CHAPTER 2

CONCEPTUAL FRAMEWORK

This chapter presents the conceptual framework of the study. The study involves the design and evaluation of a web-based constructivist learning environment. Specifically, the study aims to find out if the design of the environment led to the enhancement in higher order thinking and achievement of content of different ability students; is suitable in supporting cooperative and collaborative processes among the high, mixed and low ability students; led the teacher to play different roles, and, had different effects on different students. The following discussion is divided into six sections, namely constructivism and learning, cooperative and collaborative learning, rich learning activities, thinking and learning, the role of the teacher, examples of constructivist technology based learning environment, and a description of the proposed web-based constructivist learning model.

Constructivism and Learning

Constructivism is a process of learning whereby the learner personally constructs and interprets a given set of information based on his or her experiences. The constructivist theory of learning attributes much of its foundational principles to the works of Piaget (1950) which explains the concept of cognitive structures and how cognitive development is facilitated by engaging learners in activities that require adaptation, through assimilation and accommodation. Broadly, there are three specific characteristics of constructivism as it relates to learning (Grabingar & Dunlap, 1995). First, learning is an active and evolving process whereby the learner attempts to make sense of the world. Thus, knowledge cannot simply be acquired by the learner as a well-defined finished product. Further Szabo (1998a), notes that our optimal knowledge of the world is not absorbed but is actively processed by the learner, emerging in the form of mental models. With regards to the existence of knowledge, the pure or radical constructivists such as Steffe (1977), Confrey (1980), and von Glasersfeld (1987) believe that there is no objective or real knowledge of the world. In this regard, von Glasersfeld believes that one's personal world is created by the mind, so each and every one of us has our own real world. The radical constructivists' notion of knowledge is contrasted with the moderate constructivists who believe that there is a real world and this real world is accorded only to those constructions on which most people of a social group agree (Heylighen, 1993).

Second, knowledge is developed in an authentic learning environment whereby context plays a significant role in the building of knowledge. Third, the social context in which learning happens is fundamental to conceptual development and is fostered by sharing and testing ideas with others. In other words, the pedagogy of constructivism includes learning by doing, learning through interaction, learning in rich environments, learning at higher order thinking levels, and learning in a teacher-supported environment.

Learning by doing is a principle advanced by John Dewey who realized that rote learning methods in education were inconsistent with findings in child psychology and a changing democratic social order. Dewey (1910) rejected authoritarian teaching methods, and viewed learning as a process of inquiry. His main contention was that children should learn by doing and not be idle, passive recipients of knowledge meted out by teachers. Similarly Bruner (1960) emphasized that learning is an active process in which learners construct new ideas or concepts based on their prior knowledge. In advocating discovery learning, Bruner emphasized that concepts are internalized in a more meaningful manner if the learner is more actively involved in his or her learning. In other words, discovery learning is a process whereby the learner discovers truths based on prior knowledge and experience. The learner selects information, originates hypotheses, and makes decisions in the process of integrating experiences into his/her existing mental constructs. In a classroom situation, discovery learning may be implemented at different stages of an instructional continuum. In its purest form, discovery learning allows the learner a free choice of how and what is to be learned. At a moderate level, discovery learning permits experimentation, whereby the teacher intervenes in the form of coaching, providing learning clues and creating a learning framework for the student. In a purely prescriptive perspective, the learner discovers completely what the teacher wants him to discover.

The concept of learning by doing was further explored by Papert who was particularly interested in "looking at children as active builders of their own intellectual structures" (1980, p. 19). Papert felt that children could advance in their intellectual abilities more quickly with the right kind of environment. Papert was greatly influenced by Piaget's (1950) theory about developmental stages. Piaget (1950) believed that a child's development from one stage to another takes place through a gradual process of interaction with the environment. According to Piaget, children develop as they confront new and unfamiliar features of their environment that do not fit with their existing view of the world. When this happens, a disequilibrium occurs which the child seeks to resolve through one of two processes of adaptation. The child either fits the new experiences into his or her existing view of the world (assimilation) or changes the cognitive structure to incorporate the new experiences (accommodation). Based on the Piagetian principle, it is important that a child be exposed to a variety of learning activities. This will enable the child to come into contact with more instances of 'disequilibrium' so that its cognitive structures are in a constant state of assimilation and accommodation.

In this respect, Papert (1980) believed that learners ought to be provided with learning opportunities where they may test their hypotheses about the knowledge they encounter. In a study conducted to examine this view, Papert (1980) found that by allowing students to work with Logo, a computer programming language, students were able to create microworlds where they could test their hypotheses.

While Piaget was more concerned about the biological development of cognition, Vygotsky (1978) proposed a perspective of learning based more on social interaction. Vygotsky, a Russian psychologist, believed that cognitive development was directly related to and based on social development and the culture around a learner. According to Vygotsky, learning takes place at two levels: the inter-psychological level and the intra-psychological level. At the inter-psychological level, the interaction children have with adults and other children is critical to their construction of knowledge. Vygotsky proposed that a child's immediate potential for cognitive growth is bounded on the lower end by that which the child can accomplish on his own and on the upper end by that which the child can accomplish with the help of a more knowledgeable other, such as a peer, tutor or teacher. This notion of cognitive growth is related to what Vygotsky terms as the 'zone of proximal development' which refers to "the distance between actual development level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more knowledgeable others" (1978, p. 86). The gap between actual and potential ability can be bridged through what is metaphorically known as the 'scaffolding' process. A more experienced partner (whether peer or teacher) is able to provide scaffolds to support the student's evolving understanding of the subject matter at hand.

Cooperative and Collaborative Learning

Based on the earlier discussion, learning by doing appears to be crucial which may be scaffolded by the interactive nature of cooperative and collaborative learning strategies. Cooperative learning is a method of instruction espoused by Slavin (1982) and Johnson & Johnson (1984). Cooperative learning is a strategy, which involves students in established, sustained learning groups or teams whereby group work is an integral part of, not adjunct to, the achievement of the learning goals of the class. According to Slavin (1991a), cooperative learning is a form of small group instruction where students work in a social setting to solve problems. Guerrero et al. define a cooperative task as "one that contains a single common goal that all group members aspire to attain" (1990, p. 6). More specifically, Schunke and Bloom (1979) state that for a cooperative task to be effective there must be open interaction which allows the sharing of ideas, problem-solving and the synthesis of knowledge (in Guerrero et al., 1990). Students are encouraged to utilize one another as major resources, with the teacher acting as 'consultant' rather than 'expert'. Johnson & Johnson (1984) stress that cooperative learning is not merely having students sit together and talk while they work on their individual assignments; nor is it having students work at individual assignments with those who finish first helping their slower counterparts. Rather as forwarded by Johnson & Johnson (1984), cooperative learning should include the following five basic elements:

1. *Positive goal interdependence.* Students must feel they need each other in order to complete the group's task. According to Fulton (1990) these feelings can be created by asking students to establish shared goals, by giving students joint rewards, by providing shared worksheets and assigning roles. In this respect, it is also important to consider group composition. Cuseo (1992) recommends the following criteria that can be used by the teacher to form the group: academic achievement, learning styles, personality profiles, ethnic backgrounds, gender and age.

2. *Face to face interaction.* This involves having students to talk and discuss with each other, give and receive explanations and elaborate their ideas. For effective communication, Guerrero et al. (1990), suggest that students be trained in some communicative skills such as explaining one's point of view, asking appropriate questions, considering and integrating the views of others and resolving conflicts of opinion.

3. *Individual accountability.* This can be achieved by assessing each individual or by assigning simple tasks that lead to bigger tasks.

4. *Interpersonal and small group skills.* This includes the social skills of communication, leadership and conflict management. Other social skills include staying with one's group, speaking in low conversational voices and trusting other group members (Doolittle, 1995).

5. *Group self-evaluation.* The purpose is to allow group members time to reflect on how well they are working together as a group. It is a time when group members can clarify and improve the productivity of all members in achieving the group's goals (Doolittle, 1995).

Further, Slavin (1977) forwarded two theories why students should learn more in cooperative groups compared to traditional settings. These are the motivational and cognitive theories. Motivational theories are associated with rewards or goal structures under which students operate (Slavin, 1977). Rewarding group based on group performance or the sum of the individual performance creates an interpersonal reward structure. The cognitive theory on the other hand discusses two aspects that is the developmental and elaboration aspect. The developmental aspect is based on the fundamental assumption that interaction among children on given tasks increase their mastery of critical concepts (Damon, 1984; Murray, 1982). Vygotsky's zone of proximal development (ZPD) explains this phenomenon whereby he believes that children of similar ages are more likely to operate within one another's ZPD. The elaboration aspect is based on the cognitive restructuring and elaboration of the materials which will enhance retention and retrieval of information (Wittrock, 1978). Accordingly, one of the more effective means of elaboration is to explain the material to someone else.

Collaborative learning on the other hand, happens when students interact with one or more collaborating partners to solve a problem or to access information. A student's collaborating partners could be the teachers, other students, researchers and subject-matter specialists. Bruffee (1998) argues that cooperative and collaborative learning are two versions of the same thing: whereby the purpose of both is to help students learn by working together. He states "what teachers do in both cooperative and collaborative learning is set up conditions in which students can learn together" (1998, p. 84). Cooperative learning and collaborative learning were developed originally for educating people of different ages, experiences and levels of mastery. In some aspects, collaborative learning in colleges and universities complements and supplements cooperative learning that children may have experienced in primary schools. Collaborative learning teachers tend to trust college and university students to govern themselves in the context of substantive engagement, conversation and negotiation. This emphasis on self-governance has its source in one of the important goals of collaborative learning: to help adolescents and adults acknowledge dissent and disagreement and cope with differences. While the cooperative learning experts believe that competition can impede learning, the collaborative experts belief that the hierarchical authority structure of traditional classrooms can impede learning. Thus, collaborative learning methods hope to replace this structure with negotiated relationships among students and a negotiated relationship between these student communities and the teacher.

Rich Learning Activities

Whilst Slavin (1982), Johnson and Johnson (1984) and Bruffee (1998) were using cooperative learning and collaborative learning methods to have children reach their zone of proximal development, Brown, Collins and Duguid (1989) who were researching Vygotsky's ideas, became concerned about how to design rich learning activities. This was due to the fact that they found students suffering from the 'inert knowledge' syndrome, that is knowledge learned but not applied in everyday life. According to Brown, what students learn should not be separated from how they learned it. To counter the problem of inert knowledge, Brown et al. (1989) introduced the concept of cognitive apprenticeship. Cognitive apprenticeship is a method of learning, which is against predetermined instructional sequences. In order for learning to happen, cognitive apprenticeship employs the modeling, coaching and fading paradigm of traditional apprenticeship but with emphasis on cognitive, rather than physical skills. Thus in the classroom, the learner is seen as an apprentice who works with information to enhance his/her learning skills. In order that the learner is given the correct environment, Brown et al. (1989) suggested the concept of situated learning, that is incorporate situations from everyday life into the learning environment or be situated in real world contexts. Bednar, Cunningham, Duffy and Perry (1995) forward the following situations to explain real world contexts. Firstly, tasks given to students are not isolated, as for example giving word problems in a book, but are part of a larger context, for example giving students projects to work on. Secondly, the problem must be authentic in the sense that it is relevant to the environment in which the learning is to be applied. Lastly, it means providing learning activities that are within the learners' range of prior knowledge and experience.

Similarly, the Cognitive and Technology Group at Vanderbilt (CTGV, 1990) under the leadership of John Bransford felt that learning is enhanced when learners are placed within a real-life context. They proposed 'anchored instruction' a paradigm based upon a general model of problem solving or teaching that is "situated in engaging, problem-rich environments that allow sustained exploration by students and teachers" (CTGV, 1993, p. 65). Anchored instruction is also the name given to the method of using interactive videodisc to provide "anchors" for discussion and discovery and stresses the importance of placing learning within a meaningful, problem-solving context.

Thinking and Learning

As the field of instructional technology evolves, the need for educators to create relevant and experiential learning opportunities to enhance higher order thinking is imperative. However, before laying the groundwork for a thinking process curriculum, conceptual and operational definitions of thinking processes are needed. In this regard, a meta-analysis by Marzano, Brandt, Hughes, Jones, Presseisen, Rankin and Suhor (1988) has yielded five interrelated dimensions of thinking that is, thinking processes, critical and creative thinking, core thinking skills, metacognition and the relationship of content to thinking.

Thinking processes are complex mental operations which result from a combination of specific thinking skills. Marzano et al. (1988) identified eight thinking processes which are used during knowledge acquisition. The first three processes that is, concept formation, principle formation and comprehension are used primarily to acquire new knowledge. The next four processes that is, problem solving, decision making, inquiry and composition are used primarily during the application of knowledge. The final process, oral discourse, is used during both knowledge acquisition and knowledge application.

While many people equate critical and creative thinking with thinking processes, Marzano et al. suggest that these skills are unique aspects of all thinking irrespective of the type of process used. According to them "these terms imply judgements about the quality of thinking involved, a judgement about the relation of thinking to some ideal model. As we solve a problem or make a decision, we do it more or less creatively, more or less critically" (1988, p. 17). Individuals can engage in varying degrees of creative and critical thinking while solving problems, making decisions and conducting research. Thus, a critical thinker may be one who communicates his ideas objectively, coherently and accurately, while a creative person possesses the ability to take an idea from one frame of reference and turn it around to give it a new perspective.

Core thinking skills are the specific mental operations that are used in combination to achieve a particular goal in a more task oriented context. (Marzano et al., 1988). It is the unique combination of these core thinking skills which define the broader thinking processes identified above. Marzano et al. have generated a list of 21 core thinking skills which they have grouped into eight broad categories of focusing, information gathering, remembering, organizing, analyzing, generating, integrating and evaluating skills.

Marzano et al's core thinking skills are taken to represent aspects of higher order thinking skills. In this respect, Newmann (1991) defines higher order thinking broadly as challenged and expanded use of the mind whereby a learner makes meaning of information by interpreting, analyzing and reorganizing it. He compares this to lower-order thinking which represents routine, mechanistic application and limited use of the mind. Similarly, Willis, Hovey and Hovey (1981) define higher order thinking as the ability of individuals to tap the various intellectual faculties to the fullest by first organizing information into meaningful knowledge and then applying it to solve a problem. On the other hand, Lebow (1995) uses critical thinking, generative thinking, problem solving and metacognition to define higher order thinking. Similarly, the *Malaysian Curriculum Development Centre* defines higher order thinking as encompassing components of critical and creative thinking, problem solving and decision-making (Low, 1993).

From the above definitions, some common key words that describe activities related to higher order thinking can be derived. These key words are analysis, synthesis and evaluation, and it is apparent that they are representative of Bloom's (1956) taxonomy or model for conceptualizing higher order thinking skills. It is thus widely accepted that the higher order skills are:

Analysis — a set of mental operations where learners pull apart information from many resources and reorganize the information to give it new meaning. In doing so, students may use categorizing skills, which involves ordering or grouping of information; *Synthesis* — after analyzing the information, students synthesize it by drawing conclusions; and, *Evaluation* — when given a situation that is almost similar to what students have encountered, they are able to evaluate it and give valued judgements.

However, to build student thinking, the following are some important considerations:

(1) *The need to select thinking skills.* Beyer (1987) recommends that specific skills be drawn out from these more general higher order skills because of time constraints. He recommends two to four thinking operations to be introduced in each subject or pair of subjects. To select the thinking operations, a coordinated effort across grade levels is suggested.

(2) *The need to structure the learning environment.* The following dimensions are recommended by Onosko (1991) for a classroom that is promoting higher order thinking namely (a) coherence and continuity in a lesson whereby the content is well-designed, and learners are provided with optional resources; (b) the teacher structures few challenging tasks by giving writing assignments that are well conceived; (c) activities requiring students to offer explanations and reasons which according to Abadzi (1990) allow students to offer explanations and reasons, and restructure the information so that, many existing schemata are connected and eventually lead to greater remembrance of the information; (d) the teacher modeled thoughtfulness through Socratic questioning which is aimed at increasing students' ability to improve and appreciate their thinking by making it explicit.

(3) *The need to integrate curriculum into thinking.* A curriculum which focuses on the development of intellectual processes cannot be developed in isolation of thinking skills. According to Presseisen (1992), teaching thinking is concerned with many processes such as Piaget's assimilation and accommodation of information, creating mental frames and building web-like connections to help the learner go beyond specific information. Despite the relative success of skills-based efforts by Feuerstein (1980) with his Instrumental Enrichment Program and Pogrow's (1989) HOTS which are described as content free, a great deal of literature criticizes the skills approach for its inability to provide a meaningful context for thinking skills to be developed (Council of Chief State School Officers, 1990). In this respect, Phillips (1997) takes the infusion approach as one that is more appealing for regions in the Pacific Rim, as that would require least disruption to curricula. Similarly, for the Malaysian context, Low (1993) has recommended an integrated approach to the teaching and learning of thinking skills.

(4) *The need to use different assessment techniques.* Duck (1985) states that testing for higher order thinking involves grading that emphasizes processes as well as factual content. In grading for process, rather than looking for a certain factual answer, it is suggested that the teacher looks out for the following rubrics: a complete answer, a logical answer and a clearly expressed answer.

Role of the Teacher and Learning

Traditionally, the teacher's role was to "teach", which was achieved first by setting the learning objectives and then by transmitting the related information. The teacher decides on the type of information that would be useful to the learner, the style of presentation and the types of questions to ask. Learners on the other hand, were mainly passive, being involved occasionally if and when the teacher permitted or when the learner showed eagerness or persistence about a certain issue. In a constructivist classroom, the teacher engineers the learning, delivers it, but mostly supports student inquiry.

To engineer the learning, the teacher goes backstage and structures the learning environment. In this respect Bruner (1960) suggested that the curriculum be structured in a spiral manner and the topics be presented conceptually to the students. Similarly, Reigeluth's (1985) elaboration theory proposes that instruction start with an overview that embodies an epitome of what is to be taught. Subsequent instruction progressively presents more detailed ideas, which elaborate on earlier ones, offering in a sense, a form of spiral curriculum.

To expand the notion of structuredness, Spiro, Feltovich, Jacobson and Coulson (1988) forwarded the Cognitive Flexibility Theory as a conceptual model for instruction that facilitates advanced acquisition of knowledge in domains where singular representation of concepts may be unrealistic. In order to avoid oversimplifying instruction, flexibility theory stresses conceptual relatedness, provides multiple representations or multiple perspectives of themes inherent in a content area. According to Spiro et al. (1991), knowledge domains are not as structured as traditional theories of learning make it to be (that is knowledge is ill-structured), and failure of transfer of knowledge may be due to conceptual oversimplification. Therefore, flexible representations of knowledge are required to permit the same items of knowledge to be presented and learned in a variety of different ways and for a variety of different purposes.

In addition to providing a well-structured content, the teacher should also provide challenging tasks to the learner. These challenging tasks should ideally be based on aspects of higher order thinking. Beyer (1971), believes strongly in the classroom atmosphere that provides tasks for intellectual inquiry. Apart from that, the teacher also acts as a resource and technology manager (Lee & Reigeluth, 1994, Robyler, Edwards, and Havriluk, 1997), whereby the teacher arranges for required resources such as books, guest lectures, demonstrations, lessons, discussions and the websites.

Next, the teacher goes on stage and delivers. One important aspect of delivery is to ensure that students see the whole picture and are able to connect previously acquired concepts to present and future learning concepts or topics. To enable learners to do this, Ausubel (1963) proposed the use of advance organizers to invoke appropriate schemata. Accordingly, many studies (Hartley & Davies, 1976; Lawton & Wanska, 1977; Mayer, 1979 in Abadzi, 1990) have established that advance organizers increase the understanding of material, enable learners to stay alert longer, and process and retain material more efficiently.

Finally, the teacher goes down stage and supports student inquiry. Here the teacher is seen to play the various roles of a facilitator such as a motivator, whereby she/he motivates children to explore, and reach their inquiry through "learning on demand" (Galas, 1999). This may be done by encouraging them to create their own questions, a process which Galas terms as the "students curricula." The teacher also models inquiry and questioning by probing questions forwarded or created by learners. As a coach, the teacher provides structure and supports students' performances and reflections (Means & Olson, 1994). Here, the teacher will need skills to better understand the subject matter, to manage students by suggesting paths for exploration, and to help students construct their own understanding. As a guide, the teacher provides student-centered educational adventures that make students passionate learners and arouse the natural curiosity of the learner. Students create their learning plans whilst teachers help them develop their thinking abilities, solve the problems and spend time with the learners (Lanier, 1999). The following excerpt aptly summarizes the role the teacher plays when interacting with students in a constructivist learning environment:

> *I must still be heavily involved in all the activities in which speaking the language is the main focus, and I must locate, summarize, or create specialized materials for students with unique needs. I still must provide guidance to the students to help them locate and use the material provided for the different focus areas, and I must be able to help individuals or small groups understand some of the new ideas. Many of the focus areas require use of technology, and some students will require instruction in the use and care of the equipment.*
>
> Morrey (1998, p. 12)

Thus, in the constructivist classroom, the role of the teacher and the learner is well articulated. The teacher's role is to design challenging activities, whilst the learner is seen as an "apprentice" whose tool is information. The teacher is seen as a sage and mentor who will guide the learner when she/he encounters learning difficulties. Whilst this perspective forms the basic premise of constructivism, constructivists differ in their views on the extent of the role of the teacher. The cognitive constructivists believe that the teacher should play a limited role in the students' learning process. This is based on their adoption of the Piagetian theory of biological maturity, which says that children construct their own knowledge of the world according to the maturity of their cognitive structures. The social constructivists on the other hand, believe in a more involved role of the teacher and peers.

Examples of Constructivist Learning Environments

Constructivist-based learning environments are environments that allow learners to decide their learning paths, their pace and style of learning. Constructivist environments also look at the curriculum as a whole and design the learning environments that incorporate a number of learning methodologies such as cooperative and collaborative learning, computer supported learning and process-based assessment. Learners are provided rich learning resources and learning activities.

Constructivist environments have evolved from the closed networked integrated learning systems (ILS) in the 1990s to the more open web-based learning (WBL) environments. According to Hackbarth, "Web-based learning can incorporate the best senses of *interactivity* long associated with good CBL, and may expand to include some of those *real-time* if not *proximal-space* inter-human senses so much a part of quality education." (1997, p. 61). The Web provides the potential to revolutionize training and education to the same degree as it has revolutionized access to information and communications for users around the globe. According to Reigeluth and Khan (1994), advances in information technology coupled with changes in society are creating new paradigms for education, which require rich learning environments supported by well-designed resources and the web is one such medium that can do this.

When David Berliner (1992) was asked to design a classroom of the future, he envisioned an environment in which thinking skills are achieved and in which technology augments work on projects, "with depth, complexity, duration, and relevance to the real world." (in Biggerstaff, Laffey, and Nazworthy, 1998, p. 107). Without this new design for teaching and learning, the problems of fragile knowledge and a lack of understanding, so well described in Howard Gardner's (1991) book, *The Unschooled Mind* will persist. Biggerstaff, Laffey, and

Nazworthy (1998) note that students will not truly understand what they learn in school until provided the opportunity to apply their knowledge against meaningful challenges. They assert that the central goal of education should be for students to do challenging research that will engage them intellectually, socially and emotionally. Further, Hester & Songer (1998), note that implementing classroom teaching practices based on this constructivist epistemology can be seen as redefining who is in control of classrooms, with concomitant changes in the roles of teachers and students.

With respect to the above points raised about constructivist learning environments (CLE), a model proposed by Jonassen (1997) based on the following components is presented. The model starts with a question, case, problem or project which is the focus of the CLE and which also constitutes the learning goal. Accordingly, a question or an issue-based learning begins with a question, which is uncertain or controversial, whereas problem-based learning integrates courses at a curricular level, requiring learners to self-direct their learning while solving numerous cases across the curriculum. To support student inquiry, Jonassen proposes that a set of related cases be provided. According to him, as novices lack experiences, it is important CLEs provide access to a set of related experiences that they can refer to. Related cases assist learners in understanding issues implicit in the problem representation and support learning by scaffolding memory and representing complexity. Providing learners with rich sources of information is an essential part of CLEs as it may enable learners to solve problems and integrate learning. In a CLE it is important that learners be provided with cognitive tools, which are generalizable computer tools that are intended to engage and facilitate cognitive processing. To encourage further shared information and shared knowledge building, learners should be provided with conversation/collaboration tools. Finally, it is important that the teacher supports learning and helps learners construct and apply their knowledge to task and activities. Jonassen's CLE model rests on a pedagogic support structure, which consists of modeling, coaching and scaffolding activities.

Duchastel and Spahn (1996) proposed a design for web-based learning which revolves around two central design processes: information specification and representation, and problem-solution tasking. In Duchastel and Spahn's (1996) design, specification is related to the 'what' of content and representation to the 'how' of content. These information related decisions are guided by theoretical perspectives such as information mapping, minimalist design and structural approaches. For problem-solution tasking to be successful, the difficulty level of the problem must be carefully selected. Duchastel & Spahn cautioned that it is important to assess the model for different types of learning, namely, procedural (skill development), declarative (knowledge assimilation) and cultural.

Dodge (1996) proposed the WebQuest as a web-based constructivist learning environment. He defines a WebQuest as "a technique for engaging students in active learning" (p. 1) with the use of web resources as they strive to understand a task. Further, Yoder (1999) describes the WebQuest as a well designed activity that allows students to go beyond finding facts. Students are asked to analyze a variety of resources and use their creativity and critical-thinking skills to derive solutions to a real-world problem. The building blocks of a WebQuest assembled by Dodge (1996) include: an introduction to orientate the learner and raise interest through a variety of means (e.g. have compelling scenarios on a problem that currently troubles a local or the world's population); a task which consists of challenging questions and defines what the learner will have done at the end of the exercise; a process whereby the teacher guides students through their task, often using a numbered step-by-step guide, suggests ways to manage time, assign roles or collect data more effectively; resources which are identified by the teacher such as websites, texts, reference books, videotapes, places and peoples; an evaluation procedure which includes rubrics consisting of a variety of criteria and benchmarks for accomplishment; and finally, a conclusion to sum up the project.

Henze and Nejdl (1997), have created a Knowledge Based Systems (KBS) Virtual Classroom Project with the goal of utilizing the full power of virtual and Internet techniques to innovate teaching and learning. Their model is based on Schank's (1994) goal-based scenarios with two important features: the scenario context which is authentic in nature; and the learning structure which features an adaptive learning environment. Students are asked to work on specific projects and encouraged to discuss approaches and solutions in small working groups. Additionally, students have access to a knowledge base about the subject. As a knowledge base will not be effective if access is restricted to a few hours during the week, Henze and Nejdl feel that students should always have access to their teacher.

In the KBS, the following facilities of the Internet, artificial intelligence and hypermedia have been incorporated to build a learning environment: continuous availability of the working environment, project-based learning, team-oriented learning and mentoring, adaptive and extensible course knowledge bases, and electronic communication facilities for cooperative groups such as an e-mail list, a web-based communication room and a presentation room which is readable by everyone. Apart from that, discussion at the course level is supported by providing students with official announcements (Announcements), general discussions

(Discussion Forum), and free communication (Cybercafe) facilities.

Norman (1997) developed the HyperCourseware approach to an electronic classroom environment to fulfill the needs of learners and instructors based on an integrated classroom teaching approach. The principles underlying HyperCourseware are the availability of course materials which include comprehensive notes, charts, and lesson plans; tools which include the blackboard, calculators and notebooks, and the processes that is discussions, collaborations and assessments. As such, HyperCourseware has been written to host any subject and to support many activities common across courses. These activities range from record keeping and on-line testing to hypermedia presentations and from individual exploration to group collaboration. HyperCourseware uses the conventional objects of classroom instruction and implements them in the electronic form in the electronic classroom. Objects such as the course syllabus, the lesson plan, the lecture notes, and the class rolls, are presented in graphic form in a hypermedia database.

In a technology-based environment Schartz, Brophy, Xiaodong Lin, and Bransford (1999) created a software shell called STAR. Legacy which organizes learning activities into an easy to understand inquiry circle to overcome the risk of being disconnected when doing problem-based, project-based or case-based activities. The design rests on four pedagogically sound principles: learner centered — focuses on knowledge, skills and attitudes that students bring to the learning situation; knowledge centered — focuses on knowledge that is organized around core concepts or big ideas; assessment centered — helps students' thinking to become visible so that both they and their teachers can assess and revise their understanding; and community centered — capitalize on local settings to create a sense of collaboration, both among students and with other members of the community. To enable teachers to integrate these types of environment, Schartz et al. have created what they term as *flexibly* adaptive instructional design.

Description of the Proposed Conceptual Framework

A conceptual framework for a web-based constructivist learning environment hereafter called the WebClen to cater for the needs of learning geoscience for Malaysian primary students is forwarded based on the theoretical constructs of early and contemporary constructivist and examples of constructivist learning environments. Two major principles from the crux of the conceptual framework, namely, active learning and support (see Figure 2.1)

Active learning

Active learning refers to the following: (a) students decide on some of the learning activities; (b) all students are actively involved in knowledge construction; (c) students discuss their ideas with their group members; (d) students seek for help when they face a problem; and (e) students self-check on their progress.

Active learning is based on Dewey's (1910) belief that children should learn by doing. However, in the WebClen, a moderate amount of discovery learning (Bruner, 1960) is encouraged where the students decide on the selection of some of the learning activities. Thus while being in charge of his or her learning, the learner selects activities that have been carefully thought out by the teacher to achieve pre-determined learning goals. Apart from that, all learners are encouraged to do one main activity first. The purpose of the main activity is two fold: first, to build students' prior knowledge for more social discourse to take place; and second, to build up the basic higher order thinking skills of classifying and critically analyzing information.

To support every student's active involvement in knowledge construction, it

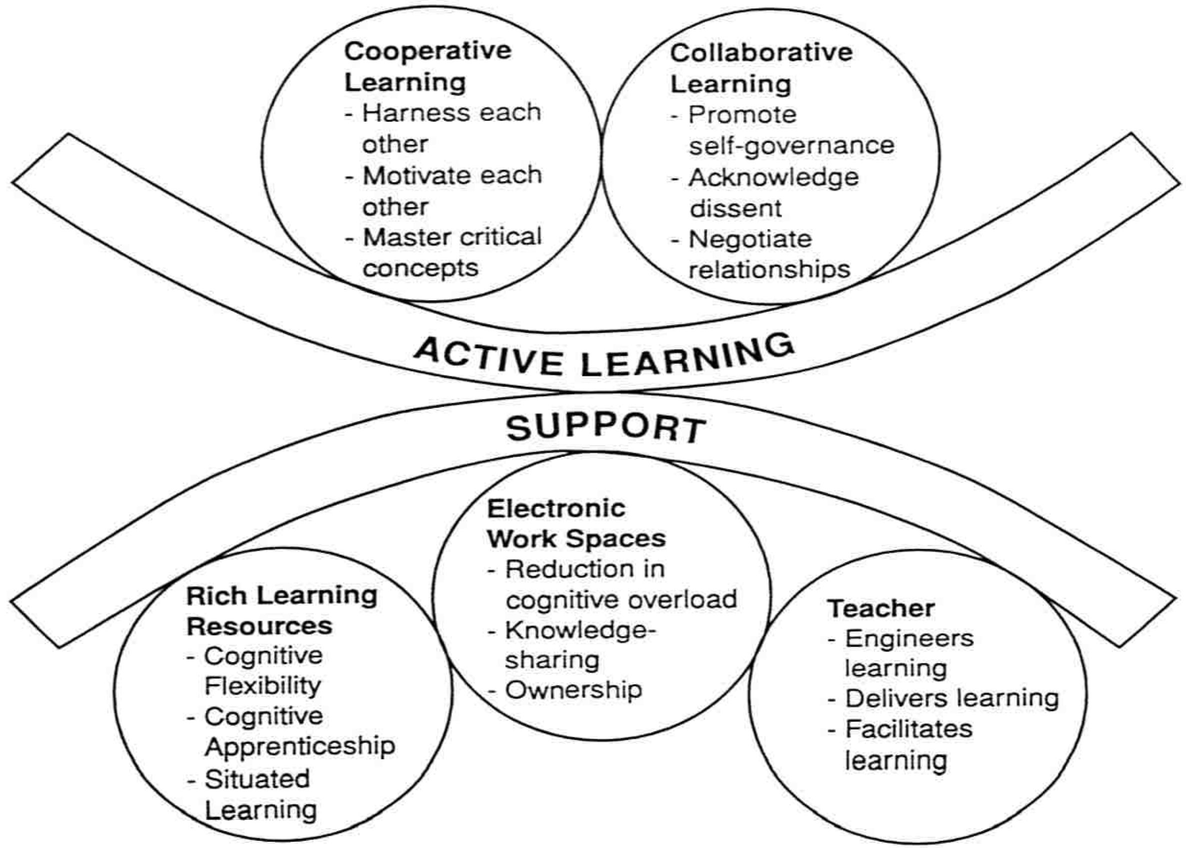

Figure 2.1. Conceptual framework of the web-based constructivist learning environment (WebClen)

is important that students are provided with personal reading and writing materials. These materials are important to support student construction of personal knowledge (von Glasersfeld, 1987). Such materials could take the form of personal file folders complete with task sheets, work sheets and printed notes. Later students are to check if their personal understanding of the knowledge is concomitant to what most people of a social group agree by discussing their work in a group Heylighen (1993).

Active learning also means students seek for help when they are unable to reach a decision about some issue or solve a learning problem. In order for students to seek help readily, it is important that students are able to reach their peers teacher, or another expert. Finally, students keep track of their learning performance by deciding on when they are ready to be assessed. Active learning is achieved through cooperative and collaborative learning technique.

Cooperative and Collaborative Learning

The WebClen propagates cooperative learning to enable students in a group to harness each other's ability, skill and knowledge; to motivate each other; and increase their mastery of critical concepts. The elaboration of the materials by students when they explain a concept to support their ideas will also enhance retention and retrieval of information (Wittrock, 1978). It is hoped that the cooperative learning methodologies employed in the WebClen will aid learners to reach their ZPD (Vygotsky, 1978).

The WebClen also includes the collaborative learning principles of enhancing students ability to make decisions 'to govern themselves' (Bruffee, 1998);

acknowledge dissent and disagreement; and cope with the differences. The online support structure of the WebClen will support learners to negotiate relationships among peers and experts.

Support

Students need to be supported in their learning processes. In a web-based learning environment, support is given in various ways, which includes the availability of rich learning resources, electronic work spaces and the teacher.

(a) Rich Learning Resources

Rich learning resources are important for the development of cognitive flexibility and advanced knowledge. According to Spiro et al. (1989), revisiting the same material, at different times, in rearranged contexts, for different purposes, and from different conceptual perspectives is essential for attaining the goals of advanced knowledge acquisition. Rich learning resources also support authentic or situated learning experiences. Lave (1988) asserts that learning is a function of the activity, context and culture in which it occurs, that is, it is situated and an important aspect of situated learning is cognitive apprenticeship (Brown et al., 1989). As an information apprentice, the learner should be provided with a wide range of resources.

To provide learners with a wide range of resources, it is recommended that websites be created or alternatively selected from the world-wide web. Further, hyperlinks made available in websites will encourage the development of cognitive flexibility. The availability of rich resources in the WebClen will allow not only nonlinear interactions but also multiple representations of knowledge, explanations, and viewpoints. Rich learning resources can also be provided in the form of printed notes, textbooks, digital databases or printed encyclopedias.

(b) Electronic Work Spaces

To support student construction of knowledge, students need to be given the right "cognitive or mind tools" (Jonassen, 1997). For the WebClen, these are referred to as "work spaces" which support the whole notion of learner centered learning, cooperative and collaborative learning, and authentic or situated learning. The principles underlying workspaces are that they should allow: (a) any one student in the group to key in the group's answer; (b) the information to be easily viewed by the learner, teacher, expert, parents and any other interested party; (c) for easy input of information in the form of text and multimedia images; and (d) the learner to make changes easily.

Teachers too need to be supported. The learning materials should be easily available and suitable to their teaching styles and their learners. The work spaces in the WebClen have been designed using the Lotus-Notes software in such a way that teachers as well as learner will be able to adapt them according to their needs.

(c) Teacher Support

In a WebClen, the teacher is seen as playing three roles: the teacher engineers the learning, delivers the learning, and facilitates the learning.

In engineering the learning, the teacher structures the learning environment. According to Beyer (1971), the teacher should provide challenging tasks to the learner. The following are some of the activities that the teacher can create in the

WebClen: reports, frequently asked questions (FAQs), maintaining journals on issues related to content, and evaluation of images, especially animated or videoclips that show processes.

In delivering learning, the teacher teaches but for a limited time period. One important aspect of teaching is to ensure that students see the whole picture and are able to connect previously acquired concepts to present and future learning concepts or topics. The easy upload of power-point files into the WebClen will enable teachers to use their conceptual maps in a big group or in small groups.

In facilitating the learning process, the teacher, coaches, counsels, models, and assesses. The WebClen has been structured to aid the teacher in the teaching and learning porcess.

Conclusion

The Web-based Constructivist Learning Environment (WebClen) and its components and its role in enhancing higher order thinking is the main thrust of this study.