CHAPTER 5

DISCUSSION, IMPLICATIONS, LIMITATIONS AND FUTURE RESEARCH

5.1 Introduction

A strong interest in the design and development of the web-based learning environment motivated this study. As an emerging technology, there are still many unanswered questions on how the web-based learning environment enhances learning. The purpose of this study was to determine the effect of the Bio-WebClen on learning and content acquisition among learners of different learning styles. Besides, the study also sought to explore the nature of the learning process as well as learners' perception of the Bio-WebClen.

Data for this study was collected by administering the Bio-WebClen to 18 Form 4 learners from a secondary school in Sibu, Sarawak of which 6 were identified as auditory learners, 6 visual learners and 6 tactile learners. The aim was to answer the following questions:

1. What is the effect of the Biology Web-based Constructivist Learning Environment (Bio-WebClen) on learning among students of different learning styles (auditory, visual and tactile)?
2. Do the activities in the Bio-WebClen enhance content acquisition among students of different learning styles?
3. What is the nature of the learning process in the Bio-WebClen?
4. How do students perceive the Bio-WebClen?

This chapter presents a discussion of the findings and its implications, recommendations to overcome the instructional weaknesses identified, limitations of the study, directions for future research and conclusion.

5.2 Discussion, Implications and Recommendations

The constructivist approach to science teaching is not new. This approach is seen to be useful in science and mathematics education (Wheatley, 1991; Hendry, 1996). The design of the Bio-WebClen helped to manifest learning theories advocated by constructivists and is an effort to link theory to practice. The findings in this study are discussed in the following sections:

(i) Effect of the Bio-WebClen on learners of different learning styles

(ii) Effects of the Bio-WebClen on content acquisition

(iii) Nature of the learning process

5.2.1 Effect of the Bio-WebClen on Learners of Different Learning Styles

There were four major activities in the Bio-WebClen: information searching, writing activities, inquiry activities and collaborative activities. The students were required to search in the WWW for information related to the content area, use the information in solving problems and then present the product in writing or online-inquiry. During the process, they were encouraged to collaborate with peers and experts to help them achieve their learning goals.

An assessment of the learners' performance in online and off-line learning activities was carried out in order to determine the effect of the learning environment on learning among learners of different learning styles.

Table 5.1.

Learning activities and leading scores of students of different learning styles

Learning Activities	Auditory	Visual	Tactile
Online reporting		√	
Interpretation of visual images	√		√
Generation of FAQs and answers			√
Peer evaluation of FAQs and answers		√	
Expert-learner online conversation	√		
Experiment			√
Online quiz		√	√
Content test			√

Note. √ = led the scores

The results of the study demonstrated that the Bio-WebClen did have a positive effect on learning among learners of different learning styles. No single dominant style tops the list in mean scores for all the activities (see Table 5.1). The auditory learners led the scores in the interpretation of images. They were also most frequently participated in online conversation with the expert. The visual learners led the scores in online reporting, peer evaluation of FAQs and answers, and online quiz. The tactile learners, on the other hand, achieved the same mean scores as the auditory learners in the interpretation of images, and they also had the same mean scores as the visual learners in online quiz.

Besides, they (tactile learners) led the scores in reporting the results of the experiment and generated the most number of FAQs and answers. Therefore, the activity, expert-learner online conversation seemed to have a better effect on auditory learners as compared to visual and tactile learners. On the other hand, online reporting and peers' evaluation of FAQs and answers seemed to have a greater effect on visual learners as compared to auditory and tactile learner. The activity on generating FAQs and answers and carrying out experiment seemed to benefit the tactile learners more than the other two categories of learners.

The auditory learners in this study did not seem to achieve as much as their peers. This implies that the learning environment was not very much in favor of their learning style. One major setback of the Bio-WebClen was the unavailability of the audio clips. The lack of online and off-line audio materials could have impeded the students' learning. It is recommended that audio clips (with reasonable downloading time) on major concepts be integrated in the Bio-WebClen. For the short term, audio clips may be stored on the hard disk of the computer.

The auditory learners in this study were found to participate most frequently in online conversation (tactile preference). Online collaborative learning, therefore, seemed to fit the style of auditory learners. An unexpected finding in this study was that the visual learners did not perform as well as the auditory and tactile learners in the interpretation of images. This contradicted the findings of Carbo (1980) and Weinberg (1983) who reported that visual learners demonstrated significant gains following visual presentation of instructional content. There are two important implications in relation to this. Firstly, it may be deduced that the auditory and the tactile learners have expanded

and adapted well to other modalities that are not their strength (e.g., the visual mode). Secondly, it may have to do with the obstacle in diagnosis as argued by Gregorc (1979) which implies that students might have reported an "artificial means" as "preferred means of learning" (Gregorc, 1979, p. 235). This means that some of the visual learners being identified in this study might not be "visual learners" and this had affected the scores in the interpretation of images. The teachers, therefore, need to realize that there are human elements in learning that cannot be measured, and that diagnosis of learning styles is not fully accurate (Gregorc, 1979). Teachers, in diagnosing students' learning styles need to employ a few methods, for example, observations, conversations with students besides administering the learning style instruments (Gregorc, 1979; Reiff, 1992).

The tactile learners in this study were found to generate the most number of FAQs. This implies that the tactile learners favoured the task of formulating questions (and answers) and keyboarding. They enjoyed the hands-on activity. Besides, the tactile learners seemed to have utilized other perceptual modes (auditory and visual modes) as well. This was clearly seen when they were involved in discussion (auditory mode) prior to electronic writing and reading their peers' questions and answers (visual mode).

As the Bio-WebClen manifests the constructivist ideals, the web-template in the Bio-WebClen conforms to the principles of rich learning environment, collaborative learning and scaffolding. Learners were provided with ample online resources through the "Link" facility. The "Link" therefore acts as an online resource room that provides information related to the content by linking it to other relevant websites. These external websites were carefully evaluated for their credibility and suitability. The "Link" is also very much like a library for the learners. However, it works beyond the constraints of a

library in that the provision of a search engine has allowed students to locate more information than allowed by the actual resource room or library. In a traditional classroom, teachers and textbooks are the sole provider of education. In a web-based classroom, students have the opportunities to access to online books, journals, museums, libraries, and data of all kinds. The only crucial issue is the evaluation of Internet resources. Students need to be taught the skills of identifying credible online resources.

In relation to the links in the Bio-WebClen, the participants in this study indicated that they were uncomfortable with links in English. This implies that more links in Bahasa Malaysia need to be created. To accomplish this, teachers need to have basic knowledge and skills on creating informational websites. It then follows that the teacher training programs need to be structured to integrate relevant information and communication technology and online pedagogical skills. Creation of local websites is important as this would help to make web-based learning a success in Malaysian schools. If external websites in English are to be included as links, it is necessary to create glossaries of important concepts in Bahasa Malaysia and incorporate them as links to the websites. Alternatively, effort can be made to incorporate moderately detailed synopses in Bahasa Malaysia as links.

The "Create" section is a free space for students who have discovered or created interesting and challenging solutions which they are happy to share. It comprises of three main activities: report writing, generating FAQs and answers and evaluating FAQs and answers of their peers. In report writing, the learners, besides acquiring basic knowledge on vitamins also develop skills to analyze, evaluate and synthesize information. For instance, in writing a report on issues such as vitamin intake, learners learned to critically

assess information from various perspectives. Report writing is incorporated into instructions for several purposes. First, it provides a feedback tool for the teacher. Second, it is a way of having students reflect back on their own learning, as well as that of their peers. Third, it is a means of sharpening the students' written skills. Development of students' written skills was traditionally considered as the responsibility of the language teachers. However, in recent years, the contribution of teachers from other curriculum areas in improving the students' written language is gaining recognition (Synder, 1993).

Writing activities provide opportunities for students to explore, understand, and extend or apply content materials. Writing exercises also support the notion of actively engaging students in learning (Classroom Activities for Active Learning, 1998). Short in-class writing task can stimulate engagement with content and promote inquiry. Writing is believed to have a powerful impact upon students' learning (Bonwell & Eison, 1991). It can help students see issues from diverse perspectives by stretching them to write with the perspective of the "other" in mind (MSU Teaching Assistant Handbook, 1995).

Reports posted online can be viewed and be commented by all the learners. The "Create" thus provides an outlet for the creative work of the students with more experience and expertise and at the same time supports the learning of those students with lesser experience and exposure. This enables and encourages the experienced and competent students to provide peer-tutoring and coaching and support for others in the class. At the same time, it encourages those with problems to seek help from peers and to be proactive in the learning process.

However, an important point to note was that most visual and tactile learners expressed a dislike of writing online report on "Vitamin and Health". The writing of this report was perceived by the teacher as requiring two skills, namely information searching and writing skills. This task is interdisciplinary as the learners have to integrate knowledge from other curriculum areas such as the language needed to complete the task. Learners' dislike of writing this report could be due to the hindrance generated by the technological functions of the computer. The learners were uncomfortable with using computers to process the learning product, to search for information in the Web and to attach files to the web-template. This impeded the process of learning. For learners to participate effectively, they need a certain level of computer literacy and computing skills. If sufficient computing skills have been imparted to the learners prior to learning in a web-based learning environment, the learners might face less frustration. There are good reasons, therefore, for familiarizing students as early as possible with computing skills. This would fulfill the two roles of technology: as a tool to promote learning, and to impart a set of computer skills that students will need in their everyday lives (Cameron, 1994).

The FAQ section has a dual function. Firstly, it promotes inquiry. Secondly, it encourages peer learning through peer assessment. It is important for students to develop inquiry skills as this helps them to acquire content knowledge (Cotton, 1997). Generating FAQs and answers fulfill this purpose. However, the findings of this study reveal that students need support in forming their questions. This implies that the teacher not only needs to help students understand what the characteristics of a good question are, but also to help the students in actually formulating the questions, particularly higher level open

questions. The role of the teachers here is to teach students questioning skills. Teachers could use reciprocal teaching method (Palincsar, 1987) for this. This method requires the teachers and the students to take turns playing the role of teaching. At the beginning of the learning session, both the students and teachers read an article silently to themselves. Whoever is playing the role of teacher formulates a question about the passage in the article. Initially, the teacher models this process, but then each student takes turn. When students undertake the process, the teacher coaches them on how to construct good questions, offering prompts and critiquing their efforts. In this way, the teacher provides scaffolding for the students, enabling them to take on the questioning task.

The FAQ section also encourages students to access each other in real time. Students can click on a question to check what has been discussed and forwarded by their peers and follow-up with comments of their own. It also acts as a dynamic database which grows as students use the Bio-WebClen and provides the form of learning support usually given by teachers.

The FAQ section can be extended to provide a facility for the teacher to post examples of common questions together with solutions, enabling modeling and scaffolding. Scaffolding is vital in learning as it helps learners to achieve the zone of proximal development (Vygotsky, 1978, as cited in Cuerra & Schutz, 1996).

Students' workspaces are extended into the "Media" facility. This facility allows students to describe images they observed based on their own understanding. A total of 37 images are available in the "Media". The students were required to describe five images most related to the curriculum. Other images serve as additional resources for report writing. The students can choose to incorporate any of the images into their report.

Nonetheless, the "Media" in the Bio-WebClen had not fully capitalized the capabilities of the Web. Most graphics were still images. It is suggested that more animated graphics and video clips be incorporated to provide a wide range of selection for learners of different learning styles.

The students' learning was also supported by two paper-based activities: writing reflective essays (collaborative and individual) and drawing a concept map. The students reflect on their own learning and relate their learning experience by writing collaborative and individual reflective essays. A collaborative reflective essay allows learners to reflect on shared experience while an individual reflective essay enables learners to express their deepest thoughts that are not sharable. A collaborative concept map allows students to construct and edit concept maps that summarize the main concepts so that they get an integrated picture of the concepts as opposed to studying isolated facts. As learning science is seen as a process of conceptual change, a pre-learning concept map can be produced to compare with a post-learning concept map to provide a better indication of conceptual change and concept attainment.

Assessment of content acquisition was achieved by the use of "Quiz" facility. There were ten objective type questions in the quiz. The students were encouraged to attempt this section after they have completed all the learning tasks. Immediate feedback facility is provided where the students can check on their scores upon answering all the ten questions.

Then there is the electronic asynchronous communication, the "Specialist". The "Specialist" serves as "cyber-tutor" to coach and to provide scaffolding. The students can send messages to the specialists (teachers or experts) to ask questions about the content.

The specialists would then reply to the questions, giving answers, guidelines or critiquing questions forwarded. This is helpful in helping students understand the nature of the questions that other students ask, and it provides a means of responding in a non-threatening way, to a wide range of questions and issues that increase opportunities for critical thoughts. However, the process of collaboration through the "Specialist" was impeded due to the lack of experts incorporated in the Bio-WebClen. The teacher (researcher) was the only expert and this affected the prompt provision of views and answers. For effective collaboration, experts from other parts of the country or other regions of the world need to be involved. School networking is an important step towards this goal. With the networking system, the "Specialist" can be extended to provide powerful classroom connectivity. It can be networked into the real world to bring authentic, real-time learning experiences to students as had been carried out by Townview, one of the public schools in Dallas (Watson, 1996). Townview used a powerful electronic conferencing tool, CU-SeeMe that enabled its students to videoconference with peers at high schools at Austin and Galveston. The CU-SeeMe is a two-way audio/ video conferencing software that can work on PC-Windows-based computer platform where images, text and sound from multiple sites can appear simultaneously on a computer screen (Bonk, Appleman & Hay, 1996). Through this software, students can work with Nobel Prize-Winning professors. This is what had been experienced by the students at Townview. Biology students in this school not only worked with computer applications that one would find in professional laboratory, they also collaborated with notable researchers. Through VideoTel conferencing, the students have the opportunities to view video demonstrations provided by two Nobel Prize-

winning professors from Southern Medical School. The professors even discuss with students ethics and the human genome project. Learning directly from Nobel Prize-winners is an experience no textbook can provide. The Bio-WebClen can emulate the initiatives of Townview to incorporate video conferencing tools.

Students' understanding of vitamins were further enhanced by engaging them in doing an experiment. The experiment chosen was in line with the requirements of the curriculum. Letting learners manipulate concrete objects provide for experiential learning. The constructivist view of science learning considers the laboratory as the primary instructional environment for involving students in scientific inquiry (Winer, Chromienne & Vazquez-Abad, 2000). This method most likely did not fit the style of the auditory and visual learners as they were found to be not very responsive to laboratory work. There are two implications pertaining to this. First, the physical environment was not favourable as the experiment was not carried out in a laboratory environment but by integrating experiment into classwork at the computer training room. Second, the nature of the learning task demanded a tactile mode. There are learning tasks that require specific learning style (More, 1993; Dunn & Dunn, 1993). Therefore, it is insufficient for teachers just to know the stronger learning styles of the students but must recognize that a specific learning task may demand a particular learning style, even if it is a weaker style. Hands-on experiment was considered as requiring the auditory and visual learners to exercise their weaker modality (tactile mode). The question is: "How do the teachers help to overcome the modality weaknesses of these learners?" According to More (1993) and Dunn & Dunn (1993), a teacher can accommodate these learners by strengthening their weaker style. To do this, the auditory and visual students are first taught through their

stronger style, and then reinforced through their weaker style. In the case of doing the experiment, the auditory learners should first listen to teacher's explanation or participate in discussions (auditory mode), after which they are required to read through the experimental instructions (visual mode) before conducting experiments and answering questions or writing reports (tactile mode). As for the visual learners, the teacher should first instruct them to read through the steps of doing the experiment as well as any written questions (visual mode) a day before they carry out the experiment. The next day, the visual students need to listen to the teacher's explanation (auditory mode) before doing the experiment and answering written questions or writing reports (tactile mode). These skills need to be imparted to teacher trainees.

5.2.2 Effect of the Bio-WebClen on Content Acquisition

The Bio-WebClen did enhance content acquisition among learners of different learning styles. This is confirmed by a significant increase in posttest scores as compared to the pretest scores of the learners. This finding is similar to that of Shih and Gamon (1999) whose study demonstrated that the learning styles of students did not have an effect on web-based learning achievement. They concluded that students of different learning styles and backgrounds learned equally well in web-based courses. The finding is also consistent with that of Kulik (1983a), Kulik (1983b), Bangert-Drowns (1985), Okey (1985) and Wilson (1993) who found that computer-based teaching and learning have the potential to improve students' achievement.

Nonetheless, the findings highlighted an issue with regards to achievement. It was found that the gain made by tactile learners was at the two different ends of the

continuum. One team of tactile learners achieved the highest gain in content test, while another team made the lowest gain. Why was there such a great difference in the achievement of these two teams of learners of the same perceptual preference? There are two issues related to this finding: instrumentation and integrated learning styles.

The Learning Style Inventory used in this study diagnosed students' learning styles based on the highest total score among the three categories: auditory, visual and tactile. For instance, a student (Student A) who scored 15 points for auditory measures, 24 points for visual measures, and 30 points for tactile measures was identified as a tactile student as he/ she scored the highest in the tactile measures. In another instance, a student (Student B) with the scores 25 for auditory, 30 for visual, and 35 for tactile was also selected as a tactile student. Student B, therefore, has a "stronger" tactile perception as compared to student A. This was the case as each perceptual preference exists in a continuum (Dunn & Dunn, 1993). In addition, the above combination of scores clearly indicated that student B also has stronger auditory and visual perceptions. According to Reiff (1992), the ability to use all learning modalities may significantly affect the acquisition of academic skills and achievement. Students who adapt to multiple modalities can process information effectively in whatever modality it (information) is presented (Barbe & Milone, 1981). This might account for the discrepancies in the scores of the tactile learners.

Further, the Learning Style Inventory used in this study only diagnosed students for their modality preferences (physiological styles). Other physiological style such as environmental characteristic, need for food during study, and times of day for optimum learning were not taken into considerations. Moreover, this study also ignored other

styles that affect learning such as the cognitive styles and affective styles (Cornett, 1983; Ast, 1988). Cognitive styles refer to the ways the learners decode, encode, process, store and retrieve information. Affective styles include emotional and personality characteristics such as motivation, locus of control, interests, willingness to take risk, persistence, responsibility and sociability. These variables might have influenced student learning as students of the same perceptual preference might have different cognitive and affective preferences.

In order to accommodate students of different learning preferences, learning style-based instruction have to be implemented in the classroom. Dunn (1990) have reported of the success of schools in implementing learning style-based classrooms. The following are some of the exemplary schools: (a) A high school in Midwest, Wyoming under the leadership of Jeff Jacobson initiated learning-style programs that had successfully raised the overall achievement of the school, (b) Corsican High School in Texas under the initiative of the former Math Department Chairperson, Sherry Dotson, implemented learning style-based instruction that had helped students who had never or barely passed mathematics, to achieve passes in the statewide tests (Dunn, 1990; Orsak, 1990), (c) Brightwood Elementary School in Greensboro, North Carolina under the principalship of Roland Andrews implemented learning style models that had contributed to the increment of reading and mathematics test scores from the 30th percentile to the 83rd percentile within 3 years, (d) Baker High School in La Porte, Texas, in implementing the learning style framework to support student learning in the classrooms had resulted in a drastic drop in the failure rate of the school from 40% to 9% within two years (Marshall, 1990). As Dunn (1990) asserted, it is not impossible for teachers to respond to students'

ltiple learning styles. It just needs two attributes of the teachers: the "know how" and effort in redesigning the classroom to respond to individual learning style differences. vould be beneficial for the schools' principals to identify the Subject Coordinators *etua Panitia*) who have practised some aspects of learning styles in their instructions to nduct seminars or workshops on learning styles for teachers. Subsequently, the Subject)ordinators could restructure and redesign the syllabus for their respective subjects to corporate activities for students of different learning styles. Indeed, teachers need to entify students' learning styles and take into consideration those learning styles when signing instruction (Moustafa, 1999). Initially, learning style-based instruction may be troduced to the "at risk" students or students being labelled as "slow learners". Marshall .990) reported her success of using learning style-based instruction for low achievers at ıe Center for Slow Learners, Richardson, Texas. Learning-style based instruction, too an help mildly handicapped students to succeed academically (Brunner & Majewski, 990).

The design of the learning environment for learners of different learning styles ıeeds the teachers or instructional designers to implement the following: (a) identify earning style characteristics of individual learners, and (b) redesign the educational environment (Dunn & Dunn, 1993). The first step in designing learning environments that cater for the differences in individuals is to diagnose the learning styles characteristic of the students. This can be achieved by using a comprehensive, reliable and valid learning style instrument. Then, the teachers need to analyze individual students learning style profiles, interpret accordingly and get to a decision on how each of the students need to be taught. After this the teacher needs to redesign the classrooms. The classrooms

can be structured to comprise of multi-instructional areas as depicted in Figure 5.1. There are two major areas: formal and informal. The formal part comprises of the ordinary classroom. The informal part comprises of a few instructional areas such as the Media Center, Interest Center (Audio and Visual Centers), Games Corner and Web-based Learning Stations. The Media Center could house a variety of educational resources for students of different learning styles. This literary become a mini resource room where print-based materials (books, magazines and articles), electronic resources (audio cassettes, video tapes, CD-ROMs), and subject matter games are allowed to be borrowed and taken out to the Interest Center, Games Corner or Web-based Learning Stations. The Interest Center is the place where the students may use the media equipment to obtain information, study concepts and develop skills. The Interest Center can be divided into two sub-stations: one for audio (Audio Center) and one for visual (Visual Center) by using shelves as dividers. The Audio Center could house the students' desks fixed with radio system and headphones while the Visual Center could be equipped with a television set and a video cassette recorder. The Games Corner is the place for students who like to learn by using educational game materials. The materials for tactile learners can be commercially produced or self-made by the students (such as task cards, electroboards, pit-a-hole cards and flip chutes). The Web-based Learning Stations housed the networked computers for all the learners. There are individual computer stations for students who prefer individual work and there are round tables for students who prefer team work. Each round table can be designed to accommodate 4-5 learners. Students can view multimedia presentations either online or from CD-ROMs.

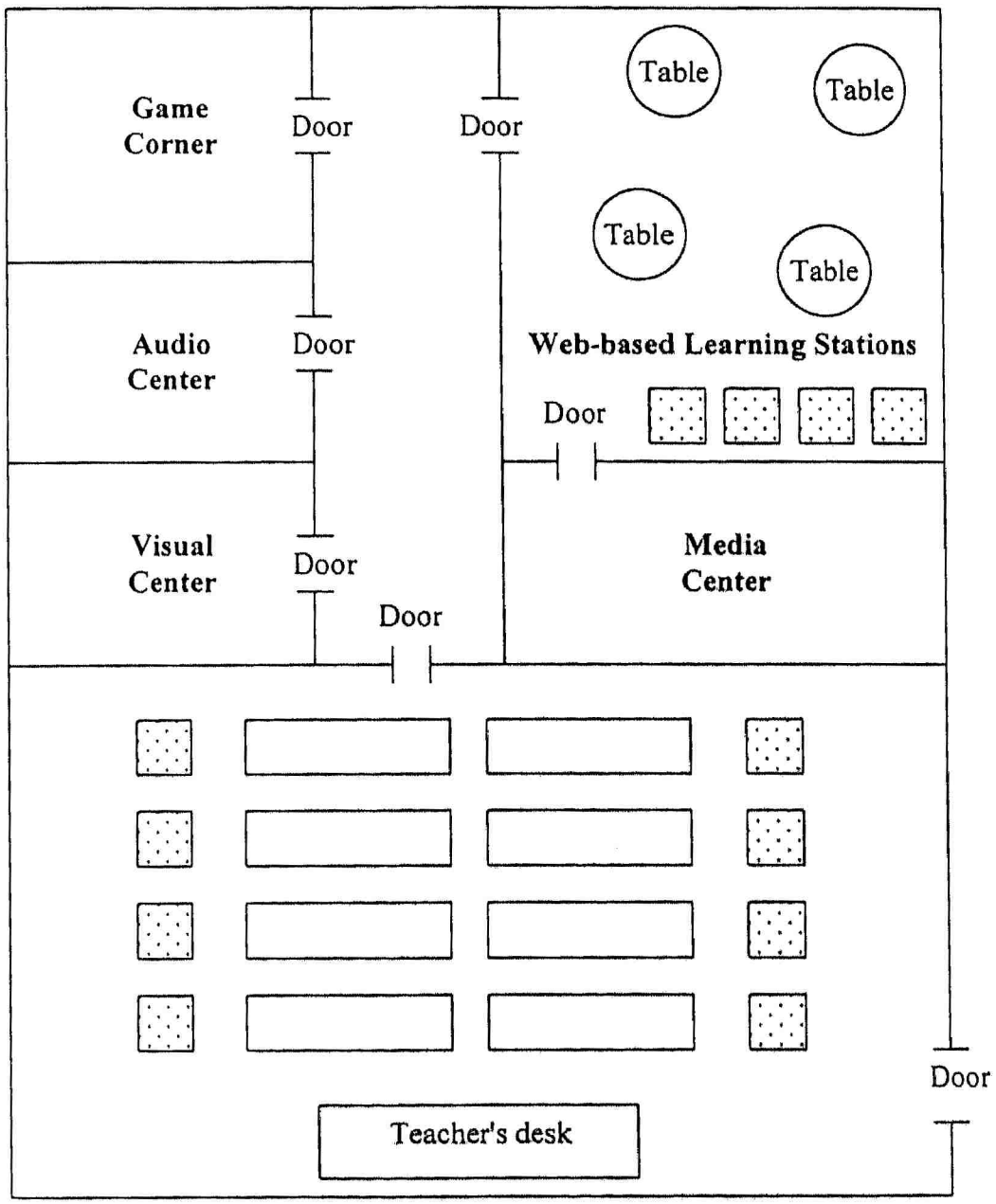

Figure 5.1. An example of learning style-based classroom.

Key:

Desk for one student

Desk for a group of students

Table for a group of students

5.2.3 Nature of the Learning Process

The nature of the learning process was investigated in terms of interaction and learners' time on task.

Most learners like team work and most of the time they were seen discussing and then taking turns using the keyboard to key in the solutions they have got. This is consistent with Synder's (1993) findings that computer use increases co-operation and collaboration. The learners were seen to interact with the content, their peers and their teacher. Interactivity is an important factor that contributes to engaged learning. An interactive instruction encourages the learners to construct and produce knowledge in meaningful ways. Students can teach others interactively and interact generatively with their teachers and peers. Three groups of learners seemed to be excellent coaches for their peers. They provided advice to their peers on where to look for the relevant information.

The study also demonstrates that the use of the Bio-WebClen in the class encourages learners' participation in learning. This is reflected in the percent of time on task of the auditory, visual and tactile learners. There is not much variation in the percent of time on task among the three categories of learners. This finding is consistent with the findings of Oliver, Malm, Malone, Nay, Saunders and Thompson (1998) who found that Internet use in the class increases student engagement and participation. The finding is also in line with Waxman and Huang (1996) indicating that students in classrooms where technology was moderately used, were found to be on task significantly more than students from classrooms with little technology used. Carey and Sale's (1997) study on the effects of using computers on students' time on tasks found that for certain students, the use of technology appears to help increase attentive behaviors, both in students

diagnosed with Attention Deficit Disorder (ADD) and those without ADD. Keeping students on-task was reported to be a practice of exemplary teachers (Tobin & Fraser, 1988). This practice was believed to reduce students' misbehavior and maintain a learning environment that is conducive to learning.

Although the Bio-WebClen had allowed active interaction and participation of students during the learning process, its interactivity can still be improved through online collaboration. There are a host of online projects for secondary school students. The AT&T Network, Global Laboratory, LabNet: The High School Science Network and National Geographic Kids Network are all online projects that could make learning more authentic and meaningful (Fowler & Wheeler, 1995). Students and teachers will have the opportunities to communicate with other students or teachers across towns or across the world. With the initiatives of the Education Ministry to equip schools with ICT facilities, computer mediated communications (CMCs) is not impossible for secondary education. Indeed, there were teachers who have reported their success with CMCs at the K-12 level (Fowler & Wheeler, 1995). Teachers had found CMCs beneficial for student learning. It not only promotes collaborative learning. CMCs also improves social interaction and writing skills and enhances cultural awareness. Most of all, it brings the world into the classrooms.

5.3 Assumptions and Limitations

The planning and organization of this study is based on the assumption that the Malaysian students have little knowledge and experiences with computers. Thus, it will support students who had never used a computer before.

Due to the limitation of time, the design and evaluation of the Bio-WebClen is based on the results of needs assessment from two teachers. The selection of instructional activities and media were restricted by the resources available to the researcher. For instance, the researcher was only able to select instructional media that she is capable of producing and those available in the average school.

The limitation of working space in the computer training room also posed another problem. Because of this problem, the evaluation of the Bio-WebClen was carried out on a selected number of students. Thus, the findings are incomplete, as they reflect only those subjects who participated in the study. Also, the subjects were selected from only one school in a rural-urban area and hence other effects such as community types (for example, rural community) were not represented in the findings.

The study used learning style inventory that diagnosed only students' perceptual preferences. However, the findings might reflect the outcomes of interaction of a few learning style variables, and not solely the outcome of perceptual preferences.

This study examined group mean scores which ignore the scores of each individual. Thus, the effect of the Bio-WebClen on individual achievement is not represented in the findings.

5.4 Directions for Future Research

The present study investigated the effect of the Bio-WebClen on student learning among students of different perceptual preferences. A second direction of research could involve perceptual strengths. Investigation of the effectiveness of the Bio-WebClen in

promoting learning among students of different perceptual strengths might complement the findings of this study.

In addition, research on students' learning strategies could be conducted to identify the learning strategies employed by learners of different learning styles in the web-based constructivist learning environment. Here, learning strategies employed by successful learners can be determined.

Further, research involving web-based learning could also explore issues such as conceptual change and learning effectiveness (that is knowledge acquisition and transfer of learning) over extended periods of use in real classroom situations.

5.5 Conclusion

The findings from this study seem promising. The Bio-WebClen does have a positive effect on learning and content acquisition among learners of different learning styles. However, it needs to be incorporated with audio clips and more interesting video clips in order to accommodate the auditory and visual learners. Although the learners engage well in learning tasks and work collaboratively, online collaboration was minimal. Incorporation of computer-mediated communications (CMCs) into Bio-WebClen is recommendable. Moreover, the students reacted positively towards the new learning environment. This serves as an inspiration for teachers to consider integrating the Web into the traditional classroom teaching. However, several elements such as access and skill, motivation and telecommunication operational procedures that involve the use of software needed in accessing, connecting, and e-mailing may impede the learners' efforts to become a self-directed and a successful online learner. Thus, it is the

wisdom of the school administrators and teachers to carefully structure the learning environment to accommodate learners of varying technological skills and learning styles.