CHAPTER 6

DISCUSSION AND CONCLUSIONS

The present study was concerned with the effects of a web-based constructivist learning environment (WebClen) on learning of geoscience. More specifically, the study examined the effects of the WebClen on higher order thinking skills and content acquisition of high, mixed and low ability learners. The study also sought to examine the nature of cooperative and collaborative processes in the WebClen. Apart from that, it was also the objective of the study to determine the role of the teacher as well as students' perceptions of the WebClen. The study involved a total of 36 students from a primary school in Kuala Lumpur, out of which 12 students were identified as high ability learners, 12 as mixed ability learners and another 12 as low ability learners.

Prior to administering the study, 3 different pretests were administered. The first pretest consisted of a 35-item Thinking Skills Test which tested 5 types of thinking skills: classification, analogical reasoning, deductive reasoning, spatial thinking, and mechanical reasoning of learners. The second pretest called the Information Skills Test consisted of 30 items testing learners' ability to extract main ideas, infer and to distinguish between facts and opinions. The third test was a 40 item multiple-choice test called the GeoScience Performance Test testing students' knowledge on the following topics: *Earth, Moon and Sun*; *Physical Phenomena*; *Rotation and Revolution of Earth and Moon*; and *The Solar System*. During the four-week instructional program, qualitative data were collected as students studied the 4 geoscience topics using a web-template as the main form of interaction in cooperative groups, supported by peer-to-peer and expert-to-learner collaboration, as well as the teacher and other print-based materials. The following methods were used to collect qualitative data: opinionaire on group work; observation methods; evaluation of student online data; and questionnaire on student perceptions of the WebClen. After the four-week instructional program, a posttest similar to the pretest was administered.

The purpose of this chapter is to present a summary of the findings, discuss the main findings, draw conclusions based on the results and recommend areas for further research. The four sections of this chapter are: a) Summary of findings; b) Discussion and recommendations; c) Limitations; and d) Directions for future research.

Summary of Findings

Research Question 1: To what extent did the various activities of the Web-based Constructivist Learning Environment (WebClen) encourage higher order thinking and enhance content acquisition among primary school learners?

The following is a summary of findings pertaining to higher order thinking:

1. With regard to writing online reports, low ability groups wrote more critical reports compared to mixed and high ability group members.
2. All groups generated questions, but low ability groups generated more frequently asked questions (FAQs) which tended to be higher order convergent. The number of divergent questions generated were proportionate according to the three ability groupings.

3. In terms of peer-to-peer evaluation of FAQ answers, high ability students gave more feedback to their peers on the FAQs and the feedback was more elaborative compared to the feedback given by mixed and low ability groups.
4. Most students were able to make decisions based on information sourced from the Internet with respect to the possibility of an asteroid crashing into earth.
5. Nearly all group members kept a journal of an online event. However, only one third of them paraphrased the information while the rest rendered information verbatim. High ability groups produced more journal that were paraphrased compared to mixed and low ability learners.
6. Although there was little variation in terms of ability to interpret multimedia images, mixed ability students scored higher than high and low ability students.
7. The number of questions submitted to the geo-expert did not vary according to the ability groups and neither did the cognitive levels of questions submitted.
8. The Thinking Skills Test revealed that the posttest scores were significant especially with regard to classification skills. Higher ability learners scored significantly higher on the posttest as compared to their mixed and low ability counterparts.
9. There was a slight improvement in the posttest scores for Information Skills Test but the gains were not significant.

The following summarizes the results pertaining to content acquisition:

1. High ability students wrote more accurate, complete and concise reports compared to their mixed and low ability counterparts.

2. There was little variation in online quiz scores. Also, it was revealed that online quizzes were not well received by students.

3. The Geoscience Achievement Test revealed that posttest scores were significant especially with regard to the following topics: *Natural Phenomena*; *Rotation and Revolution of Earth*; and *The Solar System*. Low ability students made the most gains.

Research Question 2: What characteristics of cooperative and collaborative learning were evident in a Web-based Constructivist Learning Environment?

1. Two main types of cooperative learning activities i.e. discussion and shared workload were observed in the WebClen. Upon further examination, the types of discussions differed according to ability groupings. Discussions among high ability learners centred on seeking opinions and providing suggestions related to the tasks. In terms of frequency of discussions, there was a marked decline over the four-week period. For mixed and low ability learners, discussions tended to be focused around skill related tasks such as choosing and saving images, how to use a search engine and doing online quizzes. In contrast to high ability learners, the frequency of discussions for mixed and low ability students increased over the four-week period.

2. High ability learners shared workload by delegating work, sharing out the responsibility of checking out informational resources, helping each other edit images, and checking on each other's work. Mixed ability learners shared workload mainly by dividing the task of keying in information into the computer, checking on the keyed information, and checking informational

sources. Low ability learners shared workload on keyboard use, answering quiz questions, looking for information, and completing tasks. However, it was observed that mainly two students from each group did most of the work for all the ability groups. The frequency of shared workload declined for the high ability groups over the four-week period, whilst there was an increase in the frequency of shared workload for the mixed and low ability group.

3. Two main types of collaborative activities were explored: inter-group collaboration, and collaboration with the geo-expert. High ability learners were more active in inter-group collaboration as compared to the mixed and low ability learners. The various processes that learners experienced during inter-group collaboration were the ability to accept varied assessments given by peers on a particular response and coming to a consensus about the response given. Collaboration with the geo-experts was more or less equal for all the three ability groups. Collaboration with the geo-experts consisted of probing by geo-experts, further researching by students, and selecting the better answer when two or more geo-experts responded to a query.

Research Question 3: What was the role played by the teacher in the Web-based Constructivist Learning Environment?

1. The findings revealed that the role of the teacher in the WebClen was that of a technology expert, motivator, content specialist, promoter of cooperative learning, bilingual expert, and monitor of student progress.
2. As a technology expert, the teacher provided support in hardware applications, general software applications and specific software applications. Hardware applications included familiarising students with computers and managing

limited hardware resources. General software applications included explaining the meanings of certain terms; teaching students certain skills such as using a search engine and copying and pasting; and how to manage MS Windows. Specific software applications included teaching students how to access the Web template, button functions and navigation as well as how to input information and save it. It was observed that the teacher provided most support in software applications and this support was mainly provided in the early stages of the study.

3. The teacher motivated students both offline and online. Online motivation included giving student encouragement by giving feedback on student work and uploading student photographs. Offline motivation was given when the teacher moved from group to group and praised students on their work or gave attention to individual students. On the whole, offline motivation was more frequently provided as compared to online motivation.
4. The teacher provided content support at three levels. First, the teacher used an advance organizer to activate students' schema. Second, the teacher helped students understand the topic for the week by teaching, probing, and clarifying the concepts. Finally, as a content expert, the teacher helped students with the task at hand mainly by modeling the processes involved.
5. In promoting cooperative learning skills, the teacher helped build group comradeship, reminded students to equally share the workload, discouraged keyboard domination by reminding students to switch places, and encouraged students to support each other.
6. As a bilingual expert, the teacher helped students understand information from the Internet by translating and explaining the information from the English

Language to the Malay Language. After translating the ideas, the teacher ensured that the ideas were coherent and the grammar and language were correct.

7. Monitoring student progress became an important factor for self-paced learning in the WebClen as students were left to decide on the activities they wanted to do and the amount of work they could finish. The teacher gave advice to students to be self-reliant; checked to ensure the tasks were completed, especially among the lower ability students; ensured students were managing their learning time efficiently; and gave advice on intellectual property rights. Student progress was also monitored through student self assessment, peer assessment, and teacher assessment.

Research Question 4: What were learner perceptions of the Web-based Constructivist Learning Environment (WebClen)?

The research question addressed three major issues: general perceptions of learning in the WebClen; perceptions of activities specifically relating to the web template; and perceptions on group learning.

1. The majority of students enjoyed their learning experiences in the WebClen primarily because the environment allowed them to relate geoscience concepts to everyday life; they were able to learn at their own pace; they were given an opportunity to explore knowledge that interested them; and they experienced an improvement in their ability to seek information. In this environment, students preferred the teacher to explain the concepts briefly and although the activities were designed for students to be as self-reliant as possible, student feedback showed that teacher assistance was needed in carrying out the activities.

2. With regard to the Geoscience template, students generally liked the design of the template which enabled easy navigation and found the download time fast. Students also found the different components of the template such as the GeoLink, GeoCreate, GeoMedia , GeoSpecialist and GeoQuiz useful in navigation and in giving them a sense of direction. Regarding GeoLink, students found the facility useful as it contained a lot of useful information. However, they preferred the Bahasa Malaysia website as compared to the English websites. In GeoCreate, students found that the FAQ allowed them to seek for information that interested them and the journal writing allowed them to relate the concepts learned to a real phenomenon, whilst the report writing exercise gave them the opportunity to build up their knowledge base. Generally, students found the variety of images, especially the video-clips, animations and time-based links in GeoMedia, very useful in helping them understand the processes and concepts better. However, students did not like the GeoQuiz because of the slow response rate for feedback and the glitches in upload of graphics. Although not many questions were sent to the geo-expert, the students found that they benefitted from the geo-experts' responses.
3. On the whole, students liked group learning because it allowed them to discuss with each other and seek help when needed. However, most students could not get along well with their group mates and preferred two students rather than three students to a group.

Discussion and Recommendations

This study showed how the design of the WebClen helped achieve the ideals of a constructivist theory in a naturalistic classroom setting. The findings are helpful in filling in the enormous gap between theory and implementation. The findings are discussed in three broad sections: a) effects of the WebClen on higher order thinking and content acquisition; b) the characteristics of cooperative and collaborative learning; and c) the role of the teacher.

(a) Effects of the Webclen on the Higher Order Thinking Skills and Content Acquisition

The in-depth nature of this study gives an integrated picture of the effects of the WebClen on the higher order thinking skills and content acquisition of primary school children. It is strongly suggested in this study that the design and implementation of the WebClen can significantly improve high, mixed and low ability learners' higher order thinking skills and content acquisition. It was found that low ability students wrote more critical reports and generated more frequently asked questions. The high ability students gave more feedback to their peers and wrote more journals. Mixed ability students tended to interpret multimedia images better than high and low ability students.

The results of the present study were also similar to previous findings of Mitchell (1996) concerning the effect of a technology-rich environment on the higher order thinking skills of grade four and grade six students. The activities involved writing, creating graphics, researching, controlling robots and telecommunications. The study found that there was a significant difference within the experimental group of low, average and high ability students for the sixth grade. The present study extends this finding by demonstrating the effect of open networked based learning on the higher order thinking as well as content skills of fourth grade students. Hence, this study confirms Mitchell's finding that not only a closed networked technology rich environment is capable of enhancing the higher order thinking skills of learners, but, given a chance to browse for more information and determine the pace and flow of activities, learners' overall learning improved significantly. The above findings also corroborate other studies done to determine the effects of a technology-rich environment on students learning (Jussel, 1990; Maor, 1991; Myer, 1993; Knezek, 1995; Stamper, 1996; Andrusyszyn, 1997; and Jack, 1996). This improvement can be attributed to the instructional design of the web-based constructivist learning environment. The WebClen was designed based on the core principle of active learning incorporating constructivist concepts such as cognitive apprenticeship (Brown et al., 1989) whereby the learner is seen as an apprentice who works with information to enhance his/her knowledge and situated learning (CTGV, 1990) whereby students are engaged in sustained problem-rich environments. In relation to allowing the student to become an information apprentice or an information architect (Smith, 1995), the student was allowed to acquire content to suit his/her learning needs in what is termed as the "students curricula" (Galas, 1999). Further, the design of the WebClen was also based on the principles of support guided by the cognitive flexibility theory (Spiro et al., 1988) which stresses on the availability of multiple representations of information for a content area, the availability of cognitive tools (Jonassen, 1997), and the presence and role of the teacher.

In this study, the constructivist ideals were translated into the WebClen with the availability of a web-template that had rich learning resources in the form of websites in the GeoLink facility. For each topic, students were given a choice of websites which were either designed locally or alternatively selected from the WWW based on principles of web-page design and appropriate level of content for 10-12 year old students. For example, students were provided with seventeen websites for the Earth, Moon and Sun topic (Appendix W); twenty websites for the Physical Phenomena topic (Appendix X); seven websites for the Rotation and Revolution of Earth and Moon topic (Appendix Y); and nineteen websites for the Solar System topic (Appendix Z). These websites were then uploaded into the GeoLink facility in a manner appropriate for learners to browse easily i.e. the websites were divided into main links and related links and for every website, a short synopsis was given so that learners did not waste time getting into a website to find out it did not directly support the activity they were working on. Apart from that, students were allowed to search the Internet to obtain information to support their needs. Towards this end, a specific search engine was recommended to the students that was deemed appropriate for them.

Secondly, students were given a number of problem-rich activities which sustained learning throughout the study. These activities were created based on a redesigned instructional analysis of the syllabus under study whereby concepts that were related were grouped together so that similar processes were discussed under one major topic. To support continued learning in the WebClen, the activities were not demarcated by a 40-50 minute time period, but students were given a one-week block period of 7.5 hours to finish a topic of study. Students could decide on the number of activities they wanted to do and they could also decide on which activities they would like to do first. Activities were available in two major facilities i.e. in GeoCreate and GeoMedia. In GeoCreate, three main activities were designed for the learners. These were the FAQ, writing a report, and maintaining a journal. The purpose of the FAQ activity was mainly to allow students to search for information that they were interested in, aptly termed the "students curricula" by Galas (1999). In this activity, students will first pose a question and then answer the question based on information gathered from the Internet. Students could pose any number of questions, depending on how fast they were able to work and how many "quests" they had. For example Group 3 (low ability group) created 13 FAQs, Group 2 (mixed ability) had 12 FAQs, and Group 12 (high ability) had 5 FAQs. It was found that the low ability groups wrote the most FAQ's and most of the questions were of the higher-convergent type. There were few very interesting divergent questions, especially generated by the low ability students. For example, Group 3 had the following questions: "Will the amount of water found on the moon be sufficient for 2000 people for the next 100 years?" and "Is the water on the moon similar to water on Earth?" Another activity that was designed in relation to the FAQ was peer-to-peer evaluation of FAQ answers. Here students were asked to read FAQ answers generated by their peers and grade them. The purpose of this activity was twofold: to allow learners to appreciate peer work; and in giving a grade, it was hoped that learners would process the information better.

In the report writing exercise, students attended to activities mainly to satisfy the "teachers curricula". Here students were required to do all the five suggested online reports. The online reports allowed students to gain basic information related to the topic under study by comparing and contrasting between sets of information and also summarizing on the information to state the similarities and differences between the sets of information.

In journal writing, students were given the opportunity to transfer their learning to a real situation. In this study, students kept track of an erupting volcano by reading progress reports of the volcano using a dedicated website and then stating in their own words what they understood of the report by writing a journal. Journal writing also allowed students to be creative as they could attach images to their online journal reports. For example, the Uranus group (Group 9) had an animated picture of a reporter attached to their website together with the following caption: "World's greatest reporter from Planet Uranus". A total of 50 journal protocols were recorded, and of this 25 protocols were written by the high-ability groups, 13 by the mixed ability group and 12 by the low ability group.

In the GeoMedia link, students were given a variety of media clips: graphical images of effects of earthquakes, animated pictures of how earthquakes are form, active links that show students the nature of day and night experienced by different cities in the world and video clips of volcanic eruptions. The main purpose was to have students study the clips and then describe what they saw, especially the animated, video and time-based links allowed students to describe the processes which were important for building up student understanding of process-based phenomena. The time-based Internet link helped students to compare cities of their choice on the day and night phenomena. Apart from that, students could capitalize on the zooming-in and zooming- out facility so as to relate the concept of day and night to different perspectives such as the whole world, to certain time zones, to certain regions and cities. As with the FAQ and the journal writing activity, students were given a choice to evaluate and describe any number of media clips they could afford to do. In relation to this, it was found that the high ability groups made a total of 70 out of 88 interpretations, the mixed ability groups made 51 interpretations and the low ability groups made 47 interpretations.

In the GeoCreate and GeoMedia links, there were five main activities: doing FAQs, evaluating peer FAQ answers, writing reports, keeping a journal and evaluating media clips. In carrying out the activities, students were supported in various ways. First, students were divided into groups, so that they could share knowledge and support each other. Second, students were given printed worksheets and task sheets to discuss initial ideas. Students were also supported with other printed materials mainly for reading, in the form of books, encyclopaedias, and printed notes as well as digital materials such as courseware and online encyclopaedic databases in CD format. Third, students were provided with online workspaces. Each group was given a password to access the online workspace. The workspaces embedded in the activities created an easy environment for students to translate their ideas onto a visible output, allowed students to engage in "reflective thinking" (Jonassen, 1996, p. 13), and reduced unnecessary cognitive overload of refining or enhancing their work. This was important as in the pilot study carried out prior to the implementation of the present study, students were asked to use MS Powerpoint or MS Word for their final output and it was found that too much time was spent beautifying the output and not on intelligent processing of the output. Workspaces also had an extra edge over normal software programs, in a sense that after students had worked on them, they could access them from anywhere be it from the home, library, or out of the country. Apart from that, peers, teachers, school principals, parents and other communities of learners could review student work.

Thirdly, students were provided the GeoSpecialist facility that allowed them to 'talk' to one or more experts. The experts could be local educators in the field such as teachers, college and university lecturers, or experts could be selected from the Geological Department or Department of Astronomy. For this study, two local educators were selected, one to answer students' queries in the English Language and the other to answer students' queries in the Malay Language. One educator was selected from the United States of America to answer student queries in the

English Language as well as to allow students to get a different perspective of the same issue. This is in line with Spiro et al. (1991) cognitive flexibility theory which states that flexible representations of knowledge are required to permit the same items of knowledge to be represented and learned in a variety of different ways.

Lastly, students were provided with an online quiz represented by the GeoQuiz facility. In a student-centred and student-directed environment, it is deemed important that students be able to keep track of their learning. The online quiz was also seen as an important facility to support the socio-learning environment of Malaysian schools. The Malaysian curriculum is still very examination oriented and creating a learning environment devoid of testing will not augur well for most Malaysian educators. Also it was found that online quizzes could free teachers of end of topic testing and evaluation. Online quizzes also supported the notion of allowing students to to be evaluated when they are ready (The Malaysian Smart School, 1997). Thus, the creation of online quizzes has numerous benefits. It allowed teachers to quickly find out how groups of students were performing. As the teacher moved from group to group monitoring student progress, online quizzes were easily accessed from the students' computer and discussions could be held between the teacher and the students. Online quizzes also enabled the teacher to share resources and create questions that incorporated media clips such as animations, video-clips and active time based Internet links. In this study, students could do the online quizzes in a group or individually. Students got their scores immediately and scores were recorded in a database. Students could also do the quizzes any number of times they liked.

Apart from the web-template and printed resources, the instructional design also included having students carry our experiments in the classroom. Two experiments that were conducted were the 'egg-experiment' whereby students sliced a hard-boiled egg into half to relate the layers found in the egg to layers in the earth. Afterwards, students drew the different layers they saw and there were many interpretations made from the egg experiment. Students also did the day-and-night experiment using a torchlight to represent the sun, a model of moon and a globe to represent the Earth. The experiments allowed students to feel, touch and experience the different processes of day and night as well as understand the eclipses, which were considered as abstract processes. In the process, the teacher was able to correct some student misconceptions about the processes such as how the moon revolves round the earth, what is an acceptable distance between the Earth, Sun and Moon and how shadows were formed on the Earth and Moon.

Thus it can be implied that the instructional design of the WebClen to a large extent determined the improvement of higher order thinking skills, information skills and content skills. However, despite the improvement in the thinking, information and content skills, it was observed that in a process-based environment, different ability learners benefitted learning differently. Low ability students benefitted in more predictable outcomes such as critical writing of reports and generation of FAQ's. Out of a maximum score of 4, low ability groups scored the highest with a mean score of 1.8 as compared to a mean score of between 1.0 and 1.6 for the mixed and high ability learners. Low ability learners also created more FAQs with a total of 24 FAQs out of a total of 46 as compared to between 8 and 14 from the other two groups. High ability students, on the other hand, benefitted in processes that were not so structured, such as giving feedback on peer FAQs and journal writing. High ability learners evaluated 59% of the FAQs as compared to 30% by the mixed ability groups and 11% by the low ability groups. But mixed ability students did not benefit as much from the activities as compared to the high and low ability learners.

In this study it was noticed that the low ability learners benefitted from the support given by the teacher, whether it was solicited or unsolicited. For example, the teacher often moved from one low ability group to the next providing support in keying in information by modeling to students the processes involved such as copying and pasting and then editing the information. The teacher also assisted students in formulating FAQs, translating information from the websites and facilitating students understanding of some of the responses provided by geoexperts. Mixed and high ability learners' work improved only when they sought the teacher's support. Thus, it can be said that the more the teacher supported the learners, the better it was for the enhancement of thinking, information and content skills. Teacher support is a form of scaffold that helps learners to reach their "zone of proximal development" (Vygotsky, 1978).

However, the nature of the constructivist learning environment presents a difficult task for the lone teacher. By virtue of the fact that each learner and each group is given the opportunity to individualize their own learning, the process-based outcomes are never the same at any given moment. As the teacher moves from Group 1 to Group 2, so too does her mental, emotional and intellectual disposition. The teacher has to make an immediate and unconscious shift from the needs, responses and task variables of Group 1 to those of Group 2. In other words, a constructivist learning environment demands that the teacher be able to cater to the multiple outcomes during her interactions for a number of different learning contexts. To cite an example, Group 3 may have accessed 3 links and sought the teacher's input on them. When the teacher moves to Group 4, she finds that they have 30 links to deal with. This consistent shifting or changing of attendant gears for the teacher presents a unique opportunity for her to provide individual attention and thus to provide for different zones of proximal development as may be exhibited by the learners in the classroom.

It is pertinent to note that the demands of this environment placed a heavy emphasis on the human factor in the teaching-learning process. On the one hand, the teacher had to provide for, respond to and help create a positive learning environment in the classroom. On the other hand, there were some tasks that may be done in a more predictable manner i.e. tasks which could be performed by the technology itself. Herein enters the role of intelligent agents, which may allow for offloading some tasks from the teacher herself.

What are intelligent agents and what are they capable of doing? Roesler & Hawkins (1994) described intelligent agents as independent computer programs that operate within software environments such as operating systems, databases or computer networks (cited in Baylor, 1999). Based on definitions of agents given by some experts in this area, O'Riordan and Griffith (1999) have summarized the key characteristics of intelligent agents as follows: a) autonomous, meaning that the agents do not require the user to regularly intervene in order for them to complete their task, b) collaborators, meaning they communicate with other agents to achieve their goals, and, c) learners, i.e. the agents are capable of modifying themselves to suit to users' abilities, styles and aptitudes.

From an educational point, Seiker (1994) sees intelligent agents as computer programs that are capable of simulating humanlike relationships by aiding the user just like another human would do (cited in Baylor, 1999). Aroyo and Kommers (1999) see agent technology as promising in addressing the challenges of learner directed educational environments which have been designed to harness the information and Internet technologies. The following quote sheds further light on their interpretation of the role of intelligent agents in education:

> *They provide new educational paradigms, support theories, and happen to be rather helpful entities for both students and teachers in their computer-aided learning-teaching process. Their application in the educational field is mostly as personal assistants, user guides, alternative help systems, dynamic distributed system architectures, human-system mediators and so forth.* (Aroyo and Kommers, 1999, p. 236)

In this respect, Baylor (1999) prefers to call the intelligent agent a cognitive tool, which is an intellectual computer device that supports learners' thinking processes. According to Baylor, agent technology can be used to describe distributed cognition, as agents can serve as extensions of users' mental capacities as well as act as scaffolds to learners learning process so as to reach what Vygotsky (1962) terms as their "zone of proximal development". In an educational context, intelligent agents can be created to do the following: a) manage large amounts of information, b) serve as pedagogical expert, and c) create programming environments for the learner (Baylor, 1999). The following sections will further elaborate on the first two concepts, which are more related to the present study.

When an intelligent agent manage large amounts of information, the agent is seen as supporting learners in their higher order thinking skills (Baylor, 1999). This is because when the agent starts managing the information, the learner is freed of working memory to allow for higher order processing to occur. Such agents termed as "knowbots" by Kahn & Cerf (1988, cited in Baylor, 1999) and information filtering agents (IFAgents) by O'Riordan and Griffith (1999), will navigate the Internet, locate related information and suggest the information as extra reading materials to students. Laurel (1997, cited in Baylor) says that a more competent and responsible agent will be able to generate "multiple representations of information" as is consistent with the conceptual framework of the Cognitive Flexibility Theory.

Another important role of the agent is to serve as a pedagogical expert (Baylor, 1999). In this respect, the student is seen as an apprentice which is well described by Brown et al. (1989) in their cognitive apprenticeship theory. With the aid of the pedagogical expert, it is hoped that as the student gains expertise, the agent will play a lesser and lesser role and fade away to allow for more student initiative (Baylor, 1999). To this effect, some researchers have created intelligent agents while others are in the process of conceptualising them. Seiker (1994) has created an intelligent agent called 'COACH'- a system that records learner experiences and provides personalised help. Similarly, O'Riordan and Griffith (1999) in an attempt to overcome some of the problems inherent in web-based learning environments have created the User Modeling Agent (UMAgent) that will adapt the web-based system to students with different learning aptitudes. Other kinds of intelligent agents that have been proposed are one by Baylor and Kozbe (1998, cited in Baylor, 1999) called the Personal Intelligent Mentor (PIM) that will have the potential to facilitate learners' metacognitive processing by encouraging students to think about their cognitive processing by modeling.

With the proliferation of intelligent agent technology, it is timely that such initiatives be considered for the WebClen. Some of the intelligent agent characteristics mentioned above can be incorporated into the WebClen. However, for the WebClen, intelligent agents are needed more specifically for learners to self-assess, get help in translation as well as to generate student portfolios which the teacher can refer to keep track of student progress. As the results of this study show, higher order thinking processes could have been further enhanced if the teacher had been able to provide more support to the learners. However, in a classroom of between 36-40 students, this is not feasible. Thus, the power of the technology can be used to support the teachers as well as to support learners. As an example, an agent can help learners identify errors and suggest alternative strategies in the online activity of gathering information for report writing and writing critical summaries. Student answers can be checked against suggested formats, according to the level at which the student has been identified and there is a check and balance system to ensure that the student has improved so that he/she can be placed at the next higher level. Agent technology can be employed for other activities as well, especially those that are unstructured and rely on the Internet for information. However, as the learners are still young, intelligent agent technology has to be well thought out to incorporate child psychology principles, so that children will be guided in a way that is appropriate for their level. Also as intelligent agent technology needs students to read and understand the prompts, and suggestions and probes offered by the agent, it may serve the higher and mixed ability learners better, thus leaving the teacher to cater to the needs of the lower ability learners.

(b) The characteristics of cooperative and collaborative learning

Results showed that the nature of cooperative and collaborative learning was varied and different ability groups benefitted differently as a result of student grouping. Of the two types of cooperative learning activities i.e. discussion and shared workload, it was found that higher ability students discussed and shared workload on process related tasks whilst the low and mixed ability students discussed and shared workload based more on skills related tasks. High ability students were not able to sustain the intensity of discussion and shared workload, which declined over the four weeks as compared to the mixed and low ability, which improved over the 4 weeks.

It was observed that the computer played an important role in enhancing cooperative and collaborative learning in terms of having group members consolidate their work, the ability for learners to be connected to the geo-experts, and have peers respond to peer work. In group consolidation of work, it was found that student generated information was not lost and acted as a tool to further enhance student thinking. In traditional Malaysian classrooms, group effort is often recorded on paper which somehow may not be available the next day or even if it is available, it is very difficult for learners to edit and add on new information. In this study, a group's input on a topic was keyed in, and was available anytime learners wanted to access it. The next day students had access to their work again and continued from where they stopped. Also all the group members could work on the activity at home as they were able to access their work online.

Consolidated group effort also meant the technology allowed for individual effort but the effort is attributed to all members of the group. In the ordinary non-technology classroom, there are several barriers to group-based work. For example, when a group member makes a contribution, ownership is demarcated by physical evidence such as hand-writing or paper copies. However, on the computer screen, keying in can be done by anyone while information can be 'poured in' by everyone. Thus in a single swift moment of printing out group-based products the resultant output is attributed to everyone in a group.

In collaborative learning, connections with the geo-experts resulted in students experiencing a number of different processes initiated by the geo-experts such as probing, giving suggestions on student work and providing further reading materials. In this respect, without the aid of a web-template such interactions would have been negligible. In the traditional classroom, students do not get to interact with other experts and thus their sphere of interaction is limited to what is provided by their teacher.

Pertaining to the experts to be included in the program, it is advisable to select experts that are experienced in providing online support. In this study, this was not a problem, as the experts selected had wide knowledge of the Internet and were regular net users. However, it is recommended that future experts who are selected must first be identified in terms of the ability to support learners at their level. Ideally, for primary learners, the language should be simple and explanations should be short with graphics used as support. In the training of teachers, this aspect of collaboration should be addressed.

Results also showed that students were interacting with each other and that they were able to give sustained and well thought out comments on their peers' work. This enabled the other party to have time to read and respond to the comments. However, it was found that there was limited interaction among peers and some groups were giving more responses than other groups. In a large group, it is difficult to have the teacher constantly check on these interactions. To overcome this situation, it is recommended also that intelligent agent technology be incorporated for some cooperative and collaborative processes.

In relation to this, Whatley, Staniford, Beer and Scown (1999) in their article "Intelligent Agents to Support Students Working in Groups Online" suggest the use of agent technology to monitor students working on group projects online. According to Whatley et al. (1999) for groups to be successful in working together, two factors are important: a) task level, which is concerned with the cognitive aspects of completing a given task such as critical judgement and ability to analyze, synthesize and evaluate; and b) socio-emotional level which is mainly concerned with maintenance of group operation. Thus the role of a tutor or teacher is not only to provide the necessary skills and information to perform the task but also provide support for the development of trust between members so that team spirit is maintained for full cooperation between members. In this respect, an intelligent agent called a group support agent (GSA) that can support group projects for an online system has been proposed. The agent will monitor the progress made on a collaborative project and suggest ways for students to improve on their progress as well as suggest ways on how to enhance communication between group members. The following quote describes the activity of the agent:

> *The agent will autonomously monitor the progress of the group project, suggest ways in which the students can act to improve progress and enhance the communication between members of the group. Each student working on the project will have an individual agent, operating in the background, watching progress, measuring it against the plan, and taking remedial action when necessary* (Whatley et al., p. 370).

Hence, for the WebClen, agent technology can be used to overcome a lack of cooperation and collaboration. One particular area where such technology can be applied is the learner-to-expert collaborative activity. Two issues of concern became apparent in student interactions with experts in this study. One, was when students copied verbatim everything the expert had suggested, implying that they may not have read the suggested answer. Intelligent agents can thus be created to check student answers against that provided by the expert and students can be prompted to paraphrase their answers. Two, agent technology can be created to check on students who have communicated with experts but had not acted on the opinions given by the experts. Agents may probe the student, alert the expert or supply alternative websites for the learner to check out.

Collaboration in the WebClen was also limited to two activities: peer evaluation and learner-to-expert collaboration. Another recommendation to extend collaboration in the WebClen is to involve other members of the community. In this study, parents had the opportunity to access and view their children's work through the Internet. Herein another major barrier to gaining feedback on their children's performance was broken down: parents were physically closer to the school and were able to communicate with the teacher without having to be physically present. But although parents had access to the web template, there were no structured and co-ordinated efforts made to have them involve actively in their children's work. It is thus recommended that the WebClen be further researched into to incorporate activities for parents and other members of the community.

Collaborative efforts can also be extended to other geographical areas such as between schools in a particular area or outside the country. Models of school-to-school collaboration within and outside the country such as the University of Michigan's Kids as Global Scientists (Hester and Songer, 1998) project for global exchange of information can be studied in detail and adopted for the WebClen.

The study also shows that it is important to provide personal email accounts and have a general mailing list which would allow students to talk to each other after school hours regarding their work such as discussing information in websites, clarifying instructions related to the geoscience activities and brainstorming ideas for their projects. Further, students should be taught how to collaborate effectively and how to use the groupmail to their benefit.

Grouping of students was also a major factor in determining the success of cooperative and collaborative learning in the WebClen. It was found that of the 3 groups which showed successful group dynamics, race and gender combinations appeared to play a role. For example Group 11 (high ability) had one Indian girl, one Malay girl and a Chinese boy while Group 2 (mixed ability) had one Malay girl, one Malay boy and one Chinese girl, and Group 3 (low ability) had one Chinese girl, one Malay girl and one Malay boy. Thus it is important that other ways of grouping the students be considered. In determining the group composition, a number of ways can be utilised. Students themselves can determine the composition of the group. Alternatively, the teacher based on her belief regarding which students work best together can form the groups. According to Cuseo (1992), some of the criteria that can be used by the teacher to form the group include academic achievement, learning styles, personality profiles, ethnic backgrounds, gender and age.

With respect to this, Jonassen (1996) in his book *Mindtools* suggested grouping of students according to cognitive controls. According to Jonassen, "Cognitive controls are relatively stable learner traits that describe how learners interact with, perceive information from, and make sense of the world" (p. 37). Some of the parameters in cognitive controls include field independence, cognitive flexibility and cognitive complexity which represent a general processing continuum of global versus analytic learners (Jonassen and Grabowski, 1993). An analysis of these two types of learners is represented in Figure 6.1 .

Global and analytic learners complement each other whereby the global learners are more sociable, more sensitive to others and communicate better. On the other hand, analytic learners are less sociable but good organisers of content. Thus Jonassen proposed grouping global and analytic students together so that differences in learning may result in better understanding of knowledge.

(c) The role of the teacher

Global	Analytic
User given structure	Imposes own structure
Externally directed	Internally directed
Attentive to social cues	Inattentive to social cues
Interpersonal	Intrapersonal
Influenced by the salient features	Generates own hypotheses
Factually oriented	Conceptually oriented
Use ideas as presented	Represents concepts through analysis
Influenced by format or structure	Less affected by format or structure
Nondiscriminating	Discriminating
Concrete	Abstract
Sensory	Intuitive

Figure 6.1. Characteristics of global and analytic learners

Source: Jonassen (1996, p. 38)

It was found that in the WebClen, the teacher played a number of roles as a "facilitator". The teacher was a technology expert, a content expert, a motivator, a promoter of cooperative learning, a bilingual expert and a monitor of student progress. The combined roles of the teacher had likely played a role in the ability of the students to enhance their higher order thinking skills, content skills and information skills.

In helping learners attain the above mentioned skills, the three roles that will be discussed are seen as very important. First, in providing technology support, the teacher had to be well versed with the different aspects of the technology such as hardware applications, general software applications and specific software applications. It was found that on the whole, the teacher provided more support in software applications as compared to hardware applications. Two reasons accounted for less support for hardware: the computers were relatively new, and a technician was available to provide help related to hardware applications. However, in the absence of the technician, the teacher had to tackle minor hardware problems. This implies that in a technology-rich environment, the teacher has to have sufficient knowledge on software applications and some knowledge on hardware applications. Second, in providing content support, it was found that the teacher had to be well versed in creating activities for a web-based learning environment. Apart from that, it was found that the teacher also had to be well versed with the Internet environment, especially in using the search engines for content areas. Teachers should also know how to best evaluate content specific websites as it is important that teachers be able to select some websites suitable for their learners. The third important role is in providing bilingual support whereby it was seen as important for the teacher to be proficient in both the English as well as the Malay Language.

One major implication of this study is that teachers need to be trained in more subjects and these subjects have taken a shift from the original two major subjects that were taught in teacher-training colleges and in the universities. Present teacher-training requires that students be trained in two subjects i.e. the major subject, for example the English Language and a minor subject, for example, Moral Studies. The results also imply that in this environment, the lone teacher may not be able to support a group of between 36-40 students, or that a subject specific curriculum may not sustain a constructivist environment.

Based on these findings, the following are recommended: first, either teachers be trained in the 3 core areas of the English Language, the Malay Language and technology, supported by the content specific area e.g. science or second, to restructure the school curriculum into theme-based units so that different teachers can teach the same theme but provide support in their subject specific area or third, retain the present system but incorporate team teaching.

Irrespective of the approach adopted, if teachers are to be trained to teach in a technology rich constructivist learning environment, the teacher-training syllabus would have to be restructured in order to train teachers in any one of the above mentioned areas. Besides this, curriculum planners would also have to be trained to restructure the school curriculum into units that are theme-based.

Ideally, a teacher-training syllabus should have computer literacy as one of its main subjects. Towards this end, the Malaysian Ministry of Education is doing an excellent job, whereby practicing teachers have been selected and trained for fourteen weeks in selected teacher training colleges on software applications such as managing the operating system, MSOffice and authoring. Further, it is suggested that teachers also be taught how to identify and trouble-shoot simple computer hardware problems how to rectify problems with sound what to do when the LCD projector is not giving any image, and how to tackle a computer that hangs.

If the learning processes are based on specific online learning templates, teachers need to be exposed to such templates as well. Some of the more popular web-based templates that can be used to train teachers are *Learning Space* and *TopClass*. Locally, the University of Malaya's online learning program called *Course Online* can be used. Alternatively, the WebClen can be used to show teachers the possibility of using the web and the pedagogy of having learners learn in such an environment. To date, a total of fourteen WebClens has been created by a group of 28 teachers for various subjects.

It is also important to train teachers on the pedagogy of the web technology. The idea of a "lesson plan" might not be feasible anymore but delineating the major goals for the activities are important. Teachers also need to be exposed to the different ways content is presented in the World Wide Web. This would familiarize teachers with the different ways the websites can be used in a web-based learning environment.

In restructuring the curriculum, one such school that has attained great success is the River Oaks Public School (Kindergarten to Grade 8) in Oakville, Ontario. It was observed that one crucial factor in restructuring the curriculum was to first come up with a vision for the school. According to the school principal, Gerry Smith (1995), the vision centers around a curriculum that prepares students for the 21st Century workplace. The main focus is on how to make technology a natural and transparent tool. To support the vision it is important to also restructure the timetable. In order to achieve maximum learning, the learning periods had to be extended. Says Smith :

> *I now ask myself what sense does it make to take 30 Grade 8 students first thing Monday morning and send them off first to science for 40 minutes, then to music for 40 minutes, social science for 40 minutes and finally math for 40 minutes... This type of organization promotes isolated leanings from one subject to another and the teacher as a subject specialist rather than a teacher of students. Seeing connections from one area to another makes learning meaningful and relevant. This is the way we operate in the real world* (p. 3).

The restructured curriculum, which is an integrated approach that reflects work in the real world, has four key areas as its focus: literacy, life skills, arts, and creative applications (see Figure 6. 2). The four skills are taught to students through three major strands of content: i.e. human relationships, science/technology, and

Literacy	Life Skills	Arts	Creative Applications
• Language and Math Grammar, spelling, writing, basic operations, logic, probability, numerical analysis. • Media • Technical • Scientific • Economics	• Conflict resolution • Collaborative work teams • Time management • Project management • Cooperative groups • Goal setting • Leadership	• Music • Visual arts • Drama • Physical education • Family studies • Design and technology • Multimedia applications	• Self-directed inquiry • Projects

Figure 6.2: Four key areas of focus for a restructured curriculum

Source: Smith (1995, p. 5)

global awareness (Figure 6.3).

To explain the theme-based concept, an example is taken from Grade 6 on Robotics syllabus related to Science/Technology. Once the Robotics unit is introduced, and the students have acquired the basic knowledge and skills for the unit, they will determine an area related to the unit for further inquiry. This may include researching into how a robot enhances automobile manufacturing or creating a robot to perform an identified task. Once the students have decided on the focus of their inquiry, they then develop a plan centered around the four main skills of literacy, life skills, arts and creative applications with emphasis on time management, creating evaluation checklists, integrating language, math, science and economics as well as multimedia applications. Students will also decide on a medium to communicate their findings.

Grade	Human Relationships	Science/Technology	Global Awareness
K	Me and My Family Community Helpers	Characteristics of Plants and Animals Technology Around Us	River Oaks School Farm
1	Changes in our Life Getting Along With Others	Basic Needs for Living Things Water, Water, Everywhere	River Oaks, Oakville Transportation
2	The Family Conflict	Growth and Change in Plants How Things Work	Discovering Halton Communities Around the World
3	The Time of My Life All for One and One for All	Life Cycles of Animals Simple Robotics	Oceans, Deserts & Mountains Culture, People and History of North America
4	Diverse Lifestyles Power and Influence	Plant & Animal Adaptation Engineering for Success	Canada Our Country Paddle the Amazon -The Environment of South America
5	Group Dynamics We are Changing	Ecosystem Communication Technology	Journeys of Exploration On Safari- Physical Geography of Africa
6	Games People Play Responsibility to our World	What's the Matter? Robotics	Canada's Links to the World Down Under-The Uniqueness of Australia
7	Communication and Group Dynamics Youth and the Law	Environmental Assessment Changes in Technology	Canada Through Time The European Mosaic-Political System
8	Personal Development Careers	The Biological Scientist Technology for the Future	Cities Around the World The Pacific Rim-Asia

Figure 6.3: A theme-based curriculum

Source: Smith (1995, p. 15)

The River Oak's restructured curriculum which is theme-based has been successful due to a number of reasons such as training the staff in the pedagogy of the technology-based curriculum, supporting teachers by providing them with portable computers, restructuring the time-table whereby students work with one teacher or a team of teachers for extended hours, placing computers in the classrooms, emphasizing on the development of higher order thinking skills and allowing the teachers to stay with a class for at least two years to enable a greater consistency and continuity of expectations for students and ensuring students are assessed based on portfolios as well as tests. Above all, to support students and teachers, the school has installed a high-speed data line for Internet where all 240 computers are connected. Students and teachers also establish links with schools in other parts of the world. Malaysian curriculum planners can use this and other models to create a theme-based curriculum and specify in detail what is required for the learners and teachers, and plan the time-tabling accordingly. A pilot study of such an endeavour is recommended so that problems can be weeded out.

Finally, some other issues that need to be considered include having electronic and non-electronic mini libraries set up in networked classrooms. As more and more classrooms become centres of learning, the concept of the library within a classroom can be considered. If there is a dedicated classroom for the study of geoscience for all primary four to six students, then this room can house the books related to geoscience in the classroom. Besides encouraging learners to maximise the use of the library resources, it will also create a culture of reading and research within the classroom. This will also counter the lack of information available in the current primary four to six science textbooks. To further support learners in the classroom, short printed notes can be prepared and worksheets can be created for students so that they can brainstorm their initial ideas on paper before they key the information into the computer.

Projecting learners' work using the LCD projector was an excellent way of sharing, discussing and providing feedback, and showing good models of output that serve as motivating tools for enhancing learners' performance. In this regard, it is important for a web-based constructivist classroom to have the necessary technological facilities so that teachers can carry out their duties easily and more effectively.

Also, teachers who wish to implement cooperative learning methodologies, have to be given a thorough exposure on cooperative learning concepts and principles, especially those related to encouraging higher order thinking. Although the nature of cooperative learning in a web-based environment may not differ much from a normal classroom environment, it is to the researcher's knowledge that many teacher-training programs, either at the pre-service or in-service level, do not provide teachers with a thorough understanding of this subject matter, although cooperative learning is not new to educators at large.

Thus it is suggested that more research be done in this area, or if there already exists a body of research on cooperative learning in Malaysia, researchers in this area should consolidate their findings and come to a conclusion as to the types of the courses that can be offered for teacher-training.

Other areas that teachers need exposure to are on motivation and assessment. Assessment includes paper-and pencil-testing, but may also include other procedures such as rating items on scales, observing students' performances, critiquing student product, conducting interviews and reviewing a student's background or previous performance (Kulieke, M. et al., 1999). According to Kulieke et al., assessment of student achievement is changing largely because today's students face a world that will demand new knowledge and abilities. In the global economy of the 21st century, students will not only need to understand the basics but also to think critically, to analyze and to make inferences. Helping students develop these skills will require changes in assessment at the school and classroom level. It is a common belief among educators and policymakers that what gets assessed is what gets taught, thus inevitably the format of assessment influences the format of instruction. It has been a standard practice among educators to use traditional multiple choice and true-false assessments to test facts and skills in isolation which seldom require students to apply what they know and can do in real-life situations. In fact, standardised tests do not match the emerging content standards, and over-reliance on this type of assessment often leads to instruction that stresses basic knowledge and skills. Thus, using authentic assessment in conjunction with more traditional evaluations can give teachers and parents a richer view of students' accomplishments. Assessment is authentic when we directly examine student performance on worthy intellectual tasks. Authentic assessments require students to be effective performers with acquired knowledge. Authentic assessments present the student with the full array of tasks that mirror the priorities and challenges found in the best instructional activities: conducting research, writing, revising and discussing, collaborating, etc.

In the WebClen, many different assessment methods emerged, for example, assessing students online journals based on information obtained from the Internet, assessing students frequently asked questions, evaluation of multimedia and active Internet links and students' collaborations with peers and experts. It is thus important to investigate the nature of these processes in detail and decide on the rubrics that need to be considered and the processes involved.

Limitations

This study is but an initial step in designing and implementing a web-based constructivist learning environment for a Standard 4-6 Malaysian classroom for the geo-science topics. Steps were taken to select Standard 4 students taking into account the number of students in the classroom, ability levels, gender and race. Steps were also taken to ensure what was studied was in the recommended curriculum and that the content was covered within the stipulated time.

A first limitation of the study is the fact that a control group was not used and therefore it cannot be ruled out that some of the effects were attributable to factors other than the treatment.

The second limitation is the manner in which activities were carried out by students. As most of the activities were group based, there was little opportunity for the learner to learn on his/her own. This is not natural, as learning sometimes occur in a group mode and sometimes on an individual mode. Thus it is suggested that the learning activities be re-evaluated to incorporate activities that allow students to learn on their own as well as in a group.

The third limitation of this study is related to the manner in which students were selected to form the groups. Selecting students based on a strict high, mixed and low ability grouping technique may not be the best solution to student grouping. Other factors such as previous friendships, adaptability and gender may have to be carefully studied. Thus in the WebClen, it was found that not all the 12 groups worked well. Only 3 groups had a good working relationship while the other nine groups had complained of group-mates who were not cooperative, who were not welcomed to the group, and who were competing with each other.

The fourth and final limitation of the study is the fact that it was conducted out of the normal school hours. Thus other factors such as teacher absence, class disruptions due to other activities that normally happen in a regular teaching week, and Internet and electricity disruptions had not been accounted for. Thus it is recommended that the present study be implemented during normal school hours to account for school management challenges that are bound to arise.

Directions for Future Research

More research can be conducted in five major areas: the need for a control group; the design of the template to incorporate intelligent agent features; the redesigning of the curriculum into a theme-based curriculum; the possibility of team teaching; and the implementation of the WebClen on a school-wide basis to weed out management issues.

For immediate efforts, as the study had taken into account the present curriculum with one teacher in the classroom, school-wide implementation can be conducted to identify the types of management issues that need to be addressed. This is because carrying out a study in a single classroom does not include other important issues such as time-tabling, sharing of limited computer resources, server constraints and other technical help. Towards this end, it is recommended that a study be undertaken to evaluate schools that have carried out such initiatives and the processes that were undertaken by such schools. In the Malaysian context, although there are examples of schools that have incorporated use of computers in the classrooms, efforts that make use of the web and the pedagogy of web-based learning are non-existent.

However, in other countries such as the United States and Canada, such initiatives had been started as early as the 1990s. As for example, in Indiana, efforts carried out include a study by Khan, Reigeluth and Blackwell (1992) titled the Indiana 21st Century Schools Pilot Project. The study examined the progress of three Indiana schools toward educational innovation goals under the 21st Century Schools Project. Apart from that, Naugle and Reigeluth (1994) also conducted a study on initiating school restructuring, whereby an elementary school was studied with regard to school restructuring using the School Restructuring Process Model developed by Reigeluth. Accordingly, the three phase program includes the Initiation or Preparation stage, whereby the community is assessed for readiness, facilitators are identified, commitment of stakeholders is considered, an approach for change is selected, participants are prepared and relationships are formed with non-participants. In the second phase i.e. the Design or Development phase, among the action taken were: finding common values and analyzing learner and societal needs; developing core ideas and goals; developing an image; designing a system of functions; designing enabling systems; and analyzing feasibility. The third phase is the implementation phase whereby the planning for implementation, is carried out, the design is implemented and processes are documented to be evaluated.

A more systematic plan is needed if the WEBCLEN is to be tried out on a school-wide basis in selected Malaysian schools. It is widely accepted that technological ideas cannot permeate into the school system, without considering issues related to school-wide adoption of the technology and that technology implementation is as much about change as it is about technology. For technology to support the purposes of change, it must be related to a coherent school-wide instructional agenda also known as systemic change. According to Reigeluth (1994), systemic change is a comprehensive process that requires fundamental changes at two major levels i.e. the macro level which involves the Ministry of Education, the state education system, the district and the schools and the micro level which involves the school itself. At the school level, systemic change must include the types of learning experiences, the instructional and administrative systems. The National Schools Board Foundation (1999) describes systemic change as a cyclical process that goes beyond thinking as a single process but instead as a system.

A series of case studies were carried out by the National Schools Board Foundation (1999) to identify the need for: a shared school-wide instructional vision; consensus on instructional goals; a shared philosophy concerning the kinds of activities that would support those goals; a planned and support snowball effect that endorses the early adopters and gives them incentives such as computers for their personal use and compensation and recognition for designing beneficial instructional uses of technology. It is also important to allocate the distribution of equipment throughout regular classrooms. Among some of the important issues are: having a critical mass of machines in each room (6-8), mobile lab, incremental roll-out (adequately equipped first in some rooms, then others), and school-within-a-school. Lastly, it is important to plan for time for teachers to become acquainted with the technology so that they can become comfortable and proficient with continued use.

Further the National Schools Board Foundation suggests that technology implementation plans should also consider the hardware, software and systems administration part of technology integration. Some of the more important elements that a technology implementation plan should look into are: network — 5 how the information gets there; hardware — what equipment does one need to manipulate this information; software — the programs and configurations to use this; system administration — the people/training to support the equipment; user support — the people training to solve the task at hand using the technology; content — the content specific information i.e. the specific reason to use the technology; and organization change — the organizational support and changes to utilize the technology well.

Thus it can be said that for successful implementation of a WEBCLEN, many different categories of people and resources have to be combined. According to Mehlinger (1996), for successful transformation of learning, three agendas must be effectively brought together: an accepted consensus about teaching and learning, a well-integrated use of technology, and restructuring.

Conclusion

The current study provided a more complete picture of the processes involved in a web-based constructivist learning environment. It supports the constructivist view that learners are able to take charge of their learning. It also supports the constructivist view that teachers play the role of a facilitator. However, for constructivist ideals to survive in a web-based classroom — where learners have access to world-wide information, experts and other learners — the power of modern software and computer technology has to be harnessed to higher levels.