CHAPTER 2 LITERATURE REVIEW

2.1 Purpose

The purpose of the literature review is to study the pedagogical issues in learning and study the evaluation methods in Human Computer Interaction. This study is important to come up with an educational system considering not only usability issues but also the learning issues.

2.2 Approach

The literature review for this research was done based on books, the World Wide Web and journals related to the topics being studied.

2.3 Analysis

2.3.1 Pedagogical Issues in Learning

2.3.1.1 Introduction

The growing number of older, non-traditional college students and the mounting evidence of the importance of constructivist learning environments must result in critical changes in academia [1]. Adult learners now account for almost half of all undergraduate students [2]. Although many of them are full-time students, adult learners spend less time on campus. Adult learners want creative ways to complete their education and they want instruction that allows them to make links between their experience and new knowledge. They also want their learning to be relevant and directly applicable [2]. Traditional didactic methods of teaching and teacher-centered instruction will no longer suffice. Knowles, Holton, and Swanson [3] write that "education emphasizes the educators, while learning emphasizes the person in whom the change occurs or is expected to occur." (p. 66). Constructivist learning environments, whether on-campus or on-line, can shift the emphasis from teacher to learner and provide contextualized, situated learning in a self-directed, interactive environment. The end result will be improved learning for all students, whether they be eight years old or eighty.

2.3.1.2 Behaviorist learning theory

The concern or emphasis of Behaviorism is observable indicators that learning is taking place. Contrasting this view of learning is the emphasis of cognitive psychologists who equate learning with the mental processes of the mind. Behaviorists do not deny the existence of these mental processes. In fact, they acknowledge their existence as an unobservable indication of learning.

The focus of Behaviorism is on the conditioning of observable human behavior. J. B Watson, the father of Behaviorism, defined learning as a sequence of stimulus and response actions in observable cause and effect relationships. The behaviorists' example of classical conditioning demonstrates the process whereby a human learns to respond to a neutral stimulus in such a manner that would normally be associated with an unconditioned stimulus. The supporting example often cited with classical conditioning is the case of Pavlov's dog. The focus of Pavlov's experiment was the digestive process in animals. In conducting the experiment, Pavlov noticed that the dog would salivate (response), upon hearing the ringing of a bell. This occurred because the dog had learned to associate its unconditional stimuli (normally feeding), with the neutral stimuli of the bell ringing simultaneously with the feeding process. Watson, believed that the stimuli that humans receive may be generated internally (for example hunger), or externally (for example, a loud noise). B.F. Skinner expanded on the foundation of Behaviorism, established by Watson, and on the work of Edward Thorndike, by focusing on operant conditioning. According to Skinner, voluntary or automatic behavior is either strengthened or weakened by the immediate presence of a reward or a punishment. "The learning principle behind operant conditioning is that new learning occurs as a result of positive reinforcement, and old patterns are abandoned as a result of negative reinforcement." Belkin and Gray [4], in his book entitled, The Technology of Teaching, Skinner wrote:

> *The application of operant conditioning to education is simple and direct. Teaching is the arrangement of contingencies of reinforcement under which students learn. They learn without teaching in their natural environments, but teachers arrange special contingencies which expedite learning, hastening the appearance of behavior which would otherwise be acquired slowly or making sure of the appearance of behavior which otherwise never occur.* [5, p.64].

Skinner believed that more complex learning could be achieved by this process of contingencies and reinforcement "... through successive stages in the shaping process, the contingencies of reinforcement being changed progressively in the direction of the required behavior." [5, p.10]

Applying the theoretical principles of Behaviorism to learning environments, it is easy to recognize that we have many "behaviorist artifacts" in our learning world. A dissection of the traditional teaching approaches used for years would reveal the powerful influence that Behaviorists have had on learning. The concept of directed instruction, whereby a teacher is providing the knowledge to the students either directly or through the set up of "contingencies", is an excellent example of the Behaviorist model of learning. The use of exams to measure observable behavior of learning, the use of rewards and punishments in our school systems, and the breaking down of the instruction process into "conditions of learning" (as developed by Robert Gagne), are all further examples of the Behaviorist influence.

With the advent of the computer in school, C.A.I., or computer-assisted instruction has become a prominent tool for teaching, because from a Behaviorist perspective, it is an effective way of learning. CAI uses the drill and practice approach to learning new concepts or skills. The question acting as the stimulus, elicits a response from the user. Based on the response a reward may be provided. The "contingencies" of learning are translated into different levels of the program. Rewarding the user to a different level for correct responses follows exactly the approach of operant conditioning. Educators have espoused CAI as an effective teaching approach because it allows for self-paced instruction and it liberates them from the direct instruction of all their students so as to focus on those students with particular needs.

2.3.1.3 Constructivist learning theory

The merits of Behaviorist learning theory and of their teaching practices are well documented. They have served well in teaching a growing North American population over the past six decades. Behavioral learning theory manifested itself in creating a systematic approach to teaching.

Robert Gagne and Leslie Briggs, in their book, Principles of Instructional Design, combined Behaviorist principles of learning with a cognitive theory of learning named Information-Processing. The focus of the latter theory in this combination was of the internal processing that occurred during a learning moment.

The design of instruction must be undertaken with suitable attention to the conditions under which learning occurs. With reference to the learner, learning conditions are both external and internal. These conditions are in turn dependent upon what is being learned. How can these basic ideas be used to design instruction? How can they be applied to the design of single lessons, of courses, and of entire systems of instructions? [6, p. 14]

Gagne and Briggs' principles of instructional design broke down the teaching process into a systematic process of nine steps. It is in effect, this type of systematic approach to teaching that acted as the catalyst for the creation of another view of the way humans learn.

Behaviorist learning theory had served its purpose and its approach and goals were becoming outdated according to Constructivists like Seymour Papert. Constructivist learning theory sought to improve on what Behaviorist learning theory had already established by focusing on the motivation and ability for humans to construct learning for themselves. It viewed Behaviorism as being too teacher centered and directed. Constructivists regarded the educational system as a process of matching skill objectives with test items. It was void of meaningful learning. They also saw the teaching process focus too much on individual work rather than on group work.

The final critique of Behaviorist learning theory from the Constructivist perspective helped define the core of Constructivism. To imply that knowledge is separate to the human mind and that it must be transferred to the learner in a teacher centered approach fundamentally was counter to the Constructivist theory of learning.

Constructivists believe that all humans have the ability to construct knowledge in their own minds through a process of discovery and problem solving. The extent to which this process can take place naturally, without structure and teaching is the defining factor amongst those who advocate this learning theory.

Jean Piaget, a Swiss psychologist, observed human development as progressive stages of cognitive development. His four stages, which commence at infancy and progress into adulthood, characterize the cognitive abilities necessary at each stage to construct meaning of ones environment.

Seymour Papert, psychologist and contemporary critique of Behaviorist teaching methods, writes in his book, The Children's Machine:

> *Thus, constructionism, my personal reconstruction of constructivism has as its main feature the fact that it looks more closely than other educational -isms at the idea of mental construction. It attaches special importance to the role of constructions in the world as a support for those in the head, thereby becoming less of a purely mentalist doctrine.* [7, p.142]

As the inventor of LOGO, the programming tool for children, Papert too believed that children as learners have a natural curiosity to construct meaning of their world.

The educational system as Papert saw it was too structured and it stifled this natural curiosity. The means by which children were being taught relegated them to a role of passive recipients of the teaching hence, they were not motivated to construct any learning for themselves. Learning according to Constructivists is a question of motivating an individual to attach new meaning to past cognitive experiences. According to Papert:

> *It [constuctivsm] does not call in question the value of instruction as such. That would be silly: Even the statement (endorsed if not originated by Piaget) that every act of teaching deprives the child of an opportunity for discovery is not a categorical imperative against teaching, but a paradoxically expressed reminder to keep it in check. The constructionist attitude to teaching is not at all dismissive because it is minimalist - the goal is to teach in such a way as to produce the most learning for the least teaching. Of course, this cannot be achieved simply by reducing the quantity of teaching while leaving everything unchanged. The principle other necessary change parallels an African proverb: If a man is hungry you can give him a fish, but it is better to give him a line and teach him to catch fish himself.* [7, p.139]

Papert's desire to have children become motivated learners, critical thinkers, problem-solvers and metacognitionists is to be achieved through educational reform that provides the learner with the necessary tools to participate and to take ownership of the learning process. According to Papert, the computer is the appropriate tool to achieve such desired educational reform.

These desired objectives of Papert and others who share the Constructivist view of learning are coming closer to reality as more people discover the power of computer technology. From Donald Tapscott's perspective, Papert's desired reality is happening now, as a paradigm shift to more interactive learning due to the exploitation of the digital media is taking place in our learning institutions.

Tapscott cites eight shifts in learning today:

- From linear to hypermedia.
- From instruction to construction and discovery.
- From teacher-centered to learner-centered education.
- From absorbing material to learning how to navigate and how to learn.
- From school to lifelong learning.
- From one-size-fits-all to customized learning.
- From learning as torture as learning as fun.
- From the teacher as transmitter to the teacher as facilitator.

Agreement on a constructivist theory of learning is not widespread due largely to what Derry [8] terms "ethnocentrism within various constructivisms". At the same time, Ernest [9] notes that, of seven paradigms of constructivism, the positions are all variants of radical constructivism. The outstanding consideration, however, concerns the need as Ernst sees it: "to accommodate the complementarity between individual construction and social interaction" (p.483). Whether knowledge is seen as socially situated or whether it is considered to be an individual construction has implications for the ways in which learning is conceptualized. From the radical constructivist perspective, how can their theory encompass both the collective activity and the individual experience to take into account the important classroom social interactions that are so much a part of the entire educational process? Such questions underlie the complexities involved in translating the diversity of perspectives into a common set of principles that can be operationalized. Yet, as Ernest claims in relation to the varying constructivist perspectives: "there is the risk of wasting time by worrying over the minutiae of differences" (p.459). Perhaps then, the optimal starting point for understanding the constructivist perspective to teaching and learning is to consider what constructivism is not.

Where behaviorism emphasizes observable, external behaviours and, as such, avoids reference to meaning, representation and thought, constructivism takes a more cognitive approach. This subtle difference has profound implications for all aspects of a theory of learning. The way in which knowledge is conceived and acquired, the types of knowledge, skills and activities emphasized, the role of the learner and the teacher, how goals are established: all of these factors are articulated differently in the constructivist perspective. Within constructivism itself, authors, researchers and theorists articulate differently the constructivist perspective by emphasizing different components.

Nonetheless, there is some agreement on a large number of issues, for example, on the role of the teacher and learner. In von Glasersfeld's [10] radical constructivist conception of learning, the teachers play the role of a "midwife in the birth of understanding" as opposed to being "mechanics of knowledge transfer". Their role is not to dispense knowledge but to provide students with opportunities and incentives to build it up [11]. Mayer [12] describes teachers as "guides", and learners as "sense makers". In Gergen's [13] view, teachers are coordinators, facilitators, resource advisors, tutors or coaches. Understanding the role of the teacher in the constructivist classroom provides a useful vantage point from which to grasp how the theory impacts on practice:

The role of the authority figure has two important components. The first is to introduce new ideas or cultural tools where necessary and to provide the support and guidance for students to make sense of these for themselves. The other is to listen and diagnose the ways in which the instructional activities are being interpreted to inform further action. Teaching from this perspective is also a learning process for the teacher [14, p. 11].

While the radical and social perspectives of constructivism each have their particular emphases, Ernest derives a set of theoretical underpinnings common to both:

Knowledge as a whole is problematized, not just the learner's subjective knowledge, including mathematical knowledge and logic.
Methodological approaches are required to be much more circumspect and reflexive because there is no "royal road" to truth or near truth. The focus of concern is not just the learner's cognitions, but the learner's cognitions, beliefs, and conceptions of knowledge.

The focus of concern with the teacher and in teacher education is not just with the teacher's knowledge of subject matter and diagnostic skills, but with the teacher's belief, conceptions, and personal theories about subject matter, teaching, and learning.

Although we can tentatively come to know the knowledge of others by interpreting their language and actions through our own conceptual constructs, the others have realities that are independent of ours. Indeed, it is the realities of others along with our own realities that we strive to understand, but we can never take any of these realities as fixed.

An awareness of the social construction of knowledge suggests a pedagogical emphasis on discussion, collaboration, negotiation, and shared meanings (...) [10, p.485].

Central to constructivism is its conception of learning. Von Glasersfeld [15, p.14] argues that: "From the constructivist perspective, learning is not a stimulus-response phenomenon. It requires self-regulation and the building of conceptual structures through reflection and abstraction". For educators, the challenge is to be able to build a hypothetical model of the conceptual worlds of students since these worlds could be very different from what is intended by the educator [11].

In this paradigm, learning emphasizes the process and not the product. How one arrives at a particular answer, and not the retrieval of an 'objectively true solution', is what is important. Learning is a process of constructing meaningful representations, of making sense of one's experiential world. In this process, students' errors are seen in a positive light and as a means of gaining insight into how they are organizing their experiential world. The notion of doing something 'right' or 'correctly' is to do something that fits with "an order one has established oneself" [16, p. 15]. This perspective is consistent with the constructivist tendency to privilege multiple truths, representations, perspectives and realities. The concept of multiplicity has important implications for teaching and learning:

Multiplicity is an overriding concept for constructivism. It defines, not only the epistemological and theoretical perspective but, as well, the many ways in which the theory itself can be articulated. Researchers and theorists have developed variants of constructivism or have evolved the theory in different directions. Nonetheless, there are many common themes in the literature on constructivism, which permit the derivation of principles, instructional models and general characteristics. The following section outlines how a constructivist theory of learning may be expressed as or translated into a wide variety of specific characteristics or principles of constructivist learning and teaching.

2.3.1.3.1 Characteristics of Constructivist Learning

The presentation of characteristics in this section aims to remain true to this analogy in that it recognizes and attempts to represent the variety of ways in which constructivism is articulated in the literature. Situated cognition, anchored instruction, apprenticeship learning, problem-based learning, generative learning, constructionism, exploratory learning: these approaches to learning are grounded in and derived from constructivist epistemology. Each approach articulates the way in which the concepts are operationalized for learning. The researchers and theorists whose perspectives are listed below suggest links between constructivist theory and practice. They provide the beginnings of an orienting framework for a constructivist approach to design, teaching or learning.

Jonassen [17] notes that many educators and cognitive psychologists have applied constructivism to the development of learning environments. From these applications, he has isolated a number of design principles:

- Create real-world environments that employ the context in which learning is relevant;
- Focus on realistic approaches to solving real-world problems;
- The instructor is a coach and analyzer of the strategies used to solve these problems;
- Stress conceptual interrelatedness, providing multiple representations or perspectives on the content;
- Instructional goals and objectives should be negotiated and not imposed;
- Evaluation should serve as a self-analysis tool;
- Provide tools and environments that help learners interpret the multiple perspectives of the world;
- Learning should be internally controlled and mediated by the learner (pp.11-12).

Jonassen [17] summarizes what he refers to as "the implications of constructivism for instructional design". The following principles illustrate how knowledge construction can be facilitated:

- Provide multiple representations of reality;
- Represent the natural complexity of the real world;

- Focus on knowledge construction, not reproduction;
- Present authentic tasks (contextualizing rather than abstracting instruction);
- Provide real-world, case-based learning environments, rather than pre-determined instructional sequences;
- Foster reflective practice;
- Enable context-and content dependent knowledge construction;
- Support collaborative construction of knowledge through social negotiation (p.35).

Wilson & Cole [18] provide a description of cognitive teaching models which "embody" constructivist concepts. From these descriptions, we can isolate some concepts central to constructivist design, teaching and learning:

- Embed learning in a rich authentic problem-solving environment;
- Provide for authentic versus academic contexts for learning;
- Provide for learner control;
- Use errors as a mechanism to provide feedback on learners' understanding (pp.59-61).

Paul Ernest [19] in his description of the many schools of thought of constructivism suggests the following implications of constructivism which derive from both the radical and social perspectives:

- sensitivity toward and attentiveness to the learner's previous constructions;
- diagnostic teaching attempting to remedy learner errors and misconceptions;
- attention to metacognition and strategic self-regulation by learners;
- the use of multiple representations of mathematical concepts;

- awareness of the importance of goals for the learner, and the dichotomy between learner and teacher goals;
- awareness of the importance of social contexts, such as the difference between folk or street mathematics and school mathematics (and an attempt to exploit the former for the latter) (p.485).

Honebein [20] describes seven goals for the design of constructivist learning environments:

- Provide experience with the knowledge construction process;
- Provide experience in and appreciation for multiple perspectives;
- Embed learning in realistic and relevant contexts;
- Encourage ownership and voice in the learning process;
- Embed learning in social experience;
- Encourage the use of multiple modes of representation;
- Encourage self-awareness in the knowledge construction process (p.11).

An important concept for social constructivists is that of scaffolding which is a process of guiding the learner from what is presently known to what is to be known. According to Vygotsky [21], students' problem solving skills fall into three categories:

- Skills which the student cannot perform
- Skills which the student may be able to perform
- Skills that the student can perform with help

Scaffolding allows students to perform tasks that would normally be slightly beyond their ability without that assistance and guidance from the teacher. Appropriate teacher support can allow students to function at the cutting edge of their individual development. Scaffolding is therefore an important characteristic of constructivist learning and teaching.

2.3.1.4 Socio-constructivist view of learning

In her review of theories of learning and multimedia applications, Atkins [22] suggests that learning with interactive courseware delivered on advanced technology platforms can be categorized in terms of two dominant underlying views of learning: the behaviorist and the cognitive. Within the cognitive theory, she distinguishes between 'weak' artificial intelligence and constructivist view of learning. While there are many interpretations of constructivism [23], the description provided by Soloway et al. [24] as learning understanding being "active", constructive, generative processes such as assimilation, augmentation, and self-reorganisation captures the essence of the constructivist perspective. Soloway et al. also address the issue of the social context of learning by synthesizing the work of a number of authors to state that the central notion of socio-culturism is "that learning in enculturation, the process become collaborative meaning-makers among a group of defined by common practices, language, beliefs, use of tools and so on.(p. 190). Taken together, the central notions of constructivism and socioculturism can be described as socio-constructivism. This is discussed in more detail in the next section.

As theories of learning have developed and educationalists have gained more experience of using computer-based technology, there has been a shift of emphasis from the behaviorist paradigm, through the weak artificial intelligence approach, to a constructivist view. For most educationalists, constructivism offers far more scope for realizing possible learning benefits of using information and communication technology .In fact, Reeves [25] refers to the claim by Gagne and Glaser [26] that virtually self-respecting instructional design theorists now claim to be cognitivists.

Many writers have expressed their hope that constructivism will lead to better educational software and better learning (eg., [27, 28, 29]). They stress the need for open-ended exploratory authentic learning environments in which learners can develop personally meaningful and transferable knowledge and understanding.

The issue emerging from the constructivist view of learning in the context of Malaysian learners will be discussed in the following section.

2.3.1.4.1 Characteristics of socio-constructivism

This section presents a synthesis and summary of the characteristics of constructivists learning and teaching as presented by the review in the section 2.3.1.3 on constructivist theory. These characteristics are viewed with respect to the culture of students in Klang Valley and Selangor and also the Malaysian Education system.

2.3.1.4.1.1 Multiple Perspectives

Multiple perspectives and representational of concepts and content are presented and encouraged. The collaboration and communication as well as a variety of tools used and data accessed should be stressed to provide students in a classroom with many perspectives in their scientific investigations. The students in a classroom or lecture hall come from many different backgrounds and characteristics, therefore they will have many different perspectives of a certain issue and thus, through collaboration students can learn in many different ways.

Therefore, in order to come up with an educational system appropriate for students in a classroom, it is important to find out the **user characteristics** for example, their experience and skill in computers and their language proficiency.

2.3.1.4.1.2 Goals and Objectives

Goals and objectives are derived by the student or in negotiation with the teacher or system. Students should feel a sense of ownership that allows him to state what he wants to learn out of the educational system.

For the students to come up with their own goals and objectives, the courseware should contain objectives to teach a specified lesson. Therefore, when evaluating the an educational system, students should be asked about their **goal characteristics**.

2.3.1.4.1.3 Teacher's role

Teachers serve in the role of guides, monitors, coaches, tutors and facilitators. In the Malaysian education system, a teacher's role is essential as learning is more teacher-directed. But, in the socio-constructivist view or learning, teacher should only guide the learning and tutor the students on a certain concept. A courseware should be designed to allow a student to work independently. Students must be asked about their opinion about the **method of delivery** of a courseware, ,which they used to see whether they could use the courseware independently. This to make sure that the Klang Valley students is fine with using an educational system independently.

2.3.1.4.1.4 Metacognition

Activities, opportunities, tools and environment are provided to encourage metacognition , self-analysis, self-regulation, self-reflection and self-awareness. It is claimed that by a conscious personal appraisal for learner's cognitive processes, individuals can improve their capacity to learn. Clearly, for this to be effective there is an assumption that learners feel a sense of ownership of their learning.

To accommodate this in a courseware, it should contain structured lessons, self-assessments tests, exercises and feedback so that students are provided with activities to encourage metacognition , self-anlaysis, self-regulation , self-reflection and self-awareness. Therefore, in the evaluation of an educational system, we must also evaluate the **lesson structure**.

2.3.1.4.1.5 Learner Control

The student plays a central role in mediating and controlling learning. A tenet of constructivism is that learners direct their own learning either individually through collaborative experiences. This implies that learners need to find their own path–ways through learning; a philosophy that underpins hypertext and many web-based instructional systems [30]. Students should be able to use mail services, messengers to talk to experts and get their opinions on a particular field of study. Therefore, this could be accommodated if students are independent rather than being told what to study and what not and getting instructions from lecturer on a course. In the questionnaires, students shall be asked if they could adapt to this kind of **method of delivery**.

2.3.1.4.1.6 Authentic activities and contexts/Primary sources of data

Primary sources of data are used in order to ensure authenticity and real world complexity. Through the scientific visualizations, students can view "massive amount of data". The data must be presented 'holistically'. Animated sequences can be used to show progression over time. Usage of color and shape can illustrate the interaction of variables. However, views held by learners may be at odds with designer's view and thus lead to confusion for learners. This normally happens when the designer is from totally a different culture and background compared to the learner.

Therefore, the communication between the developer of an educational system and the user must match in order to provide the user with an authentic environment while using the system. **Communication** issues must be discussed with the users while evaluating an educational system.

2.3.1.4.1.7 Knowledge Construction

This construction takes place in individual contexts and through social negotiation, collaboration and experience. Learners build knowledge by engaging themselves in collaborative and scientific investigations. The emphasis on problem solving must stress on knowledge construction as opposed to knowledge "telling". Students need to identify what it is they do not know and as a group, must try to extend their understanding. Students who are under the same education system will have better communication among themselves because they experience more or less the same method of learning. But then again, in a multiracial country like Malaysia, it might not be true at the University level since the students come from many different schools and much different culture. Despite staying in the same country, they have a communication barrier to a certain extent. Therefore, **user characteristics** are important when evaluating an educational system.

2.3.1.4.1.8 Knowledge Collaboration

Collaborative and cooperative learning are favoured in order to expose the learner to alternative viewpoints. Social interaction and knowledge sharing must be stressed to get a clearer picture on the study and research. Students can collaborate with teachers and other experts or even with fellow classmates to share their views and construct knowledge.

The notion of peer group learning implicit in a social constructivist view introduces a social dimension in which learners delegate, to some extent, the control of the learning experience to other members of the group and to the group dynamic as a whole [30]. There is also an implication that with the autonomy that computer based learning environments can bring to the learner, there will be a shift in the balance of responsibility from the teacher to the learner, which is important in the Malaysian education system where currently teacher is a director of the learning process. It is again important to find out the **method of delivery** of a courseware the Klang Valley students use. This must be asked when evaluating an educational system in the Malaysian environment.

2.3.1.4.1.9 Previous knowledge construction

The learner's previous knowledge constructions, beliefs and attitudes are considered in the knowledge construction process. The learner's personal skills, fluency in language used in the context, mental models on the research field and background will affect the knowledge construction in the particular learning context. Students must compare their knowledge, beliefs and understandings with experts or other students.

A group of students who come from the same school, same classroom and same education system, will still have different mental models because the way a student construct knowledge depends on his skills, attitudes and beliefs. This shows that users' characteristics are important to see their reaction towards an educational system.

2.3.1.4.1.10 Problem solving

Problem-solving, higher order thinking skills and deep understanding are emphasized. It depends on how a student constructs knowledge and uses it for problem solving. It is therefore important to evaluate the **lesson structure** of an educational system to see if it encourages students to think and solve problems.

2.3.1.4.1.11 Consideration of errors

Errors provide the opportunity for insight into students' previous knowledge constructions. Meaningful errors can serve as feedback for students to enhance their understanding. Therefore, students must be asked to evaluate the **functionality** of an educational system to see if the error messages are positive. Error messages, which are too general, do not provide the student with some insight on how to find the solution.

2.3.1.4.1.12 Exploration

Exploration is a favoured approach in order to encourage the users to seek knowledge independently and to manage the pursuit of their goals. Due to a teacher-directed learning method, Malaysian students are not used to exploring something in their own ways , but they tend to scope what is asked by their teachers. However, with a computer based learning system, students will be encouraged to navigate and look for information beyond the teacher's scope. An educational system need appropriate **navigation** to ensure that the students could explore independently and they will not get frustrated.

2.3.1.4.1.13 Apprenticeship learning

Learners are provided with the opportunity for apprenticeship learning in which there is an increasing complexity of tasks, skills and knowledge acquisition. This is important for novice users because they are unlikely to get lost. The students must be asked about the **lesson structure** whether there are structured lessons.

2.3.1.4.1.14 Authentic Assessment

Assessment is authentic and interwoven with teaching. Students are encouraged to pass up their work through e-mail or mark their own work by comparing the answers given in the application. The **lesson structure** must accommodate questions with feedback as well so that students can do self-assessment.

The above characteristics will be interrelated with Nielson's software heuristics and the culture of Malaysian learners for the preparation of a set of questionnaires to evaluate some of the educational software used by the Malaysian students for the purpose of learning.

2.3.2 Evaluation Methods In Human Computer Interaction.

As we know, evaluation is concerned with gathering data about the usability of a design or product by a specified group of users for a particular activity within a specified environment or work context.

There are few general reasons for doing evaluations which are : [31]

- **Understanding the real world.** How do users employ the technology in the workplace? Can design be improved to fit the work environment better? This kind of activity is particularly important during requirements gathering and then later for checking that the prototypes of the system do fulfill user needs.

- **Comparing designs.** Which is the best? There are various occasions when designers want to compare two or more designs or design ideas. For example, early in the design process there may be debate about exactly which functions are essential and how best to represent them on the screen display. On such occasions the designers may run tests that aim to compare two or more designs. Comparisons may also be made of design specifications using techniques that do not involve users.

- **Engineering towards a target.** Is it good enough? Here the design process can be viewed as a form of engineering. The designers have a target, which is often expressed as some form of metric, and their goal is to make sure that their design produces a product that reaches the goal. The kind of metric against which a prototype or system may be tested could be, for example: x% of novice users should be able to print out a document correctly first time.

- **Checking conformance to a standard.** Does this product conform to the standard? For example, is the screen legibility acceptable? Standard bodies have rigorous testing procedures to test that products conform to the standards that they have set.

In the field of Human Computer Interaction (HCI), we learn numerous evaluation methods such as observing and monitoring, users opinions, experiments and benchmarks, interpretive and also predictive. But, as we go through all these evaluation methods, we will come across many advantages and disadvantages of each of these methods.

2.3.2.1 Observing and Monitoring

In one way or another, several different kinds of evaluation depend on some form of observation or monitoring of the way that users interact with a product or prototype. Observation or monitoring may take place informally in the field or in a laboratory as part of more formal usability testing. Alternatively, it may be done from a participative or ethnographic perspective with the aim of really trying to understand how much users themselves interact with technology in natural settings. There are a number of techniques for collecting and analyzing data. Data may be collected using direct observation with the observer making notes or some other form of recording such as video may be used. Keystroke logging and interaction logging can also be done and often they are synchronized with video recording. The way data is analyzed will depend on the question that the evaluators want to answer. [31]

This is a good evaluation method but it is not so appropriate for evaluation of educational systems. A user, or a student will have to try out the software many times before an evaluation can actually take place. Usability of an educational software or hypertext cannot be tested if the users are for the first time using it. In this case, observing and monitoring is also not applicable.

2.3.2.2 Experiments and benchmarks

Doing well-designed laboratory experiments is not easy. A testable hypothesis needs to be stated and all but the variables of need to be controlled. Knowledge of statistics is also necessary to validate the results. Controlling all of the variables in complex interactions involving humans can be difficult and its value is often debatable. Consequently HCI has developed an engineering approach to testing in which benchmark tests are given to users in semi-scientific conditions. The experimental set up and procedure roughly follows the scientific paradigm in that the experimenter attempts to control certain variables while examining others. Often the user works in a usability laboratory, which is specially created for this kind of work. Although some of the same techniques are used to collect data (for example, video, audio and interaction logging) ,as when just observing or monitoring usage the evaluation is usually more rigorously controlled because the data is collected will be analysed quantitatively to produce metrics to guide the design[31].

2.3.2.3 Interpretive

The purpose of this kind of evaluation is to enable designers to understand better how users use the system in their natural environments and how the use of these systems integrate with other activities. The data is collected in informal and naturalistic ways, with the aim of causing as little disturbance to users as possible.

Furthermore, some form of user participation in collecting, analyzing or interpreting the data is quite common. The kinds of methods that belong to this category include participative and contextual evaluation- two evaluation methods specially devised for HCI –and ethnography – a technique borrowed from anthropology. In the latter, researchers attempt to immerse themselves in the environment of study. Notes, video and audio recordings may be made as in other methods. However, the way that the data is collected is much less formal than usage of benchmark data and the way that it is analyzed and interpreted is quite different. [31]

Interpretive evaluation is suitable for evaluating system with a small number of users and also stresses on the usage of equipments such as video and audio players to assist the collection of data.

In this study, the large number of students who act as evaluators and inadequacy of equipments in hand are two main factors that discourage me to choose this particular evaluation method of my research.

2.3.2.4 Predictive Evaluation—Software Heuristics

Predictive evaluation technique include heuristic evaluation, walkthroughs and modeling. [31]. Of these, heuristic evaluation appears most suitable for teachers for predictively evaluate educational software. Most forms of walkthroughs developed for HCI are strongly cognitively oriented and require very detailed task knowledge, which is feasible for evaluating software designed to promote clearly defined skill development but not for software which encourages creativity and which can be used in different ways by different students modeling approaches, e.g. the GOMS technique developed by Card et. al. [32], are typically too fine grained to be practical use to teacher evaluators.

Any technique used by teachers needs to be relatively quick and easy to use. Heuristic evaluation is designed to address key usability issues in a cost effective way. High-level guidelines or heuristics focus reviewers' attention as they work their way through the system, using their expertise to role-play the behavior of a typical user. The latest version of usability heuristics published by Nielson [33, p.30] are as follows: These heuristics will be used to come up with questionnaires for the evaluation of educational systems in this research.

Visibility of system status: the system should always keep users informed about what is going on , through appropriate feedback within a reasonable time. The **lesson structure** in an educational system should contain appropriate feedback about student's response to speed up learning and keep students informed of their status.

Match between the system and the real world: the system should speak the user's language , with words , phrases , concepts familiar to user, rather than system oriented terms. Follow real world conventions, making information appear in natural and logical order. For example, in order to develop a courseware for the Klang Valley students, the developer must understand the learning culture of the students there. Therefore, it is important to know the **user characteristics** before developing a courseware for the target users.

User Control and freedom: users often choose system functions by mistake and will need a clearly marked 'emergency exit' to leave the unwanted state without having to go through an extended dialogue. In this case, the **communication** in the educational system is important where students must not experience a state, which is difficult to exit or cancel a command.

Consistency and standards: users should not have to wonder whether different worlds, situations, or actions mean the same thing. Follow platform conventions. The **display layout** must be standardized throughout the application.

Error prevention: even better than good error messages is a careful design, which prevents a problem from occurring in the first place. The **functionality** of an educational system must contain error messages, which are not too general.

Recognition rather than recall: make objects , action and options visible. The user should not have to remember information from one part of the dialogue to another.

Instructions for use of the system should be visible or easily retrievable whenever appropriate. The educational system must be **easy to learn**.

Flexibility and efficiency of use: accelerators- unseen by the novice user - may often speed up the interaction for the expert user to such an extent that the system can cater for both inexperienced and experienced users. Allow users to tailor frequent actions. Therefore, in an evaluation of education system, it is important to find out the user's **satisfaction** and the **flexibility** of the system in the context of its usage.

Aesthetic and minimalist design: dialogues should not contain information, which is irrelevant, or rarely in need. Every extra unit of information and diminishes their relative visibility. The **functionality** must not contain too much information per topic and there must not be too many functions in one interface.

Help users recognize, diagnose and recover from error: error messages should be expressed in plain language (no codes) precisely indicating the problem, and constructively suggest a solution. **Communication** between the user and the computer through error messages must be clear and carefully written.

Help and documentation: even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Any such information should be easy to search, focused on the user's task, and list concrete steps to be carried out. If there is constant help in using a system, users could avoid in making errors while using the system. Even if they make errors, they should be able to recover from it quickly by using the help and documentation in the system. Therefore, the system is more **practical** to use.

Normally each evaluator does two or more passes through the interface with the aim of inspecting the flow of the interface from screen to screen, and the specific features of each individual screen, such as dialogue boxes, feedback messages, etc. Research has shown that the use of these heuristics by five expert evaluators will typically lead to the identification of about 75% of the design problems associated with a package [34]. Thus, in HCI evaluation the application of a carefully selected set of heuristics by a group of experts can lead to a principled but a cost effective evaluation methodology. We suggest that this approach to be adopted in predictive educational software evaluation.

Checklists of questions, which attempt to deal with both learning and usability issues, date back to early days of educational software use (e.g. [35]). They are still popular (e.g. [36]) with new list appearing for current software environments such as CD-ROM based applications [37] and hypertext software [38]. The ability of checklists to predict educational issues in all but a naïve and superficial way has been questioned by several researchers (e.g. [39]). McDougall and Squires cite a number of authors who identify problems, which evaluators have found with a use of checklists as predictive evaluation tools:

- It is difficult to indicate relative weightings for questions [40]
- Selection amongst educational software of the same type emphasis similarities rather than differences [41]
- The focus is on technical rather than educational issues [42]

- It is not possible to cope with the evaluation of innovative software [40]
- It is not possible to allow for different teaching strategies [41]
- Off-computer, teacher generated uses are not considered [45]
- Evaluation in different subject areas requires different sets of selection criteria [45]

Squires and McDougall [41] maintain that these problems are symptomatic of the failure to adopt a situated perspective on the use of educational software. They suggest that the first four problems stem from a focus on the software application as an object of evaluation in its own right rather than the evaluation of its use, i.e the use of software is not conceived in a distributed fashion. In their opinion the next two problems indicate that the diversity and complexity of the classroom, and the teachers' role in managing this complexity, do not feature in the design of checklists. They claim that the last problem again indicates non-situated perspective-generalised notions of good practice in a subject discipline are employed, rather than issues relating to specific educational situations.

David Squires and Jenny Preece, in their paper [54] suggested an evaluation method to predict quality in educational software. They proposed predictive evaluation guidelines for teachers, which systematically capitalize on past experience while taking cognizance of a socio-constructivist view of learning. According to them, formal predictive evaluations are typically based on the use of checklists, but they argue that these fail to take account of the widely accepted view of learning as a socio-constructivist activity, Their approach is to adapt the notion of 'heuristic evaluation' introduced by Molich and Nielson [46] as part of a usability evaluation exercise. Heuristics evaluation is done by experts (in this case, expert teachers) using a set of guidelines, known as heuristics. The purpose of the heuristics is to encourage evaluators to focus systematically on all the important aspects of the educational software design. The heuristics evaluation process requires teachers to review the software, and from their knowledge of how they would present the software to pupils and how pupils and how pupils learn, the teachers judge the suitability of the software for its intended educational purpose.

The predictive evaluation method is a well-known method to predict the quality of software by experts and it becomes even better if the heuristics defined by Nielson is used together with the learning views. It is proved to give proper results to a certain extent.

But, I feel that, users themselves could become evaluators of an educational software that they use because they know what they want and most importantly these are the people that are going to use the system. Therefore, it is better if they become testers and give the feedback on a certain educational system so that we could find the difficulties that they are facing and they can define also their characteristics when they do a certain test.

2.3.2.5 Users Opinion

What is lacking with the methods described so far is an indication of the users' subjective opinions about the system or prototype. Users' attitudes can have a strong influence throughout the design and development of products. At the requirements stage of design, for example, users express their opinions of existing work practices while at the implementation stage their attitudes affect the acceptance of the computer system and its effective use at the workplace. Checking users' opinions at various stages of design is essential and can save a lot of time by ensuring that unusable, unnecessary or unattractive features are avoided. Interviews and surveys provide ways of gathering data on users' preferences, but they differ in the amount of preparation required, their style of presentation and the flexibility of question asking. The data collected from interviews tends to be qualitative but surveys are generally quantitative. Surveys also offer the advantage that large number of people can be reached, so there is a possibility of obtaining statistically significant results if required [31].

This evaluation method can be used for the evaluation of educational software or hypertext to a certain extent but it has to be incorporated with some other methods to make it more appropriate for the purpose. For my research project, I have looked into the use of questionnaires in getting users opinion on the usability of educational software or hypertext that are being used. This will be discussed further in the next section.

2.4 Software heuristics and socio-constructivist view of learning

As mentioned in section 2.3.1.4, there has been a shift of emphasis from behaviorist paradigm, through the weak artificial intelligence approach, to a constructivist view. For more educationalists, constructivism offers far more scope for realizing possible learning benefits of using information and communication technology [25][26]. Many writers have expressed their hope that constructivism will lead to better educational software and better learning. [e.g. 27, 28, 29]. They stress the need for open-ended exploratory authentic learning environments in which learners can develop personally meaningful and transferable knowledge and understanding.

As described in section 2.3.2.4, research has shown that the use of software heuristics will typically lead to the identification of about 75% design problems associated with a package. [34]. Thus in HCI evaluation the application of a carefully selected set of heuristics by a group of experts can lead to a principled but a cost effective evaluation methodology.

Therefore, in this research, the author has come up with a set of questionnaires based on the software heuristics described in predictive evaluation (in point 2.3.2.4) and also the socio-constructive view of learning.

In this research, the users opinion evaluation method was used to evaluate six educational systems, as it is most appropriate to ask the users themselves to rate the usability of an educational system according to the questions given to them. The questions served as guidance for them to present their opinion in a meaningful way.

2.5 Learning theory in Malaysian schools

Behaviorist viewed learning as a sequence of stimulus and response actions in the learner. They reasoned that teachers could link together responses involving low-level skills and create learning "chain" to teach higher-level skills. The teacher would determine all of the skills needed to lead up to the desired behavior and make sure students learned them in a step-by-step manner. [55]. Behaviorist learning theory also stresses on direct instruction which is a systematic method for presenting material in small steps, pausing to check for student understanding and eliciting active and successful participant from all students [56].

With regard to the behaviorist theory explained above, the author concluded that the Malaysian education system has been stressing on the behaviorist learning theory. In research done by Ambikavathi [57] and Subahan et. al. [58] and in Shift 14 [59], it is noted that the learning method being used in Malaysian schools resembles the behaviorist learning theory. For example, the learning in Malaysian schools is still more teacher-directed.

Thus, it is not advisable to get users opinion much on the socio-constructivist approach in learning in the questionnaires. The evaluators, who are Malaysian students, might not be able to relate the questions with the educational systems and this would produce incorrect results.

Therefore, usability issues were integrated with only some of the socio-constructivist issues in the preparation of the questionnaires.

The overview of the questionnaires is discussed in the next section.

2.6 Conclusion

The main categories in the questionnaires a presented below.

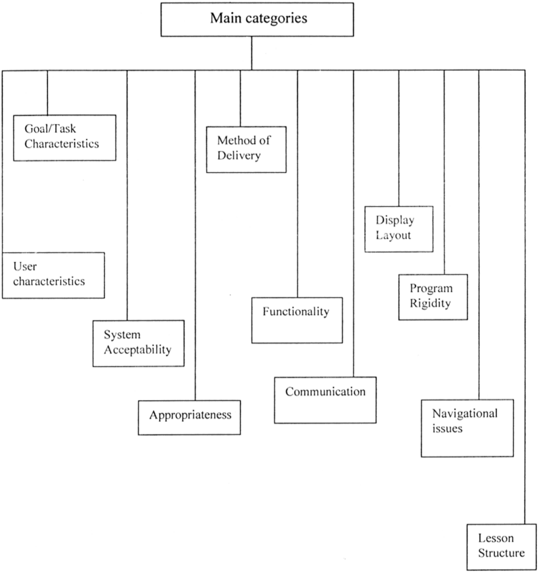

Figure 2-1 - Hierarchical Representation of the categories in questionnaires

The questions in the questionnaires are described below:-

Name of System : ______________________________

Level of Usage		*Type of Software*	
Pre-School	☐	Information Retrieval	☐
Primary	☐	Learning software	☐
Secondary	☐	Computer based training	☐
University	☐	Tutorial software	☐
Company	☐	Analysis	☐

User Characteristics

Please tick (✓) your answer.

1. **What is your level of experience?**

☐ Novice ☐ Basic Expert ☐

Novice: User does not have any kind of prior knowledge in using the software
Basic: User has some basic knowledge in same context of the software
Expert: User is an expert in using the software.

2. **How skillful are you when using computers for learning?**
Please circle a number.

1 2 3 4 5
not at all extremely

3. **Do you think English is a barrier for you to be able to use the software efficiently?**

☐ Yes ☐ No

4. How fluent are you in English?

Please circle a number.

1	2	3	4	5
not at all				very fluent

Goal/Task Characteristics

1. What is your motivation for using this software/hypertext?
Please tick (✓) your answer.

☐ To gain more knowledge.

☐ To learn new skills.

☐ For the fun of it.

☐ Part of course requirement in school/university

☐ Interest in the subject.

☐ To retrieve information for problem solving.

☐ Others Please specify : ____

System Acceptability

Social Acceptability

1. Is the software acceptable to you ?

Yes ☐ No ☐ Why?________________________
____

Practical Acceptability

Please tick (✓).the appropriate boxes.

	Extremely	Quite	Slightly	Reasonable	Not at all
Is it easy to learn?					
Is it faster than printed form?					
Is it easy to remember? e.g it becomes simpler the second time you use.					
Are you satisfied using the system?					
Do you make many errors while using the system?					
Is it easy to recover from errors?					
Do you always encounter system failure while using the system?					

Appropriateness

1. Is it compatible with the curriculum in School / University?

extremely quite slightly reasonable not at all

Method of Delivery

1. Do you prefer having the manuals, textbooks and fiction available in an online form instead of in a printed form?

Disagree much Disagree a little neutral Agree a little Agree much

2. Do you need to follow instructions from your teacher to use the system?

Disagree much	Disagree a little	neutral	Agree a little	Agree much

Functionality

Please write 'y ' for Yes and 'n' for No.

1	Too many functions in one interface.	
2	Too much information per topic.	
3	Error messages are too general. It does not provide you with some idea on how to find the solution.	

Communication

Please write 'y ' for Yes and 'n' for No.

1	No onscreen instructions.	
2	Experience a state which is difficult to exit /cancel a command.	
3	Wrong , misleading and confusing information.	
4	Spelling errors.	
5	Usage of icons not suitable. (Not Understandable)	
6	Confusing names to describe a feature in the software.	
7	Information overload (too technical , too detailed until becomes very confusing.	
8	Bad error messages (usage of bad or foul language).	

Display Layout

Please write 'y ' for Yes and 'n' for No.

1	Are the screens organized?	
2	Is it easy to find what you want on the screen?	
3	Screen layout : Is the screen balanced ,rows/columns aligned ?	
4	Is the screen distracting and looks busy ?	
5	Is the colour the only differentiator between items ?	
6	Is the menu navigation appropriate (able to move back to previous menu, move to the top of the menu structure and leave the program at any time , able to jump at any topic you want)?	

Program Rigidity

Please write 'y ' for Yes and 'n' for No.

1	Can you use the system without having any prior knowledge in the field of study?	

Navigational Issues

1. When you use the software, can you answer the following questions?

	yes	no
Where am I ?	( )	( )
How did I get here?	( )	( )
What can I do here?	( )	( )
Where can I go to?	( )	( )
How do I get there?	( )	( )

Lesson Structure

Please answer yes or no in the blanks.

________ *There is a structured lesson to teach specified objectives.*

________ *A detailed description on how to perform a specified skill is provided.*

________ *The lesson contains useful examples.*

________ *Enough exercises are provided for adequate practice.*

________ *Feedback is provided about required response.*

________ *When appropriate, feedback is explained in detail.*