CHAPTER ONE

INTRODUCTION

1.0 Introduction

The emergence of World Wide Web has caused a lot of changes and innovations in the way people communicate, work, and learn. It has mesmerized educators for over a decade with its potential of distributed learning and universal educational resources delivery. An educational revolution is gradually taking place, which includes changes in the development and delivery of instruction. The changes provide an opportunity to improve the learning with the appropriate use of learning theories that are coupled with technologies.

With the rapid development of Information Communication Technology (ICT) in teaching and learning, the school is no longer essential as an information supplier. The amount of information channeled through the Internet has outstripped people's abilities to process and utilize the information. They are not only required to learn, but also need to analyze and evaluate the validity and reliability of the information received. The education system now should emphasize the students as producers but not simply consumers of information. Hence, it is increasingly important for students have to possess higher order thinking skills in order to process and to apply the information.

While a lot of people are eagerly developing the Web-based learning environment, there are question marks on how to keep the online learners captivated and self-motivated to achieve the learning objectives and able to use higher order thinking skills (HOTS). One of the solutions is to identify the learners' needs, and economically customize the individual learning in order to promote the successful learning (Wiley, 2000). This has brought to the transition from the one-size-fits-all approach to customization with the growing use of the learning object design (LTSC, 2000). Learning object is an instructional technology currently used by the educational technologists and instructional designers for the choice of the instructional design, development and delivery (Hodgins, 2001; Wiley, 2000).

This chapter provides a background study for the research project by providing an overview of learning objects and generative learning, higher order thinking skills (HOTS) and the instructional design model. Besides, the statements of problem, suggestions of problem solving, objectives of research, questions of research, suggested framework of instructional design model, framework of research theory, rational of research, importance of research, scope and limitation of research, and the definition of terminology used in research are discussed in this chapter.

1.1 Research Background

Modern life requires people to face various experiences and environments (Tal and Hochberg, 2003). However, for many years, contemporary education is paying more focus on the "transmission of information" from teachers and books. In reality, students should be equipped with higher order thinking skills (HOTS) in their learning process (Dunlap and Grabinger, 1996a; Osborne and Wittrock, 1983; Hollingworth and McLoughlin, 2003; Jonassen *et al*., 1993). The learning process requires the students to construct their understanding meaningfully and to search for innovative solution in problem solving.

1.1.1 Higher Order Thinking Skills

Higher order thinking skills (HOTS) represent multi-faceted and complex cognitive processes that develop and improve the processing and construction of information (Resnick, 1987; Swartz, 2001). The term HOTS used in this research refers to the analysis, synthesis and evaluation according to Bloom's Taxonomy of thinking (Bloom *et al*., 1956). Thus, the recall of knowledge, comprehension and application are classified as lower order thinking skills (LOTS) (Dori, Tal and Tsaushu, 2003; Bloom *et al*., 1956; Morgan, 1996). Skills such as analyzing, synthesizing and evaluating information in the learning process are important in order to develop HOTS (Bloom *et al*., 1956; Bloom, Hasting and Madaus, 1971; Ennis, 1987; Zohar, Weinberger and Tamir, 1994; Jonassen, 1992; Tal and Hochberg, 2003; Morgan, 1996). A lot of researchers have pointed out the increasing importance of HOTS in the teaching and learning process.

Problem solving requires the use of HOTS such as analysis, synthesis and evaluation. This is in line with the argument from Kallick (2001a) that the cognitive operations such as analyzing, inferring and evaluating are necessary in problem solving. According to Jonassen (1992), argumentation is an appropriate outcome for problem solving where students generate arguments and make reasoning to defend their solutions. This encourages them in using HOTS. Besides, reflective thinking is also often related to HOTS (Quellmalz, 1987; Vockell, and van Deusen, 1989; Fogarty and McTighe, 1993; Wai and Hirakawa, 2001; Fogarty, 2002; Harrigan and Vincenti, 2004). Reflective thinking helps students to be aware of their thinking as they perform tasks or learning and this engages them in HOTS. Hence, the reflective thinking was used as an important cognitive operation for scaffolding the encouragement of HOTS in this research.

From the above description, it is apparent that HOTS requires students to manipulate information and ideas in ways that transform their meaning and implication. This occurs when students combine facts and ideas in order to analyze, synthesize, and evaluate in generating knowledge. The manipulation of information and ideas through these processes allows students to solve problem, generate knowledge and promote understanding.

1.1.2 HOTS and Computer Science

As technology changes at an ever-increasing speed, the students must have the ability to adapt to changes and become lifelong learners. This is especially true in the computing field. The students have to be good in both thinking and problem solving skills. However, most of the colleges focus more on rote lecturing, assignments and tests (Tan Wee Chuen, Baharuddin Aris and Mohd Salleh Abu, 2005). They rarely promote HOTS among the students in order to understand and apply problem solving and logical reasoning skills in the learning of Computer Science (Parham, 2003; Arup, 2004).

Harrigan and Vincenti (2004) noted that HOTS are important in college teaching and learning. A lot of studies have been conducted to study the teaching and learning process in Computer Science domain in higher education. Empirical results from the studies show that many students can not demonstrate HOTS in their learning (Chmura, 1998; Henderson, 1986; Arup, 2004). Most of the students resort to trial and error, and memorizing facts from their learning, rather than learning problem solving skills. However, these HOTS such as analysis, synthesis and evaluation thinking skills are found important in the learning of Computer Science. This was demonstrated by Parham (2003) in which there is a direct correlation between the students' HOTS and their performance in their learning.

Hadjerrouit (1999) noted that the conventional predominant teaching model viewed learning as the passive transmission on knowledge and this cause serious misconception and lack of conceptual understanding in Computer Science learning. This is further supported by Arup (2004) that the existing learning in computer system tends to regurgitate what the instructors have taught and does not imply the ability to use HOTS among the students. This is also proven by the studies from Maj, Veal, and Charlesworth (2000); Holmboe (1999) and Mirmotahari, Holmboe and Kaasboll (2003) that the college students are lacking of knowledge of computer technology and the basic skills to operate computer systems.

Another main problem of Computer Science students is the lack of deep understanding of the relationships in the facts they have learned (Scragg, Baldwin and Koomen, 1994; Mirmotahari, Holmboe and Kaasboll, 2003). Students are better in the practical skills than theoretical questions. In computer education, the prior knowledge of students is the foundation for further knowledge construction (Holmboe, 1999; White, 2001; Mirmotahari, Holmboe and Kaasboll, 2003; Scragg, 1991). New information must be linked to information already understood (Rosenberg, 1976; Hamza, Alhalabi and Marcovitz, 2000). Learners would generate and test ideas that either have been created from their prior knowledge.

The content of the computer has to stay abreast of the rapidly developing computer technology. HOTS are essential to the students in this rapidly changing technological society (Morgan, 1996). The growth of knowledge in computer needs more timeliness in teaching resources, expertise and preparation time (Wolffe *et al.*, 2002). This leads to a large amount of information being drained to the students. Instructors and students have been burdened with the task of communicating massive and rapidly changing computer content. Consequently, the overemphasis on content has resulted in the lack of attention on the HOTS that are necessary for the students to successfully solve the complex scenarios (Arup, 2004).

Researchers in the education field are progressing toward the teaching and learning with technology to develop HOTS. Studies of *HOTS* program from Pogrow (1988a, 1988b), Herrington and Oliver (1999), Tay (2002) and Tal and Hochberg (2003) showed encouraging results. Technology can be used as a mindtool for conceptual development (Reeves, 1998; Jonassen, 2000) and to enable higher order learning (Ting, 2003; Reeves, 1998; Pogrow, 1988a, 1988b). In this context, the learner acts as a designer in the learning process (Jonassen, 1994; Jonassen and Reeves, 1996). Jonassen, Mayes and McAleese (1993) found that individual learns the most from the design of instructional materials. Therefore, if the students were given opportunity to construct or design their own learning, it creates an active learning environment. This process requires the students to think more meaningfully and therefore helps to develop their HOTS.

1.1.3 Generative Learning and HOTS

A lot of instructional strategies have been proposed to develop the HOTS. One of the most frequent proposals is generative learning. Generative learning is an important constructivist learning environment (Bannan-Ritland, Dabbagh and Murphy, 2000; Dunlap and Grabinger, 1996a; Duffy and Jonassen, 1992; Morrison and Collins, 1996; Grabowski, 1996; Bonn, and Grabowski, 2001; Jonassen, Mayes and McAleese, 1993; McLoughlin, 1998). According to Bonn, and Grabowski (2001), generative learning provides the necessary theoretical framework for research in a constructivist perspective. As described by CTGV (1993), the generative learning is the first key element of constructivism learning environment. In generative learning environment, learning is generative; learners focus on the construction of their own learning. In this research, the Web-based learning system used the generative learning to design the constructive learning environment.

Originally, generative learning is conceived under the cognitive information processing proposed by Wittrock (1974). The focus of generative learning model is that, learner is an active participant who works to construct meaningful understanding by generating relationships between the information. The cognitive psychologists and educationists usually refer the skills associated with this kind of thinking activities as HOTS. These activities are completely in contrast to those which simply copy down information and memorize them, where the students passively receive information and respond to the exercises or examinations that require only facts recalling and simple understanding. Dunlap and Grabinger (1996b) pointed out that generative learning is a higher-level thinking activity. HOTS depict the dynamic role of learners in which they act as thinkers actively participate in constructing knowledge. Such a view of learning fits well with the empirical evidence from the studies of technology and Computer Science learning and teaching (refer Chapter 2 for further discussion).

Learning that emphasizes on the connection between the new and old concepts, and among the concepts is important to enhance understanding (Nickerson, 1995). The connection among the concepts is also important in learning Computer Science (Rosenberg, 1976; Hamza, Alhalabi and Marcovitz, 2000). However, the conventional teaching models in Computer Science often view learning as a passive transmission on knowledge. This results in misconception, lack of conceptual understanding and the poor understanding of the relationships in the concepts that the students learned (Hadjerrouit, 1999; Maj, Veal, and Charlesworth, 2000; Holmboe, 1999; Mirmotahari, Holmboe and Kaasboll, 2003; Scragg, Baldwin and Koomen, 1994). In contrast, generative learning provides a learning environment that enhances the learning through actively construct meaningful understanding by generating relationships among the concepts.

According to Dunlap and Grabinger (1996a), content is often presented to the learners in the format that promotes memorization rather than higher order thinking. Most of the schools are still examination-oriented. The teaching and learning often focus in answering specific questions in the examinations. With the generative learning, it promotes active processing in the linkage of the concepts and supportive environment that encourages them to think and construct knowledge from their understanding. Higher education institute is the most appropriate venue for this learning approach because their goals are to promote advanced knowledge acquisition and HOTS (Jonassen, Mayes and McAleese, 1993).

Concept map provides an important tool in generative learning environment (Osborne and Wittrock, 1983; Bannan-Ritland, Dabbagh and Murphy, 2000). Concept map functions as a tool to engage learners to generate and to organize the ideas in the content being studied. According to Jonassen (2000), concept map engages learners in the reorganization of knowledge, explicit description of concept and their interrelationships, deep processing of knowledge that promotes better remembering, retrieval and application of knowledge; and relating new concepts to existing ones that improves understanding. This is consistent with the theoretical perspective of generative learning.

The concept map used in this research is called as lesson map. It is an outline form of concept map as suggested by Alpert and Grueneberg (2000), and Dabbagh (2001). The lesson map used in this research enables the construction of concepts require HOTS when students organize the lesson map, select important and relevant concepts to add to the map, search the crosslink and indicate the relationships between concepts. These activities engage students in HOTS that are analysis thinking while they are organizing the concepts in hierarchical structure, synthesis thinking while they are searching crosslink and indicating the relationships between the concepts and evaluating while they are searching and judging the important and relevant of the concepts (Jonassen, 2000; Dabbagh, 2001; Alpert and Grueneberg, 2000).

Jonassen, Mayes and McAleese (1993) pointed out that the generative learning results deeper levels of knowledge processing and construction, and these necessitate the HOTS. They further pointed out that constructivist learning environments aim to engage students in higher order and meaningful learning. Besides that, Jonassen (1992), Jonassen, Mayes and McAleese (1993) noted that the outcomes of constructivist learning environments should assess HOTS in order to reflect the intellectual processes of knowledge construction. Studies show that generative learning and teaching provoked learners' thinking skills and developed their understanding (Laney, 1990; Schaverien, 2000; McLoughlin, 1998; Dunlap and Grabinger, 1996a, 1996b; McGriff, 2002; Osborne and Wittrock, 1983; McLoughlin, 1998). The process of generative learning engages student in HOTS (Grabowski, 1995; Grabowski, 1996; McLoughlin, 1998). From this perspective, the generative learning is strongly related to the HOTS.

Gao and Lehman (2003) noted that most of the researches in generative learning emphasize in the facts and concepts-level learning and deal little with HOTS. Therefore, further research on generative learning that focuses on HOTS is necessary.

1.1.4 Learning Object Design

Nowadays, most of the instructional designers understood the importance of pedagogical perspectives in the design and development of Web learning environments. According to Snow (1989), instructions differ in structure and completeness and highly structured instructions (linear sequence, restricted and high external control) seem to help those with low ability but hinder those with high ability. The concept of one-size-fits-all design is no longer suitable in the design and development in e-learning. The learning environment should be highly flexible in structures and hands control out of the hands of the systems or instructors to the learners. Therefore, the concept of learning object design fits this very well as it provides flexible paths to the users' exploration in the teaching and learning process. The non-linearity of the learning object design allows students to access information in different patterns and to take control in their own action and learning.

A learning object is a small, reusable digital component that can be selectively applied alone or in combination by computer software, learning facilitators or learners themselves, to meet individual needs for learning or performance support (Shepherd, 2000). There are three interdependent components in the learning object design model: the learning object itself; metatagging (a standardized way to describe the content in code); a Learning Content Management System (LCMS) that stores, tracks, and delivers content.

Learning object design is the design of instructions into small learning contents that can be reused in different context and combined to form learning that are appropriate to the individual (Wiley, 2000; Hodgins, 2001; Wagner, 2002; Mills, 2002;

Longmire, 2000a, 2000b; Robbins, 2002; Lau, 2002; Gibbons, Nelson and Richards, 2000; Hanaffin, Hill and McCarthy, 2000; South and Monson, 2000; Collis and Strijker, 2003). The design of instructions into learning objects can be deployed into multiple setting and learning goals. It is a current trend of computer-based instructions and learning that are grounded in the object-oriented paradigm of Computer Science.

The idea of information in small chunks which are reusable and flexible in a learning environment has received a lot of compliments from the educators and instructional designers of e-learning environment. According to Reigeluth and Nelson (1997), when teachers first gain access to instructional materials, they often break the materials down into their constituting parts and then reassemble these parts in ways that support their instructional goals. Thus, the notion of small and reusable units of learning content, learning components, and learning object design have the potential to provide the flexibility and reusability by simplifying the assembly and disassembly of instructional design and development.

E-learning industry has anticipated the day where learners could personalize, assemble, and access e-learning on demand for years (Mortimer, 2002). Most electronic learning content is currently developed for specific purposes. How does a learner select only a small part of content that suit their learning needs? The educational software development is an extremely expensive process in terms of cost and time (Wiley, 2000; Downes, 2000; Longmire, 2000a). With the learning object design, the learning objects can be reused and shared. Molenda and Sullivan (2002) noted that there is a critical need for more efficient design and production of the digital learning materials. Thus, learning object design had become more practical now especially with the essential features of the World Wide Web.

1.1.5 Relationships between Generative Learning, HOTS, Learning Object Design and Web Technology

The current design and development of learning objects has overlooked the use of learning objects in supporting learning (Bannan-Ritland, Dabbagh and Murphy, 2000; Shi *et al.*, 2004). Most of the discussions and researches in learning objects concentrate on the standards, metadata and others technical issues related to the development of the learning object system design. The evidence of the dynamic attributes of learning object design in learning is still not well addressed (Shi *et al.*, 2004). The unique attributes of the learning objects lies in providing a customized, individualized and flexible learning environment. The required approach can be grounded in constructivist principles of learner centered, learner-controlled and learner-constructed learning. Thus, there is a need for research and development works to study the pedagogical issues of the learning object.

According to Wagner (2002), the development of learning objects involves a significant shift from behavioral to cognitive perspectives and from objectivist to constructivist perspectives. One of the principles of constructivism is that learners are active participants in the learning process (Jonassen, 1994; Reeves, 1998; Friesen, 2001; Bannan-Ritland, Dabbagh and Murphy, 2000). In addition, Collis and Strijker (2003) mentioned that the learning object design makes a pedagogical shift from the emphasis on learning as acquisition of predetermined content, towards the emphasis of learning as participating and contributing to the learning experience. Therefore, learners construct their own understanding from experiencing objects, activities and processes by exploring, analyzing, synthesizing and evaluating knowledge in self-directed or collaborative fashions rather than in a predetermined structure. These processes involve learners in HOTS.

From the theoretical perspective of the generative learning, learning object design can be configured as generative learning environments (Bannan-Ritland, Dabbagh and Murphy, 2000). The attributes and nature of learning object design match well with a generative learning. Learning object design offers the flexible, reusable and generative learning environment by allowing learners to participate more actively in the construction of knowledge and understanding. Learners are able to generate the relationships between the learning objects that are flexible and reusable, and this engages them in HOTS.

Toh (2004) indicated that the learning object design has the potential to deal with the expanding growth of knowledge and skills. The attributes of the learning object that allow learner-centered, generative-oriented activities have not yet been fully explored and may reveal significant implications for the development of the educational technology. As the amount of information about the computer system is growing parallelly with the fast changing technology, learning object design can help to reduce the cost and time of the e-learning system development where it allows the reusable content between the courses that teaching in the same concept.

It is apparent that the learning object design with generative learning environment engages students in HOTS. This learning environment encourages and requires students to manipulate the content which is designed as small chunks of learning object. The HOTS occur when students analyze, synthesize, and evaluate to design their learning by connecting and generating the relationships between the learning objects with the use of concept mapping. This enables students to generate, to evaluate their ideas and to construct their learning actively.

The Web provides an excellent environment for generative learning, especially with the use of learning object design. The advent of the WWW technology tools and features, and the growing of learner –centered instruction have provoked the Web-based learning (Bonk and Reynolds, 1997). Web-based learning environment is able to support student-centered learning and learning by doing (Lim, 2000; Jonassen and Reeves, 1996). The Web-based learning designed with appropriate instructional theoretical models can act as mindtool to promote HOTS (Jonassen and Reeves, 1996; Reeves, 1997; Bonk and Reynolds, 1997). The Web-based learning design that based on generative learning can provoke learners' thinking skills and developed their understanding (Schaverian and Cosgrove, 2000; Shepherd, Clendinning and Schaverian, 2002). The dynamic attributes of learning object design support the reuse of resources on the Web (Mohan and Brooks, 2003). In addition, the use of hypermedia that allows extensive links between learning objects supports learning (Dodds and Fletcher, 2003; Zhu, 1999). Hence, Web-based technologies are able to support the use of learning object design in learning. These reveal the great potential of the development of Web-based learning objects that incorporates with the generative learning to improve HOTS and learning.

1.1.6 Instructional Design Model

Instructional design (ID) theories are very important for the development of high quality instructional program that meets the users' needs. According to Reigeluth (1996), instructional design is concerned with differentiating the methods of instruction that are suitable for different situations. ID plays an important role in the application of learning object design if it is to succeed (Wiley, 2000). The ID model of the design and development of this research is modified from the ISDMELO (Instructional System Design Methodology based on e-Learning Object) which is based on ADDIE model (Baruque and Melo, 2003). The ISDMELO methodology which is built on the fundamental of learning object-based instructional design has been developed for the design and development of Web-based educational content.

From the research background outlined above, it is thus necessary to concretize a conceptual framework by designing and developing suitable learning models for computer-based learning environments, which ultimately lead to effective learning.

1.2 Problem Statements

In the information age, HOTS are important to facilitate people to cope with rapidly changing world. Learning to think is necessary in promoting life-long learning. The education system should nurture the productive growth by paying more emphasis on teaching for HOTS (Onosko, 1990). In addition, Morrison and Lowther (2001) pointed out that the school can no longer focus on a body of knowledge that a student needs to master. The emphasis of helping students to master in content should be shifted to a focus on thinking. When students develop their HOTS, they are more equipped to control their learning and to develop deep understanding of the content. Students need to have the ability to think so that they can learn instead of pure memorization of facts. HOTS are emphasized by Resnick (1987) as a different learning process as compared to rote learning and information withdrawal. This is of utmost important in view of the massive growth of knowledge in the ICT world.

Researchers in Computer Science education have noted that the predominant model of instruction that views learning the passive transmission has caused the lack of conceptual understanding in Computer Science (Arup, 2004; Scragg, Baldwin and Koomen, 1994; Tan Wee Chuen, Baharuddin Aris, and Mohd Salleh Abu, 2005). Some of the researchers even demonstrated that the problems are due to the inability of HOTS (Parham, 2003; Arup, 2004; Tan Wee Chuen, Baharuddin Aris, and Mohd Salleh Abu, 2005). Details about the problems of the learning of Computer System will be discussed in chapter 2.

As the learning object design is new in the instructional design, it is challenging to design and develop a Web-based learning environment that is based on this design. It is difficult to implement the learning object design in the traditional learning environment. The inherent strength of World Wide Web technology is the distribution and sharing of information in hyper-space. However, most of the Web-based content materials nowadays are actually similar to the approach of linear mode delivery of the learning materials found in traditional lecture presentations. This conventional "one-size-fits-all" learning environment is no longer suitable and satisfactory for the needs of the learners. Converting these to a digital deliverables through the Internet would not make any change to these passive learning materials and does not promise in fostering understanding as well as HOTS. Furthermore, Beaver and Moore (2004) noted that there is a wide range of educational software but most of them are not designed to encourage HOTS.

Numerous studies have documented the effectiveness of the incorporation of drill and practice computer programs into teaching and learning. However, Morgan (1996) highlighted that many drill and practice computer programs engage students only at lower levels of Bloom's Taxonomy (Knowledge, Comprehension, Application). Morgan (1996) also pointed out that the use of technology in education must ensure that the technology is being used to engage students to HOTS. Thus, the shift of teaching and learning now is not to be a process of regurgitating and reproducing information but a process of constructing knowledge and learning environment that involves learners in HOTS. It is essential to understand that the design of e-learning is a design for promoting HOTS and not a design for teaching or delivering information.

As reviewed in literature study, limited research has been done on the learning object design and it's effectiveness in learning. Current research and development of the learning object design are primarily focusing on establishment of technical issues (Bannan-Ritland, Dabbagh and Murphy, 2000; Tan Wee Chuen, Baharuddin Aris and Mohd Salleh Abu, 2004). There is little research on the pedagogical based learning objects in the design of Web-based learning, especially in Malaysia. To improve learning, the learning object design and the generative learning in instructional design based on ISDMELO was adapted as the elements of design and development of the Web-based learning system in this research.

The prototype of Web-based learning system focused on one of the subjects offered in Diploma of Computer Science, which is selected in conjunction with the implementation of the subject in the first year of Diploma in Computer Science. This research aims to design and develop a prototype of Web-based learning system in Computer Science that incorporates the learning object design and generative learning to improve the HOTS as well as the understanding of the students in their learning.

1.3 Research Rationale

As citizens in the information age, students need to have strong problem solving skill and thinking skill (Morgan, 1996). Hence, experiences that encourage and improve students in HOTS should become a common practice in education. This is important as the development of information technology has become ubiquitous in schools and colleges. The Malaysian Education Ministry has taken appropriate steps to ensure the students to be good thinkers. The curriculum design has focused in the development of HOTS.

The Malaysian Education Ministry has introduced Information Technology (IT) (Teknologi Maklumat) from the Form 1 to Form 6 in the secondary schools. One of the purposes is to develop HOTS such as analysis, synthesis and evaluation. Besides, it also aims to promote the problem solving skill that involves thinking skills as mentioned earlier (Zanariah Abdullah and Rosmayuzie Ab. Satar, 2001). This reveals the effort of the Malaysian Education Ministry in promoting HOTS through the teaching and learning of IT. It also shows the importance of HOTS in learning IT.

The attention to thinking skills is explicit with the extensive research in this field. Peck and Dorricot (1994) noted that the students must be able to access, evaluate, communicate information and solve complex problems. According to Kallick (2001b), when the computer is used with full potential, it is able to enhance thinking skills and create new knowledge. In this context, technology can be harnessed to support and encourage the students learning and HOTS (Morgan, 1996; Peck and Dorricot, 1994).

A lot of learning problems and issues have been identified and discussed from the research conducted in Computer Science domains (see Scragg, Baldwin and Koomen, 1994; Miron, O'Sullivan, and McLoughlin, 2000; Parham, 2003; Henderson, 1986; Maj, Veal and Charlesworth, 2000; Yurcik and Osborne, 2001; Holmboe, 1999; Magagnosc, 1994; Yehezkel *et al.*, 2002; Skrien, 2001; Ivanov, 2003; Makkonen, 1997; Mirmotahari, Holmboe and Kaasboll, 2003). The learning problems are mainly due to the inability of students in HOTS and the lack of inter-relatedness among the concepts they have learned. Empirical evidence obtained by Parham (2003) demonstrated that the inability of students' HOTS will affect their performance in Computer Science. Details of the learning problems were discussed in 2.6.

The students' problem solving skills are essential in computer subject such as Computer System, in which they are required to analyze, synthesize and evaluate the complex scenarios. All these activities involve HOTS. Timely resources in the content of Computer System are needed due to the high pace of computer technology development. Students have been burdened with the task of communicating a large amount of the fast changing content. This has brought to the overemphasis on the content and has resulted in the lack of emphasis on the HOTS that is necessary for students to successfully deal with complex scenarios (Arup, 2004).

The literature and research findings clearly show the need to promote HOTS among the Computer Science students. In this research, Computer System subject has been chosen as a topic of study for the effectiveness of the Web-based learning system based on the result found in the preliminary study. This subject is taken by the Computer Science students as fundamental knowledge of computer technology.

The issues of the flexibility and pedagogical perspective in the development of e-learning have brought to the concept of learning object design in the development of educational software. The traditional courseware that comprises the instructional content and a navigation scheme to move around the content no longer meets the expanding growth of knowledge (Toh, 2004). The learning object design features are engaged with the design and development of a more flexible and generative learning environment. The delivery of the learning materials in the form of chunks of lesson, organization and customization of the materials based on the learning objectives can now be realized with the use of learning object design. However, the current development on the learning object design in e-learning tends to overlook the use of learning object design in supporting learning (Bannan-Ritland, Dabbagh and Murphy, 2000; Shi *et al*., 2004). The pedagogical perspective in the design and development of learning object has been left behind and put in a less important place compared to the standard, metadata and technical issues.

Van Zele *et al*. (2003) pointed out that very little is known about the educational pitfalls or benefits of the learning object design, and the reports on its implementation and evaluation in higher education are lacking. In addition, Agostinho *et al*. (2003) noted that there is little research on how learning object design should be incorporated into constructivist and learner-centered approaches to learning. At present, the discussion of learning object design is commonly related to the concerns content, its values and management (Tan Wee Chuen, Baharuddin Aris and Mohd Salleh Abu, 2004). Currently most of the studies conducted in the use of learning object design emphasize more on the technical issues and the design for the use of instructors and trainers. Besides, the learning object design is still focusing on the potential in gaining profit and incentive from the e-learning industry, leaving behind the emphasis on the impact of the learning object design to learning. Thus, the pedagogical intent in learning design has to be addressed as the important issue in supporting and enhancing the learning process (Ramsay *et al*., 2004; Bannan-Ritland, Dabbagh and Murphy, 2000; Shi *et al*., 2004; Toh, 2004; Bradley and Boyle, 2004; Agostinho *et al*., 2003).

As reviewed earlier, it is important to conceptualize and design the Web learning based on pedagogical perspectives. However, most of the educational software tends to emphasize the sophisticated multimedia display (Cohen, 1983; Campoy, 1992; Koper, 1998). According to Jonassen (1991), instructional designers should focus more on the thinking technologies rather than developing a sophisticated multimedia delivery technology. Mere multimedia does not turn students into active participants during the lectures (Van Zele *et al.*, 2003). The learning system should be designed towards a more student-driven and student-oriented interactive learning. Merely providing pre-determined structure of content will not aid significantly in learning. The one-size-fits-all traditional courseware no longer meets the requirement of personal knowledge construction. Learning object design and generative learning provide the environment that allows students to construct their own learning. This learning environment enables the students to be active participant in their learning and most importantly, engages them in HOTS.

Currently, common Web-based learning systems are more to enrich access to course materials, search course materials, post project or assignment, provide tutorials and learning support, and enable the Web discussion. There is lack of integration of Web technologies into actual teaching and learning (Reeve, 1996). The promise of the Web technologies must be accompanied with pedagogical perspective (McLoughlin, 1998). The use of communication technologies to support learners' centered learning is well documented in the literature and research (eg. McLoughlin, 1998; Reeve, 1996).

A lot of literatures highlight the need for learner-controlled learning in the design of technological learning environment (eg. McLoughlin, 1998; Jonassen and Reeves, 1996). Web technology is conceived as enabling the students-centered learning. Web-based technologies are able and suitable to support the use of learning object design in learning (Hawryszkiewyez, 2002). The interactivity and flexibility of the Web enable the design of a Web-based learning tool that leverages the learning object design and generative learning. It provides an environment that enables students to explore and manipulate the learning objects so that students can continuously reconfigure to construct their knowledge.

For the reasons discussed above, this research focuses on the development and design of a Web-based learning system, using the learning objects in the design approach of learning content and generative learning in the design of learning strategy to assist the learning in Computer System as well as to improve the HOTS. A conceptual model is suggested, namely **G**enerative **L**earning **O**bject **O**rganizer and **T**hinking **T**asks (GLOOTT). This model incorporates the three important components, namely the learning object design, generative learning and HOTS in a technologically-supported learning environment. The model aims to facilitate the students to engage themselves in HOTS as well as to **promote understanding** in the Computer System.

A comprehensive study was conducted in this research to evaluate the effectiveness of GLOOTT model in improving learning and HOTS. Besides, the researcher hopes that this study will contribute to the framework of instructional design and development based on the learning object design and generative learning in the Web-based learning environment to improve the students' HOTS.

1.4 Research Objectives

This research aims to achieve two main objectives:

(i) To design and develop a prototype of Web-based learning system that based on the learning object design and generative learning.

(ii) To evaluate the Web-based learning system in the aspects of:

   (a) The improvement of learning through test.
   (b) The improvement of HOTS based on Bloom's taxonomy.
   (c) The engagement of HOTS.
   (d) The effectiveness of the Web-based learning system as perceived by the instructors and students.

1.5 Research Questions

Based on the research objectives discussed earlier, the research is carried out to answer the following questions:

(i) What levels of HOTS are exhibited by the Computer Science students after the conventional teaching and learning of Computer System in the first year of Diploma of Computer Science course?

(ii) Is there any significant difference between the students' score in the test before and after the use of the Web-based learning system?

(iii) Is there any significant difference between the students' HOTS before and after the use of the Web-based learning system?

(iv) How do the students' HOTS engagement change when they use the Web-based learning system?

(v) How effective is the Web-based learning system as perceived by the instructors?

(vi) How effective is the Web-based learning system as perceived by the students?

1.6 Research Theoretical Framework

The theoretical framework of this research incorporates a few important components from different perspectives. Learning object design was adapted for the instructional design structure, while the pedagogical perspective, the generative learning and HOTS were incorporated into the design of the Web-based learning system. The Web was used as a delivery medium for the system. All these aspects had been studied in detailed in order to meet the objectives of this research.

The Web-based learning environment in the system design is based on the generative learning from constructivism learning from Bonn and Grabowski (2001), Grabowski (1996), Bannan-Ritland, Dabbagh and Murphy (2000), Dunlap and Grabinger (1996a, 1996b), Duffy and Jonassen (1992), Morrison and Collins (1996), and Wittrock (1974; 1991; 1986). The features of the generative learning include:

(i) Provide a learning environment that enables the active process of knowledge construction.

(ii) Provide a learning environment that supports the construction of knowledge.

(iii) Learners are active participants in constructing their knowledge.

(iv) Design a learning environment that emphasizes on the construction of knowledge and allows learners to interpret their learning and build the mental model to represent the knowledge.

(v) Provide a learning environment that requires students to participate actively in the learning process and construct the knowledge meaningfully rather than in a predetermined structure.

(vi) Provide a generative learning environment that enables learners to construct and design their own learning.

(vii) Design learning activities that engage learners in HOTS.

(viii) Design the learning environment that allows students to generate organizational relationships between different components of the knowledge through learning aids such as concept mapping that engages students in HOTS. The generative learning environment also includes the activities for knowledge integration and elaboration such as problem solving.

(ix) Design activities to encourage students to actively participate in constructing meaningful understanding by generating relationships among the information received and apply it to support problem solving.

From the descriptions above, it is apparent that generative learning requires students to construct their learning in a meaningful way and this will engage them in HOTS. The generative learning environment encourages students to analyze, synthesize, and evaluate facts and ideas in the process of knowledge generation. Such learning environment engages students in HOTS.

The cognitive operations of HOTS emphasized in the system are analysis, synthesis and evaluation. These cognitive operations are based on the works from the taxonomy of Bloom *et al.* (1956), Bloom, Hasting and Madaus (1971), Tal and

Hochberg (2003), Parham (2003) and Swatrz (2001) with consideration on the curriculum of the Computer Science course for college students.

According to Dede (1990), learning environment that contains a highly developed information-gathering tool to stimulate the learners to actively construct knowledge will engage students in HOTS. Besides, the organization of information into an integrated system to show relationships among the information through concept mapping will encourage and assist students in HOTS (Ivie, 1998; Hollingworth and McLoughlin, 2002; Hobgood, 2002).

In addition to the HOTS activities mentioned above, reflection and thinking tasks were integrated into the system to provide a more comprehensive generative learning environment. Reflection was designed to scaffold the students so that they are conscious in applying the HOTS and aware of their learning. Quellmalz (1987), Fogarty (2002) and Harrigan and Vincenti (2004) pointed out that reflection will foster HOTS because it enables students to reflect on their learning. In addition, finding from Harrigan and Vincenti (2004) demonstrated the reflection engages students in HOTS.

According to Costa and Kallick (2001), thinking tasks such as problem solving, scenario generation and exercise are important to engage students in HOTS. In this research, the thinking tasks are scenario-based problem solving and multiple-choice question exercise to reinforce the students' HOTS as well as to test their understanding. This aligns with the generative learning that advocates the inclusion of concept mapping and scenarios-based problem solving as generative learning activities.

The strategy of learning environment in the system that based on the generative learning and HOTS aligns with the features of learning object design. According to Ip and Morrison (2001), learning object has the potential to be integrated into different learning paradigms. This is further elaborated by Bannan-Ritland, Dabbagh and Murphy (2000). They pointed out that the premise underlying the features of a learning object that support flexibility and reusability is aligned and heavily related to generative learning from constructivism learning. This is further supported by Agostinho *et al*. (2003) that research should be conducted about the incorporation of the learning object design with the constructivism learning environment.

Figure 1.1 depicts the theoretical framework about the incorporation of the generative learning, learning object design and HOTS in the research. Based on this, a conceptual model of Web-based learning system, GLOOTT is proposed and applied in the design of the learning environment in the system development.

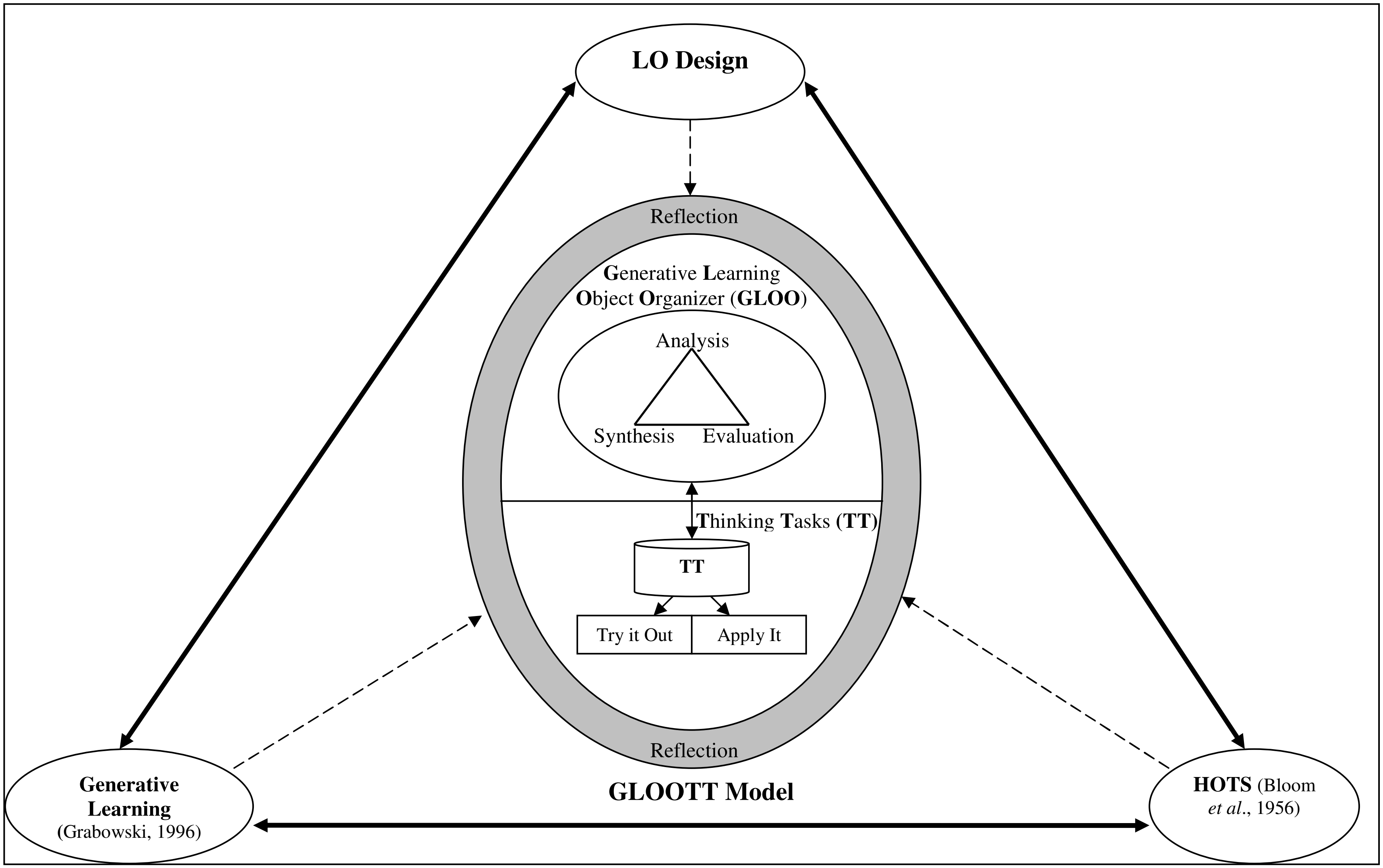

Figure 1.1: Conceptual Model of the System Design and Development

Jonassen and Reeves (1996) stated that technology can be used as a mindtool that enables learners to act as designers to design and construct their learning, rather than as passive recipients in the learning process. Computer and information technology can stimulate students to become active learners and provide tools to manipulate their learning (Morgan, 1996). The GLOOTT model incorporates three important components, namely the learning object design, the generative learning based on Grabowski (1996) and HOTS based on Bloom Taxonomy of thinking (Bloom *et al*., 1956) in technology-supported learning environment. The Web-based environment is a promising technology that enables the designers to create flexible and powerful learning systems that support the design of GLOOTT model.

The GLOOTT model provides a pedagogically-enriched learning environment to engage students in HOTS and to promote their understanding. The GLOOTT model consists of Generative Learning Object Organizer (GLOO) and Thinking Task (TT) as depicted in Figure 1.1. TT consists of Try it Out that contains multiple-choice questions and Apply it that contains scenario-based problems. Details about the design and development of Web learning system would be discussed in Chapter 4.

To the best of the researcher's literature study, a learning object design system that is based on theoretical learning approaches which pervades in constructivism and focuses on learner-centered learning and HOTS has not yet been developed. Most of the learning object design systems focus mainly in the designs of teaching materials for trainer and instructor. Besides, minimal research has been done to demonstrate the effects of learning object design on learning (Bannan-Ritland, Dabbagh and Murphy, 2000), and the researcher has not found substantial research showing the effects of the learning object design with pedagogical design on academic achievement and HOTS. The suggested conceptual model (GLOOTT model) incorporates the theoretical, pedagogical and technological perspectives from generative learning, learning object and essential cognitive operations of HOTS in the Web-based learning environment.

1.7 The Framework of Instructional Design Model

The instructional design (ID) model used in the research is modified from the ISDMELO (Instructional System Design Methodology based on e-Learning Object) (Baruque and Melo, 2003). Figure 1.2 illustrates the proposed framework of the instructional design model used in this research.

The ID model of the research incorporates learning object design principles, generative learning design principles, and Web-based learning design principles in order to promote understanding and improve HOTS of the students in the learning process. The prototype of the Web-based learning system is designed, developed and evaluated to determine its effectiveness in a college. The modified ISDMELO model is used because it was developed for the design and development of Web-based educational content that was built on the fundamental of instruction design based on learning object. The ISDMELO model is modified from the ADDIE model (Molenda, Pershing and Reigeluth, 1996) that provides systematically instruction plan. In addition, the ISDMELO is grounded on pedagogical principles and supports the adoption of learning theories such as constructivism, cognitive and behaviourism. The details about each phase of the ISDMELO were discussed in Chapter 3.

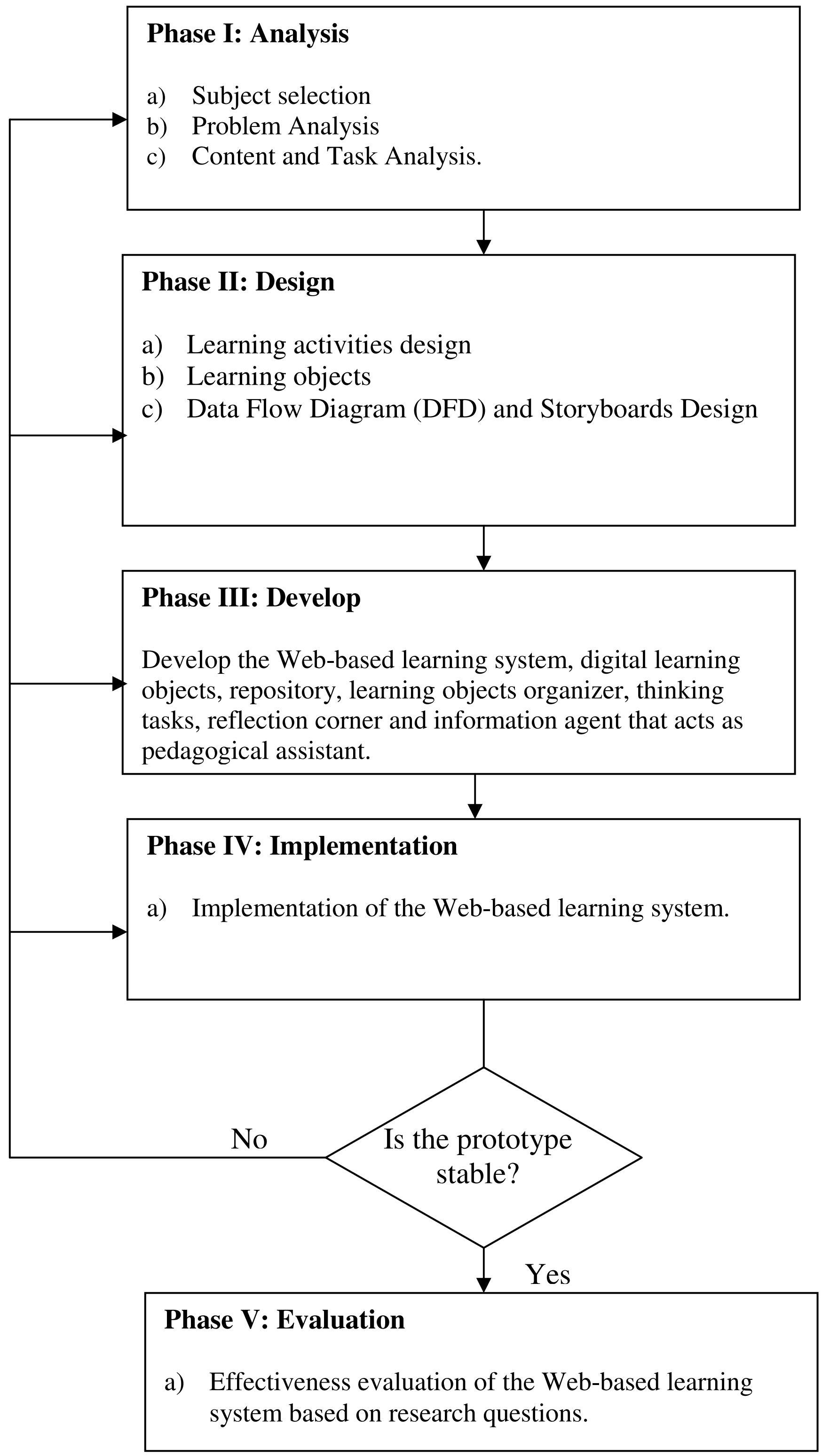

Figure 1.2: The Framework of ID Model
(Modified from ISDMELO, Baruque and Melo, 2003)

1.8 Research Importance

This research proposes a theoretical framework of Web-based learning system that provides the instructor with the flexible and reusable learning content in Computer System (CS). The Web-based learning system helps the instructor to identify students' engagement of HOTS and their understanding. The findings will help the instructors, especially Computer Science instructors in planning the teaching and learning of CS using the Web.

This research also proposes a unique framework of instructional design model that provides an alternative of instructional design based on the learning object design and generative learning. The findings from this research would demonstrate the effectiveness of technology in improving students' learning and HOTS. In addition, it also contributes in the design and development of the Web-based learning especially with the use of learning objects. Results from this study are important to show the effectiveness of the learning objects in learning as most of the current researches in learning object design mainly focus in technical and standard issues. Besides, the findings from this study would contribute to the existing evaluations of Web-based learning and learning object design. The results would also suggest that an empowered learning can be achieved by putting more emphasis on the pedagogical design learning environment rather than the technological aspects in order to develop a system that is able to encourage students to learn actively and improve their HOTS.

The proposed system conceptual model from the research theoretical framework, namely GLOOTT model, the Web-based instructional design framework, research methodology and findings may be used as guide or reference besides provoking ideas for other researchers who are interested in learning object design, generative learning, HOTS and Web-based learning. On the other hand, it also can be used as a guide in helping the higher education institutes, educational technology and other relevant parties in the design and development of e-learning system to engage students in HOTS.

1.9 Research Scope and Limitation

This research aims to design and develop a Web-based learning system that incorporates the generative learning strategies and learning object design to provide a learning environment that engage students in HOTS. The cognitive operations of HOTS in this research are Analysis, Synthesis and Evaluation. The features and rationales of generative learning, learning object design and HOTS have been discussed previously in the rationale and theoretical framework of study.

The activities of generative learning used in this research are concept mapping and scenarios-based problems solving. These generative learning activities are well documented in the literature as discussed in the research background and research rationale. The use of learning object design in teaching and learning has received increasing attention in the recent years. The main advantages of the learning objects are flexibility and reusability. However, it is a widely belief that the learning object design does not add significant value to the learning if there is an overemphasis on the technical aspect rather than supporting learning. In this research, the learning object design was focused on how its application to support learning. The HOTS are widely discussed in the literature and research. The Bloom's Taxonomy of Thinking is used to identify the students' HOTS in this research because it is well documented in the literature and research in determining the level of HOTS.

This research focuses on learning of Computer System for the college students from Computer Science Department in Southern College. The subtopics of the subject studied in this research were Introduction to Computer System, System Unit, Input, Output and Storage. The Web-based learning system designed in this research is a learning tool that can be used for other subjects. However, in studying its effectiveness in learning Computer System, the research was limited to Computer Science students in a college. The content of the learning had been validated by the lecturers who had taught the subject. The effectiveness of the system was studied from the aspects of engagement of HOTS, improvement of HOTS and learning of the students. This research did not consider the interest and learning styles of the students that could affect their performance and learning. Moreover, the findings of this research should not be generalized to other students. It is important to point out that the main purpose of this research is to conceptualize and to design Web-based learning objects based on the pedagogical perspectives. The emphasis of this research is to study the effectiveness of the proposed design in learning rather than the technical issues relating to the learning object design.

1.10 Operational Definition

The following are definitions of some terminologies used in this dissertation for clearer comprehension of the issues in this research.

(i) Learning Object

A learning object is an object or set of resources that can be used to facilitate the learning of certain subject (Mills, 2002). It is flexible and reusable. It is stored and accessed using meta-data attributes. A learning object is a self-contained, reusable chunk of instruction that can be assembled with other objects. A learning object can teach facts, concepts, principles, procedures and processes.

(ii) Granularity

The meaning of granularity in this research is the size (content) of the learning objects (Wiley, 2002a; Wiley, 2002b). It is the amount of information and content to be included into a learning object.

(iii) HOTS

HOTS is the abbreviation of Higher Order Thinking Skills. The cognitive operations of HOTS in this research are Analysis, Synthesis and Evaluation (see Johnson, 1999; Jonassen, 1992; Parham, 2003; Swatrz, 2001; Marzano, *et al*. 1988; Bloom *et al.*, 1956; Bloom, Hasting and

Madaus, 1971) with the consideration of the curriculum in learning Computer System.

(iv) Bloom's Taxonomy of Thinking

Table 1 describes the features of the Bloom Taxonomy of Thinking used in this research (Bloom *et al*., 1956).

Table 1.1: Bloom Taxonomy of Thinking (from Bloom, *et al*., 1956; Bloom, Hasting and Madaus, 1971)

Bloom Taxonomy of Thinking	**Features**
Knowledge	Knowledge is defined as the remembering of previously learned material. This involves the recall of specific elements in a subject matter. Knowledge represents the lowest level of learning outcomes.
Comprehension	Comprehension is the ability to grasp the meaning of material. It is described in three different operations: translating material from one form to another, interpreting material and estimating future trends. These learning outcomes represent the lowest level of understanding.
Application	Application is the ability to use learned material to new problems and situations. For examples, the application of rules, methods, principles and theories. The learning outcomes represent the higher level of understanding than knowledge and comprehension.
Analysis	Analysis is the ability to break down material into its constituent parts into the relative hierarchy of ideas with the relations between the ideas. This includes the identification of parts and the hierarchical organization, and analysis of the relationships between the parts. Learning outcomes are higher than knowledge, comprehension and application. Analysis is recognized as an element in HOTS.

Synthesis	Synthesis is the ability to put parts together to form a whole. This involves the process of arranging, combining and working with parts them in such a way as to constitute a new pattern or structure. The learning outcomes emphasize on the formation of new patterns or structures and creative behavior. Synthesis is recognized as an element in HOTS.
Evaluation	Evaluation is defined as the ability to judge the values of materials for some purposes or solutions. The judgments are based on definite criteria either those determined by the students or those given to them. The learning outcomes are at the highest cognitive hierarchy. Evaluation is recognized as a cognitive operation in HOTS.

(v) Learning improvement

In this study, the improvement of learning is defined as the improvement of the score in the test that was designed based on the learning goals of Computer System.

(vi) Effectiveness

In this study, the evaluation of the Web-based system effectiveness is focused on the improvement of students' learning and HOTS before and after the use of the system through the one group pretest and posttest.

(vii) Generative Learning

Constructivist design provides learning environment that enables students to synthesize, analyze and evaluate as well as to create and contribute resources (McLoughlin, 1998). Generative learning is a type of instruction developed by constructivists that is widely documented. The generative learning activities involve the creation of relationships and meanings of the learning. In the generative learning, students are active in the knowledge construction. Experts and researchers advocate that concept mapping and problem solving are activities of generative learning. Concept mapping and problem solving will engage students in analysis, synthesis, and evaluation skills. Thus, it is important to integrate these skills into learning in order to promote HOTS. In the generative learning environment, students are active in constructing meaningful understanding of information found and generating relationships among the information.

(viii) GLOOTT Model

GLOOTT refers to Generative Learning Object and Thinking Tasks. It is a pedagogically-enriched conceptual model that was designed based on learning object, generative learning and HOTS.

(ix) GOOD Learning System

GOOD learning system refers to Generative Object-Oriented Design Learning System. It is the Web-based learning system designed based on the system conceptual model, namely GLOOTT Model in this research.

(x) Computer System (CS)

CS is a core subject of the first year Diploma in Computer Science course in Southern College.

(xi) Lesson Mapping

Lesson mapping is the mapping of concepts in the learning of CS based on the design of concept mapping. It is the generative learning activity designed in the Web-based learning system that aims to engage students in HOTS. It is an outline form of concept map suggested by Alpert and Grueneberg (2000), and Dabbagh (2001).

(xii) Electronic Portfolio

Electronic portfolio is the portfolio that is saved in electronic format (Lankes, 1995). The electronic portfolio used in this research contains only the record of "How am I doing" checklist list in the Web-based system. The checklist is used to record the students' engagement of HOTS when they use the Web-based learning system.

(xiii) Learning Object Design

Learning object design is an application of object-oriented thinking to the world of learning. It is a term used to describe the design of leaning into flexible pieces of learning content that could be assembled and reassembled as needed. Learning objects are small reusable components such as video, tutorials, procedures, stories, animations, simulations and so on.

1.11 Summary

This chapter presents an overview of the background and rationale for this research. Chapter 2 will present a detailed analysis of the literature relevant to this research, which is a key part of the theoretical framework and the framework of instructional design model used in this research. Chapter 2 will also present the instructional design and the learning object design, generative learning, HOTS, the learning of computer and literature that pertinent to this research.