Posttest module

5.3.3.8 **Result module**

Whenever respondents want to see their progress in pretest and posttest, they can press the result button. It shows the score of users in each critical thinking skill as well as the total score of the users. As it is explained in the pretest and posttest module, these modules were designed based on the WGCTA-UK edition (Watson & Glaser, 2002) to find how the prototype is usable in improving critical thinking skills. Therefore, the users need to do pre-test to know the level of critical thinking skills. After some learning programs and tasks, the users should do post-test. Each user can get 17 as a total score as well as 4 in inference, 4 in recognition of assumptions, 3 in deduction, 3 in interpretation, and 3 in evaluation of arguments. Figure 5-8 shows how result module works. For example, Figure 5-8 shows the user's inference score in pre-test was 4 and in post-test was 3, which it shows that the inference skill was not improved, while the recognition score in pre-test was 1 and in post-test was 2, the deduction score in pre-test was 1 and in post-test was 2, and interpretation score in pre-test was 3 and in post-test was 4, which demonstrate the positive effect of the system in improvement of them. However, the evaluation score in

pre-test and post was not changed (2). The total score of the user in pre-test was 11 and in post-test was 15, which confirms the usability of the system in improvement of the critical thinking as a whole.

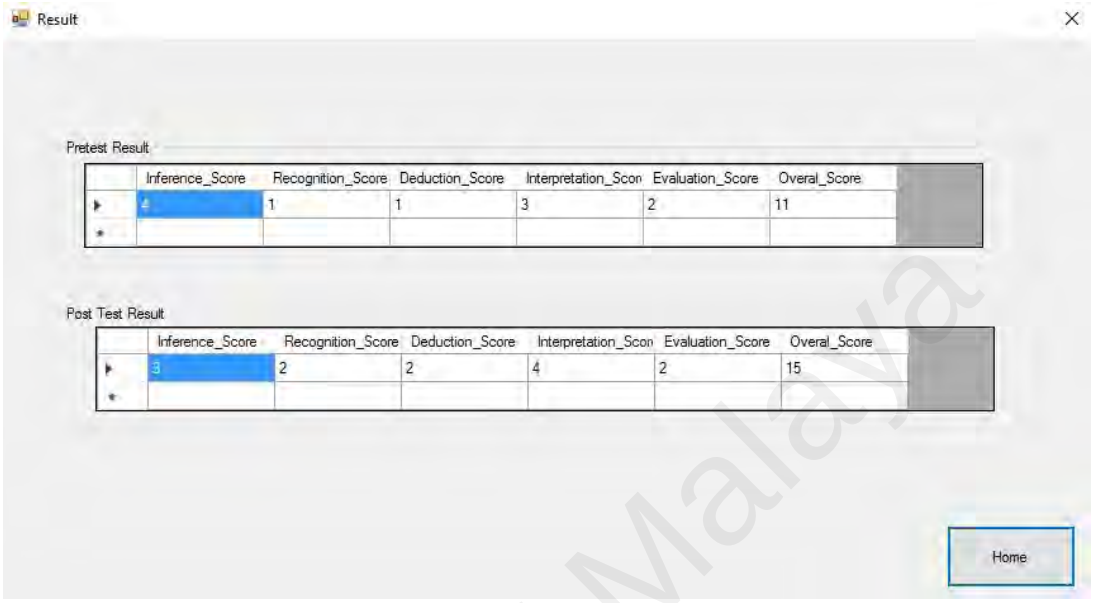

Figure 5-8: Result module

5.3.3.9 **Exit**

After finishing the pretest, task, and posttest modules, the user has to log out from the system by pressing the "Exit" button. When users press the "Exit" button, nobody can access their information except the administrator.

5.3.3.10 **Report module**

The system administrator who is the only person that has access to this option of the proposed system. The administrator can take report based on the students 'ID, their majors, age, degree, and gender as well as their pre-test results, task results, and post-test results individually or all the results together. These reports can be limited in different period of time: daily, weekly, monthly, and annually.

5.3.3.11 **Utilities**

This section is provided based on the user requirements (see Section 5.2). There are five (5) features under utilities: (1) Learning methods: which are applied in the LeCTIS

to cultivate critical thinking. According to the qualified research papers, Socratic questioning is an effective strategy to foster critical thinking skills. In addition, concept mapping is another learning strategy that we applied for weak students in critical thinking. Therefore, the learning module is supported by two different learning strategies to foster critical thinking. Furthermore, learning module has the second part in introducing the main concepts of critical thinking with related examples. As a result, the LeCTIS can enrich students with critical thinking. (2) Task module: is a good point to evaluate students before going to posttest. In this section, the users have to answer six (6) questions based on whatever they learned in the learning module about the type of questions to get useful information rather than superficial answers. Moreover, the second part of the task module is about how to write a paper and some related questions to interact with the users. (3) Evaluation module: is another utility of the LeCTIS, in which the users find out their level in critical thinking as well as their weak and strong skills of critical thinking. The users can also see their results of task module. Indeed, evaluation module presents the relationship between each stage of the information seeking process model and each skill of the critical thinking. (4) System administrator: is able to get reports in different orders, such as users' age; degree, name, major, and gender; and in various modes, such as pre-test, task, , evaluation, post-test, or a combination of them in one report. (5) Users: which are the participant of the proposed method, can request the system to reset their password and send to their email address if they forget it. The users need to use the initial password to enter the system and change the password to increase the security of their information.

5.3.4 System evaluation

This section explains method of system evaluation and the results of the evaluation.

5.3.4.1 Method of evaluation

The results of the system evaluation are sufficient to indicate that the system is usable from the postgraduates' perspective, and it can assist with the detection of usability flaws.

Detecting the usability of the tool is important before the tool can be used in a real setting. Therefore, the evaluation of the LeCTIS was conducted in September and October, at the beginning of the second semester of 2015 academic year. Seventeen (17) postgraduates from different fields of study in the University of Malaya voluntarily participated in the system evaluation. Software usability evaluation (SUMI) also was done among these postgraduates. The evaluation was conducted at the time convenient to the participants. As a result, the prototype evaluation took four (4) weeks to complete. It was arranged in such a way that one postgraduates evaluated the LeCTIS at one time.

The evaluation was carried out in the postgraduates' rooms or in the discussion room with the personal computer installed. The evaluation procedure consisted of twenty minutes for briefing on the purpose of the LeCTIS, twenty minutes for doing pretest, twenty-five minutes for finishing the learning section, ten minutes for doing the task, five minutes for performing the evaluation, and twenty minutes for doing the posttest. The participants should follow all the procedures in the LeCTIS. According to their results in the pretest and the posttest, the role of the LeCTIS in cultivating critical thinking is approved. The researcher's role was a facilitator to guide participants and supervise the procedures carefully to take notes, and avoid errors or missing data.

5.3.4.2 Results of system evaluation in terms of usability and functionality

To get a clear picture of the participants in the system evaluation section, their characteristics completely described in Table 5-2. To protect their privacy, pseudonyms were used.

Table 5-2: Demographic details of participants (n=17)

No	Participants	Gender	Age range	Degree	Field
1	Guilda	Female	31-35	PhD	Computer science
2	Georgia	Female	31-35	PhD	Computer science
3	Ahmad	Male	36-40	PhD	Computer science
4	Miki	Male	26-30	Master	Art and social science
5	Mary	Female	31-35	PhD	Computer science

No	Participants	Gender	Age range	Degree	Field
6	Mohamad	Male	26-30	PhD	Computer science
7	Sona	Female	26-30	PhD	Science
8	Katty	Female	31-35	PhD	Science
9	Eric	Male	26-30	Master	Engineering
10	Shervin	Male	26-30	Master	Education
11	Elena	Female	20-25	Master	Education
12	Naeim	Male	31-35	PhD	Engineering
13	Hanna	Female	36-40	PhD	Law
14	Robin	Male	31-35	PhD	Medicine
15	Jack	Male	31-35	PhD	Economic and administration
16	Kelly	Female	26-30	PhD	Medicine
17	Melisa	Female	20-25	Master	Science

The analysis of the responses to the questions about the evaluation of the LeCTIS in terms of usability were positive. It can be seen that only 29% of the respondents were disagreed with the asked question in the LeCTIS (Table 5-3). This indicates that the postgraduates had minimum difficulties for using the LeCTIS, and the user interface of the LeCTIS is clearly usable. To calculate the mean and standard deviation for items in Table 5-3, these scores were used: “Disagree=1”, “Undecided=2”, and “Agree=3”.

Table 5-3: Analysis of responses for usability evaluation (n=17)

Items	Agree	Undecided	Disagree	Mean	Std.
I would recommend this software to my colleagues.	52.9%	17.6%	29.4%	2.35	0.786
The instructions and prompts are helpful.	88.2%	0	11.8%	2.76	0.664
I enjoy the time I spend using this software.	76.5%	17.6%	5.9%	2.71	0.588
Working with this software is satisfying.	82.4%	11.8%	5.9%	2.71	0.688
The way that system information is presented is clear and understandable.	100%	0	0	3.00	0.000
The software documentation is very informative.	94.1%	5.9%	0	2.94	0.243

Items	Agree	Undecided	Disagree	Mean	Std.
Working with this software is mentally stimulating.	58.8%	23.5%	17.6%	2.41	0.795
I feel in command of this software when I am using it.	58.8%	0	41.2%	1.94	0.899
I can understand and act on the information provided by this software.	88.2%	0	11.8%	2.76	0.664
There is too much to read before you can use the software.	58.8%	0	41.2%	2.18	1.015
Using this software is frustrating.	41.2%	5.9%	52.9%	1.88	0.993
The software has helped me overcome any problems I have had in using it.	52.9%	35.3%	11.8%	2.41	0.712
The speed of this software is fast enough.	82.4%	11.8%	5.9%	2.76	0.562
It is obvious that user needs have been fully taken into consideration.	76.5%	0	23.5%	2.76	0.437
The organization of the menus seems quite logical.	100%	0	0	3.00	0.000
Learning how to use new functions is difficult.	11.8%	0	88.2%	1.24	0.664
There are too many steps required to get something to work.	47.1%	0	52.9%	2.00	1.000
It is easy to make the software do exactly what you want.	82.4%	17.6%	0	2.82	0.393
I will never learn to use all that is offered in this software.	0	23.5%	76.5%	1.24	0.437
The software presents itself in a very attractive way.	82.4%	17.6%	0	2.82	0.393
It is relatively easy to move from one part of a task to another.	100%	0	0	3.00	0.000
It is easy to see at a glance what the options are at each stage.	100%	0	0	3.00	0.000

Note: the scales used for SUMI items are: Disagree=1; Undecided=2; Agree=3

The results of system evaluation in terms of functionality also show that except the posttest module, respondents confirm the good functionality of the LeCTIS (Table 5-4).

To calculate the mean and standard deviation for items in table 4, the following scores were used: 'Very weak' = 1, 'Weak' = 2, 'Satisfactory' = 3, 'Strong' = 4 and 'Very strong' = 5. It was decided that in an educational organization, the software package should at least provide all of the features requested by the novice users of the system and at least 80% of those requested by experts. Functionality criterion levels were therefore set at 100% for novices and 80% for experts (Noyes & Harriman, 1995). In this study, satisfaction for the functionality was set at 80% for all users. If the end-users returned an average rating of more than 80%, then the software package would be considered to be of acceptable quality for its application. It can be seen that all modules were rated 'satisfactory' and above for its functionality (all postgraduates were satisfied with the modules' functionality). Four (4) of the seven (7) modules have the mean score above 4 that it means good functionality. Therefore, the modules had an appropriate functionality designed for postgraduates to handle the system.

Table 5-4: Analysis of responses for functionality of the modules

Items	Very weak	Weak	Satisfactory	Strong	Very strong	Mean	Std.
Registration	0	0	5.9%	82.4%	11.8%	4.06	0.429
Pre-test	0	0	35.3%	64.7%	0	3.65	0.493
Learning process	0	0	17.6%	52.9%	29.4%	4.12	0.693
Task	0	0	5.9%	41.2%	52.9%	4.47	0.624
Post-test	0	0	58.8%	41.2%	0	3.41	0.507
Evaluation	0	0	5.9%	64.7%	29.4%	4.24	0.562
Utilities	0	0	35.3%	58.8%	5.9%	3.71	0.588

Note: the scales used for SUMI items are: Very weak=1; Weak=2; Satisfactory=3; Strong=4; and Very strong=5

Postgraduates made comments on their experiences of using the system written in Part C:

Q1. In your opinion, what are the strong points of the tool (if any)?

Q2. In your opinion, what are the weaknesses of the tool (if any)?

Q3. Please give your comments and recommendations (if any) on other issues that would help to improve your satisfaction on the use of the tool.

Table 5-5 shows the selected verbatim statements by respondents. The postgraduates believed in the usefulness of this system to cultivate critical thinking. Generally, users agreed with the attractiveness of the system and emphasized on the user-friendliness of it. Moreover, they think that the user requirements have been considered in developing this system.

Table 5-5: Strengths and limitations of the system in respondents' opinions

Strengths	Limitations
➢ The system divided the learning part into two movies with simple and attractive notes about critical thinking to prevent frustration. ➢ The system is so simple to run and to work. ➢ It is user-friendly that attract user's attention to the next steps. ➢ The system provides some useful links to the information resources and dictionaries for getting more information and understanding strange idioms, expressions, or concepts. ➢ The evaluation module is good to see the results. ➢ Learning process module is very simple and attractive for users to know more and continue. ➢ The task module is easy to do and interesting.	➢ Users should pass pre-test and post-test with the same questions due to the nature of pre-test and post-test. ➢ Users should pay attention to all procedures and briefing the system. Otherwise, they may have difficulties to continue their work. ➢ Although the learning module considered the time, totally, it needs too much time to work.

5.1.1. Results of the acceptance testing

This testing process begins after the system developed is defined as a complete package. Testing was conducted with the aim of ensuring that systems meet user requirements as defined in the determination of user requirements. In this test, the user has the opportunity to use and test the system and the effect of the system on users. As a

result, a pre-test post-test experiment was designed among 17 postgraduates. The analysis of the responses to the pretest and posttest results was done by paired sample t-test. It was conducted to compare the pretest and posttest results. There is a significant difference between the pretest results ($Mean = 8.53, SD = 1.625$) and the post-test results ($Mean = 11.41, SD = 1.622$); $t\,(-7.156) = 16, p = 0.000002$. These results confirmed that positive effect the LeCTIS on cultivating the critical thinking of postgraduates. In other words, the LeCTIS is able to cultivate critical thinking of postgraduates through learning procedures and teaching the nature of critical thinking and relevant questions.

This system was designed based on determining weak skills of critical thinking in order to improve them to reach the point, which is cultivating critical thinking as a whole. According to above, the paired sample t-test was applied to show the usability of this system in improving each skill of critical thinking.

i. ***The role of LeCTIS in cultivating "inference"***

The results of the paired sample t-test show that there is a significant difference between "inference" score in the pretest ($Mean = 1.41, SD = 1.176$) and "inference" score in the posttest ($Mean = 2.18, SD = 0.951$); $t\,(-4.190) = 16, p = 0.001$. According to the results of Section 4.2.2.2, the weakest skill of critical thinking among postgraduates is "inference'. Therefore, it is needed to improve it due to the vital role of "inference" and the complicated nature of it. These results approve that the LeCTIS can cultivate "inference".

ii. ***The role of LeCTIS in cultivating "recognition of assumptions"***

The results of paired sample t-test indicate that there is a significant difference between "recognition of assumptions" score on the pretest ($Mean = 1.76, SD = 1.091$) and "recognition of assumptions" score on the posttest ($Mean = 2.71, SD = 0.686$); $t\,(-3.771) = 16, p = 0.002$. Although, the "recognition of assumptions" is

known as the strongest skills of postgraduates, the findings revealed that the prototype was a useful tool to improve "recognition of assumptions" if respondents are weak in it.

iii. ***The role of LeCTIS in cultivating "interpretation"***

The results of the paired sample t-test show that there is a significant difference between "interpretation" score on the pretest ($Mean = 1.88, SD = 0.781$) and "interpretation" score on the posttest ($Mean = 2.29, SD = 0.686$); $t\,(-2.746) = 16, p = 0.014$. The results suggest that the LeCTIS is useful to develop "interpretation" as a skill of critical thinking, especially when the respondents are weak in it. According to the analysis of the first survey (Section 4.2.2), the participants could get acceptable results in "interpretation". Therefore, "interpretation" is not in the weak skills category, but this system has a positive impact on improving "interpretation" that is appreciable.

iv. ***The role of LeCTIS in cultivating "deduction"***

The results of the paired sample t-test mention that there is a significant difference between "deduction" score on the pretest ($Mean = 1.82, SD = 0.636$) and "deduction" score on the posttest ($Mean = 2.24, SD = 0.664$); $t\,(-2.384) = 16, p = 0.030$. It shows that the LeCTIS has a useful role in fostering "deduction" as a critical thinking skill. It can be seen that regarding the best score of the participants in "deduction" skill in the first survey (Section 4.2.2), the system is effective to improve "deduction" to show the power of this system to improve critical thinking in practice.

v. ***The role of LeCTIS in cultivating "evaluation of arguments"***

The results of the paired sample t-test clarify that there is a significant difference between "evaluation of arguments" score on the pretest ($Mean = 1.65, SD = 0.786$) and "evaluation of arguments" score on the posttest ($Mean = 2.00, SD = 0.612$); $t\,(-2.400) = 16, p = 0.029$. The results suggest that this LeCTIS has a positive impact on improving "evaluation of arguments" as a skill of critical thinking. Similarly, to the "interpretation" score of the participants in the first survey (Section

4.2.2), “evaluation of arguments” is not in the weak skills category, and participants could obtain acceptable scores in this skill. The analysis shows that the system plays an effective role in improving “evaluation of arguments”.

5.4 Summary

Moreover, this chapter presented the users’ requirement extracted from the first interview questions as well as the association between critical thinking skills and information seeking processes, which was originated from the second survey and the first interview. Afterwards, the LeCTIS was designed and developed based on the user requirements and its features were explained. The evaluation of system and the related results were described to show the functionality and usability of the system. The results of the system evaluation showed that the proposed LeCTIS was good in cultivating the critical thinking skill.

CHAPTER 6: **CONCLUSIONS**

6.1 Introduction

This chapter discusses on research questions and their related answers. It also presents the significance of the study as well as the future work. The aim of this chapter is to address these research objectives: (1) to investigate the association between critical thinking skills and the information seeking processes; (2) to design and develop a prototype (LeCTIS) to teach critical thinking in information seeking processes; and (3) to evaluate the usability and functionality of the prototype (LeCTIS) in facilitating critical thinking in the information seeking process model. Therefore, the research questions put forward as follows:

RQ1. What is the level of critical thinking among postgraduates?

RQ2. How postgraduates think critically when seeking for information?

RQ3. What are the requirements for a critical thinking learning system?

RQ4. How usable is the prototype (LeCTIS) in facilitating critical thinking skill in the information seeking process?

6.2 Answering research questions

Within the context of this study, each individual research question has been answered and discussed in Chapters 4 and 5. Research questions 1, 2, and 3 are addressed in Chapter 4 and the fourth research question is addressed in Chapter 5. In this section, a summary of salient findings is presented, followed by discussions of each research question.

6.2.1 Research question 1: What is the level of critical thinking among postgraduates?

Critical thinking is an important outcome of higher education, especially for postgraduates while they need to seek for information among a huge amount of information through surfing the Internet. Critical thinking helps the students to select information and decide about the quality of information they received. However, the lack

of critical thinking is the main problem among postgraduates. It can be seen that 74.38% of postgraduates got low and middle scores in critical thinking and only 25.61% of postgraduates could get acceptable scores in critical thinking (see Section 4.2.2.1). This result is compatible with the other studies in the United States, which showed that approximately the half of respondents the over 700 managers got an average or below average scores in response to the American Management Association's 2012 Critical Skills Survey (AMA, 2010). In fact, these results show that the level of the critical thinking among postgraduates is low, and it needs to be cultivated.

Moreover, the comparison between mean score of critical thinking skills shows that "inference" is the weakest skill while "deduction" and "recognition of assumptions" are the strongest skills (see Section 4.2.2.1). According to the one sample t-test result, postgraduates demonstrated the weak point in making inference. To clarify, the respondents have problems in discriminating the degree of truth in information. Therefore, they have a problem in deciding on the selection of the qualified information. On the other hand, the respondents have strong points in terms of recognition of assumptions and deduction. As a result, they can recognize structured and ill-structured assumptions that help them to find the information gaps. "Deduction" is also very helpful for the students to draw valid conclusions to make decisions about the relationship among premises in a specific situation.

6.2.2 Research question 2: How do postgraduates think critically when seeking for information?

Analysis of the second section of the survey and the first interview questions revealed that there are several relationships between critical thinking skills and information seeking processes. Critical thinking plays a vital role in seeking for information, particularly in evaluation of received information since Head and Eisenberg (2010) mentioned it, which is consistent with the current study findings. In fact, participants

applied different critical thinking skills during seeking for information. Findings from the second interview approved the results of analysis of the second section of the survey and show how participants use different critical thinking skills in each step of the ISP model. For instance, participants started to interpret and find general information about the topic or problem. Therefore, "interpretation" is the most applicable skill of critical thinking in the first step of the ISP model. In the selection step as the second step of the ISP model, participants tend to use "recognition of assumptions" due to a huge amount of information and need to make an appropriate decision about the validity and reliability of information. "Interpretation", "recognition of assumptions", and "inference" are three important skills of critical thinking, which are applied by the participants during exploration as the third step of information seeking process model. The participants continue to recognize some sort of assumptions about the topic as well as "interpretation" and "inference" skills while they are formulating the found information about the topic. Information collection is the fifth step of seeking for information where the participants prefer to interpret the topic and applied "inference" and "deduction" as the required skills of critical thinking. Finally, the participants used "inference", "evaluation of arguments", and "deduction" to conclude. It can be seen that, the participants applied various critical thinking skills as well as some criteria to be evaluate the received information.

6.2.3 Research question 3: What are the requirements for a critical thinking learning system?

To determine the requirements of developing a critical thinking learning system (LeCTIS) the second interview was designed. The interview was conducted among seven (7) postgraduates who got acceptable score in critical thinking test (see Section 4.3, page 127). Analysis of the second interview shows that postgraduates mentioned several factors affected critical thinking practices. The most important factors, which influence on critical thinking practices are: (a) environment; (b) mood and personal traits; and (c)

various tasks from their lecturers. The findings are consistent with the previous studies in which emphasized on these general barriers to thinking critically: lack of training, lack of information, preconception, and time-constraints (Broadbear, 2012; Brodie & Irving, 2007; Kang & Howren, 2004; Scriven & Paul, 2007). Moreover, the participants indicated several points as requirements for developing a system in cultivating critical thinking, including (a) the system should protect the IDs; (b) the system should propose various topics to teach and test according to the user's knowledge and fields; (c) the system should provide any facilities to be familiar with strange idioms, expressions, or vocabularies that are difficult for users; (d) the system should consider the user's time specially for learning parts; (e) the system should consider any criteria to evaluate users who want to pass all procedures; (f) the system should consider users based on their knowledge about critical thinking; (g) the system should provide an interaction between learning materials and the users; (h) the system should test the user's critical thinking ability; and (i) the system should show any differences in critical thinking skills if it is happened (see Section 5.2).

6.2.4 Research question 4: How usable is the prototype (LeCTIS) in facilitating critical thinking skill in the information seeking processes?

According to the results of the interviews and the survey as well as reading the literature, the LeCTIS was designed to facilitate critical thinking among postgraduates while they are seeking for information. The LeCTIS consists of these modules: (a) registration; (b) introduction; (c) pretest; (d) learning; (e) task; (f) posttest; and (g) evaluation (see Section 5.3.3). The LeCTIS tested the level of critical thinking among the participants in the pretest module. Then, they used the learning process, which benefits from Socratic questioning method as the main instructional approach to cultivate critical thinking. The next module is doing the task to show whether participants are eligible to go for posttest module. The evaluation module indicated how participants progress in critical thinking. By considering the user's indications about their preferred information

sources, some useful links were provided in introduction module for user who likes to have further information on topics or definitions of some expressions. In the task module, users are able to follow the information seeking processes by writing a paper in practice, which it considers the criteria to evaluate the information and their feelings during seeking for information. In addition, influenced factors during seeking for information were considered to get acceptable outcome of the learning process.

The LeCTIS supports several features that they are known as modules as same as Computerized Training in Critical Thinking $(CT)^2$ (Fischer, Spiker, Harris, et al., 2008) and interdisciplinary model (Duron et al., 2006), but they are different in details. In comparison, the LeCTIS considers the time of users and the whole time for working with it was about 2 hours while users need about 8 hours to work with $(CT)^2$ (Fischer, Spiker, Harris, et al., 2008). Moreover, the LeCTIS is easy to work for all users in any disciplines however, the $(CT)^2$ (Fischer, Spiker, Harris, et al., 2008) was developed for the U. S. army. Although Duron et al. (2006) believed that the proposed model can be applied for all disciplines, it needs fundamental changes. The LeCTIS is easier rather than $(CT)^2$ and the interdisciplinary model Duron et al. (2006) in implementation.

The system evaluation was carried out to be sure about the usability and functionality of the LeCTIS. The results of system evaluation in terms of usability were positive. Moreover, the results of system evaluation in the view of functionality showed that except post-test module, respondents believe in good functions of the LeCTIS (see Section 5.3.4.2).

The analysis of the responses to the acceptance testing of the LeCTIS, which was done by pretest and posttest experiment revealed that the LeCTIS can improve critical thinking of the participants. Indeed, the posttest scores of participants are higher than their pretest score. Therefore, the LeCTIS plays a positive role in cultivating critical thinking (see Section 5.1.1).

6.3 Significance of study

The significant of this research is as follows:

The aim of this research is to investigate the relationship between the critical thinking skills and the information seeking processes. Most of the existing studies on the information seeking process model were in the library contexts. They also highlighted the relationship between information seeking process and information literacy. The other studies on the information seeking process model considered the role of personal traits and emotions during seeking for information. However, the contribution of this research is investigating the relationship between critical thinking skills and each step of the information seeking process model and proposing a conceptual framework.

The other significant contribution of this research is examining the level of critical thinking among the graduate students. Although the participants think that they are good at thinking critically, this study shows that only 25% of the postgraduates could get an acceptable score in the critical thinking tests. This result warns higher education institutes to emphasize the soft skills besides the academic qualifications.

Most of the existing studies related to critical thinking were conducted in the medical schools or among nursing students. In addition, the majority of the participants of the studies on critical thinking were undergraduate students, secondary school students, and postgraduates. One of the important contributions for this study is that the current researchers worked on critical thinking among postgraduates in a variety of majors, such as education, engineering, medicine, computer science and information technology, law, business and accountancy, languages and linguistics, economics and administration, science, built environment, art and social science, and dentistry.

According to the relationship between each skill of the critical thinking and the steps of the information seeking process model, a prototype (LeCTIS) was designed and implemented. The LeCTIS can cultivate critical thinking among students by using

Socratic Questioning as an effective instructional method. Furthermore, the built-in modules in the LeCTIS are flexible and user-friendly to meet all users' needs with different knowledge and requirements. Consequently, the results of usability, functionality, system testing, and system evaluation (comparison with (CT2) and interdisciplinary model) shows that critical thinking can be thought and cultivated.

6.4 Future research

This section presents the possible open issues for further investigations, as follows:

The current research was undertaken to implement a prototype (LeCTIS) to cultivate critical thinking among postgraduates through the information seeking process model. The logics behind this study and theoretical lens are flexible enough to extend the study for different education levels such as undergraduates, secondary school, and preliminary school.

This research aimed at cultivating critical thinking among postgraduates while some instructors are weak in the critical thinking, and they need training to be critical thinkers. As a result, education systems should have regular and attractive programs for the instructors and teachers to learn thinking critically. The LeCTIS can teach and develop critical thinking among teachers with flexible and updated instructional methods.

In this research, the demographic characteristics of participants were restricted to age, gender, field, and degree while for the future study, the nationality, culture, and language of participants can be considered to make better decisions for policy makers and have different plans to meet their needs.

To design and develop the LeCTIS prototype, this system was implemented by Microsoft Windows Platform, which was enough for this study due to time limitation and too much participants as the scope of this research. However, it is good to design this prototype as web-based system to make it applicable for all participants around the world

to meet their needs. Therefore, it is suggested to have a forum for this system to make it more applicable and useable for whoever likes to work with.

Questionnaires and interviews are the most data collection tools for this research, but the researchers encountered with some difficulties such as time restrictions and many irrelevant answers. To overcome these problems, for the future study, it is better to use qualitative tools such as observation and think aloud more than a questionnaire.

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LIST OF PUBLICATIONS AND PAPERS PRESENTED

Journals

- Haghparast, M., Noorhidawati, A., & Hanum, N. F. (2016). Postgraduates' critical thinking practices while seeking for information. *Malaysian Journal of Library & Information Science*, 21(3), 35-56, Accepted (ISI Indexed Q3, Impact Factor: 0.476)
- Haghparast, M., Hanum, N.F., & Noorhidawati, A. Investigation of Association between Critical Thinking Skills and Information Seeking Processes. *Information Processing and Management,* Minor revision (ISI indexed Q2, Impact Factor: 1.397)
- Haghparast, M., Hanum, N.F., & Noorhidawati, A. Modeling of critical thinking in information seeking process for students at higher learning institutes. *Computers and Education,* Under review (ISI indexed Q1, Impact Factor: 2.881)
- Haghparast, M., Hanum, N.F., & Noorhidawati, A. Cultivating Critical Thinking through Instructional Strategies: A Systematic Review. *Nurse Education Today*, Under review (ISI indexed Q1, Impact Factor: 1.591)

Conferences

- Haghparast, M., Hanum, N.F., & Abdullah N. (2014). *Are students thinking critically while seeking for information?* Paper presented in International Conference on Libraries, Information and Society (ICOLIS), Kuala Lumpur.
- Haghparast, M., Hanum, N.F., & Abdullah N. (2014). Cultivating Critical Thinking Through E-learning Environment and Tools: A Review. Paper presented at the International Conference on Innovation, Management and Technology

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- Haghparast, M., Hanum, N. F., & Abdullah, N. (2013). *Modeling an e-learning tool to cultivate critical thinking in students based on information needs and seeking behavior.* Paper presented at the International Conference on Teaching, Assessment and Learning for Engineering (TALE), Bali.