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Acquiring Scientific Skills in a Technology-Based Classroom

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Brief description of Lecture(including its purpose): Computer technology has been incorporated in science learning. Some customized their technology-based instructional materials, while others use materials available on the Internet. The purpose of this study was to unravel the learning processes that occurred in the learning of science; particularly in acquiring scientific skills in a Technology-based learning environment. The study employed an exploratory qualitative case study which involved nineteen Grade Five children. The participants were selected using the purposive sampling technique. During the study, children explored the specially designed Web-based instructional materials known as 'Science Process Skills in Scientific Exploration', in short SPicE. The primary data collection techniques used in this study were interviews, children's conversations, observations, children's diary entries and entries from the on-line discussion. Data from interviews, conversations and observations were transcribed while relevant entries from children's diaries and on-line discussions were extracted. Data were analyzed using the constant comparative method. The findings of the study suggest that there were three dimensions of learning; the cognitive, interpersonal and intrapersonal dimensions. These learning dimensions were intertwined among each other and were influenced by the design features of SPicE.	
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Abstract

Computer technology has been incorporated in science learning. Some customized their technology-based instructional materials, while others use materials available on the Internet. The purpose of this study was to unravel the learning processes that occurred in the learning of science; particularly in acquiring scientific skills in a Technology-based learning environment. The study employed an exploratory qualitative case study which involved nineteen Grade Five children. The participants were selected using the purposive sampling technique. During the study, children explored the specially designed Web-based instructional materials known as 'Science Process Skills in Scientific Exploration', in short SPicE. The primary data collection techniques used in this study were interviews, children's conversations, observations, children's diary entries and entries from the on-line discussion. Data from interviews, conversations and observations were transcribed while relevant entries from children's diaries and on-line discussions were extracted. Data were analyzed using the constant comparative method. The findings of the study suggest that there were three dimensions of learning; the cognitive, interpersonal and intrapersonal dimensions. These learning dimensions were intertwined among each other and were influenced by the design features of SPicE.

1.0 Background

Technology has been integrated in the teaching and learning processes since in the late 1950's and it is commonly known as computer-assisted instruction (CAI), computer-based instruction (CBI), computer-based learning (CBL), and computer-assisted learning (CAL). If learning utilizes the attributes of the Web, it is known as Web-based learning (WBL) or Web-based instruction (WBI). Basically, computer technology in education setting is seen as an educational medium in which the technology is used to assist the teaching and learning process. Examples of such application are drill and practice, computer visualization, simulations and computer-facilitated communication between learners as well as between instructor and learners.

Science learning includes acquisition of scientific knowledge, acquisition of scientific skills and inculcation of scientific attitudes. The present study however, will only focus on the acquisition of scientific skills, particularly the acquisition of science process skills. Science process skills could be categorized as basic science process skills and integrated science process skills. Some science educators (e.g., Brotherton and Preece, 1995) believe that integrated science process skills are not suitable to teach at the primary level. Integrated science process skills such as controlling variables are regarded as one of the characteristics of the formal operations stage of Piaget's Cognitive Development Model, while most primary school children are operating at the concrete level. Thus, these skills need to be taught specifically using various forms of instruction. For example Ramli Atan (1994) and Almekinders, Thijis and Luben (1998) used specially designed modules. Klahr, Chen and Toth (1999) and Allen (1973) taught science process skills directly to elementary school children and Quinn and George (1975) used film loops in developing the skill of formulating hypothesis. With the current development in computer technology, some (Lazaworitz and Huppert, 1993; Nakhleh and Krajcik, 1993; Settlage, 1997; and Huppert, Lomask and Lazarowitz, 2002) explored the use of technology in the teaching of science process skills. Most of the studies involving the use of computer technology showed positive results in terms of achievement, attitude and problem solving ability as compared to their control group counterpart. Lazarowitz and Huppert found that students in the computer-assisted learning environment achieved significantly higher mean score on their academic achievement. Nakhleh and Krajcik discovered that students using a computer interface portrayed more meaningful conceptual and analytical verbalization and the students were able to relate the observed phenomena with their prior knowledge, while Nor Aziah et al. (1998) reported that the use of their specially designed Web-based material motivated their students to study science. All of the studies reviewed focused on the product of learning and not on the processes that learners undergo in such learning environments. In addition, little information is available regarding the usage of computer technology among primary school children, particularly in Malaysia. Thus, the purpose of the study was to unravel the learning processes that occur in a Web-based learning environment. Specifically, the main research question that guided the fieldwork was what learning processes do children undergo in the Web-based learning environment?

2.0 Research Objectives

The objectives of this study are to:

1. unravel the learning processes that children undergo in a technology-based classroom; and
2. discover the nature of the learning processes

3.0 Research Methodology

The present study is part of a larger study on children acquiring science process skills in a Web-based learning environment. It is an exploratory case study that employed qualitative research methods. The main source of data came from conversations between students-students, student-computer and also student- teacher. Audio recorders were placed in each group to record their conversations.

The participants were also video taped to capture the non-verbal behavior while interacting with the instructional materials, which is known as SPicE. In addition, data were also obtained from SPicE's database on the participation of the children in the *Forum Section* as well as the *Electronic Worksheet*. The study was conducted for a period of five weeks, three periods weekly of 30 minutes each. The first week of the study was the week of familiarization. They were made familiar with the research tools such as the audio and video recorders. Both the audio and video recorder was turned on but the recording was not treated as data. During the week of familiarization, they were also introduced to using the computer as well as getting connected to SPicE web site. This was then followed by four weeks of the field study.

3.1 Selection of Site and Participants

Purposive or purposeful sampling was employed in this study as Merriam (1998) argues that the sample should be comprised of participants from whom the most can be learned. A primary school which had computers with Internet connection was chosen as this study seeks to unravel the learning processes children underwent in a Web-based environment. The participants were nineteen Fifth Grade children; eleven girls and eight boys, of middle class socioeconomic background. The criteria for selecting these children were consent from the children's parents for their children to participate in the study and the children's ability to talk and express themselves freely while being audio and video-taped. These were important criteria since verbal data were the main data source for this study.

3.2 The Web-Based Instructional Material (SPicE)

The study utilized a specially designed Web-based instructional material, known as *Science Process Skills in Scientific Exploration* or in short SPicE. However, SPicE used in this study is a prototype version and focused on only the skill of controlling variables. Although many science Web sites were readily available on the Web, many of the sites were in English. During the time the study was carried out, Malaysian students learn Science in their National Language which is the Malay Language. The sites which were in Malay language were mostly dedicated to scientific knowledge and none focused on cognitive skills such as the science process skills. It was for these reasons that the Web-based material had to be developed, focusing on the integrated science process skill of

controlling variables, in-line with Malaysian science curriculum and presented in the Malay Language. See Rohaida Mohd. Saat and Kamariah Abu Bakar (2000) and Rohaida Mohd. Saat (2001) for an account of the development of SPicE. Basically, SPicE consists of various pages or sections. The first section is the *Pengenalan* (Introduction Section). It gives the objectives and also a brief overview of the Web site. Then the site navigates user to the page or section of *Mengawal Pembolehubah* (controlling variables) where it provides description of the skill of controlling variables. Further explanation of the skill, such as the types of variables, is given as hypertext.

Two types of activities are offered, that is *Hands-on* and *Simulasi* (simulated) activities. The Hands-on activity offers learner a real Pendulum Experiment to explore using apparatus such as washers, strings and paper clips. After performing the activities, user completes the students' worksheet linked to the Hands-on activity page and sends directly to the researcher via electronically. The simulated activity provides three different activities: *Persaingan* (Competition), *Tanjakan* (Ramp) and *Panas! Panas!* (It's Hot!). All of these activities are hierarchical in nature. For example *Tanjakan* consists of five levels in an ascending pattern. The first level deals with the value of variables, where the color of the ball does not affect the distance the ball traveled. The second, third and fourth level attempt to illustrate that input or independent variables will affect the output or dependent variables. The final level requires the user to manipulate various independent variables in order to determine the furthest distance travelled by the ball. Another section at the *Mengawal Pembolehubah* Page is the *Cabaran SPicE* or the SPicE quiz. This section provides multiple choice questions pertaining to the simulated and hands-on activities. Once user chooses an option, feedback is given immediately whether it is correct or incorrect. The user cannot move on to the next question without getting the question correct. Lastly, the *Mengawal Pembolehubah* page also provides a link to a discussion 'room" under the icon *Forum*. The user poses questions pertaining to activities previously performed, questions and tasks in this link or section. The expert is also available to assist the students to any problem that they may encounter. Linkages to other related sites are given under the *Hubungan* (link) hyperlink. There are six web-sites provided in this section and most of these sites are of the primary level.

3.3 The Fieldwork Activities

The children were given targeted tasks and these tasks were based on SPicE. Each child was given a printed guide that included the children's learning objectives and their learning tasks. However, once they have completed the given task, the children could explore any other sections of SPicE. As mentioned earlier, the first week of the fieldwork was the week of familiarization. No data were collected during that week. The children performed the 'Hands-on' section of SPicE during the second week. In this section, the children performed an actual pendulum experiment where they investigated the effect of various types of string and also string of different lengths, to the number of oscillations made. All experiment procedures were presented in SPicE. The children were required to enter data into SPicE's electronic worksheet. This worksheet was then sent electronically to the SPicE database. The teacher then evaluated the worksheet and feedback was given to the children during group discussion with the children in class.

In addition to the hands-on activities, the children were also encouraged to participate in the electronic Forum provided by SPicE. Since electronic discussion is new

to the children, the teacher started up the discussion by posting two questions. This initiated participation among the children. In the third week of the fieldwork, the children explored the "Aktiviti Simulasi" or the simulated activities provided by SPicE. All levels of these three activities are linked to students' worksheets and the user completes the worksheets and sends them to SPicE's database electronically. Figure 2 illustrates the page linking to the three simulated activities. Each task has an electronic worksheet linked to i**t,** and data obtained from the activities were entered by the children and sent directly to the SPicE database.

Linkages to other related sites are given under the *Hubungan* (link) hyperlink. There are six web-sites provided in this section and most of these sites are primary level. Among the Web-sites are *Fossweb*, and *Alaminda*. Fossweb is a Web site developed by the FOSS team (FOSS, 2000) at the University of California at Berkeley. This site provides interactive science activities for primary school children. Most of these activities involve manipulation of variables. One of the activities provided is a virtual aquarium. This activity allows student to manipulate various variables such as the number of fish, the amount of food and the temperature of the water in the aquarium, where the main aim of this activity is to keep the fish alive. The *Alaminda* site is a local Web-site and caters for subjects: Malay Language, English Language, Mathematics and Science, both at primary and secondary levels. The content of the science subject is in accordance to the local curriculum and focused on the acquisition of scientific knowledge. Besides content, the site also provides questions and problems for students. In the final week of the fieldwork, the children explored 'Cabaran SPicE" or the SPicE quiz. In this section, SPicE provides multiple-choice questions pertaining to the simulated and hands-on activities. Once the children selected an answer, a synchronous feedback was provided. This section served as a form of self-assessment.

3.4 Analysis of Data

The constant comparative method of analysis (Strauss and Corbin, 1990; Merriam, 1998) was used in data analysis. All the audiotapes were transcribed verbatim. The videotapes on the other hand, were transcribed in the form of descriptions of the students' behavior. Forum entries were downloaded and analyzed based on the types of questions posted and accuracy of their responses. The children's electronic worksheets were also downloaded from the database and analyzed based on their responses as well as the types of queries posted. The order of analysis was chronological, according to the sequence in which the data appeared. All these data were first reviewed and coded. Only data that reflected the children's learning were used in the analysis of this study. These codes were analyzed until patterns or processes emerged. These categories and themes were further analyzed to form relationships between them. Three broad themes emerged based on different learning processes. Processes reflected mental act as making predictions, formulating hypotheses and drawing conclusions were categorized under the theme "Cognitive Dimension", processes that were associated with social interactions were categorized as "Social or Interpersonal Dimension" and processes that reflected the inner feelings of the children, such as feelings of determination, were grouped under the "Intrapersonal Dimension". There were several sub-themes under each theme.

4.0 Findings

The analyses revealed that during the study, children appeared to actively engage in their learning and they showed interest in exploring the potentials of SPicE. All of the children were observed either working in groups or working on their own in completing the tasks and activities provided by SPicE. The verbal data and non-verbal data suggest that they were engaged in various learning processes such as predicting, making conclusions, coaching their peers and competing among themselves. Based on the nature of these processes, they were classified into three learning dimensions, which were cognitive, social interaction or interpersonal and intrapersonal dimensions.

4.1 Cognitive Dimension

Children's behaviors and utterances during their group discussions as well as while they were manipulating SPicE, suggest that they were very much involved in learning processes such as making observation, trying to explain the phenomena that they experienced, predicting and making interpretations. These behaviors and utterances reflect the usage of cognitive domain or the mental act in their learning activities. Most of these processes occurred while the children were engaged in activities in the 'Hands-on" and the "Simulasi" (Simulation) sections. In the "Hands-on" section, children performed a pendulum experiment using different types of thread of different lengths and most of the children were involved in measuring and comparing the threads as demonstrated by this excerpt, "…is this the fine thread… 35 (cm)?" This situation was further illustrated in the video recordings where children were recorded measuring the different types of thread and can be best portrayed in the following video transcript,

> *"Five children (Afiqah, Alin, Zack, Ramli and Said) were working at the teacher's table in front. Halimah and Fahmi joined them later. They were preparing the threads. They then formed two groups: a group of three girls and a group of four boys. The boys were measuring the thread at the teacher's table, while the girls were measuring the thread slightly away from the table."*

In another situation, while the children were interpreting result of their pendulum experiments, the children tried identifying some form of patterns between the lengths of the thread and the number of oscillations as evidently exhibited in this expression, "...this is descending!". Based on the pattern established, they then made connections between the variables as mentioned by Said, "The longer the thread, the number of oscillations decreases". Another example of the children making relationship between variables was when the children were exploring the simulated section of "Panas! Panas!" Level One. In this Level, the children clicked on the thermometer and readings of the temperature of water in the beaker appeared on the computer screen. They compared the temperature of water in three different sizes of beakers and then formed a relationship that the temperature of water increases as the size of the beakers decreases. As mentioned earlier, the simulated section offered three different simulated activities: *"Persainga*n", *"Tanjakan"* and *"Panas! Panas!"* Each activity comprised of three to five levels of tasks. For example, the children explored the animated simulation by clicking on different colored sails or balls in the first Level of "*Persainga*n" and "Tanjakan" activities respectively. All these tasks were designed to establish the basic understanding of variables. In these tasks, the children could observe that color did not affect the distance

the car or the ball traveled. While exploring these simulated activities, expressions uttered by the children were mostly related to something that they observed physically displayed on the computer screen, such as “Yes! …it’s the smaller beaker”, the effect of any manipulated variables for example “The same weight…the same distance!”, and statements of “cause and effect” in the effort of making connections, such as “the lighter the color of the wrapper, the lower is the temperature (of the water)”. The processes mentioned above involved cognition or mental processes and they are best categorized under the theme Cognitive Dimension. These processes were further categorized into eight groups or sub-themes. The categorization was made based on the nature of the processes. The sub-themes emerged are making observations, measuring and using numbers, making inferences, making predictions, controlling variables, formulating hypotheses, drawing conclusions and giving critiques. Definitions were given to each sub-theme to reflect the identified cognitive dimension, for example the sub-theme of Making Inference is defined as giving explanation based on observations, however they may not necessary be correct since they are yet to be tested, and the sub-theme of Formulating Hypothesis is defined as forming relationship between one or more variables.

4.2 Interpersonal Dimension

In the present study, children worked in groups of two and three. With such setting, the children could interact with each other as captured in the audio and video recordings. Data from these recordings suggest that the interactions were mainly focused on the children coaching each other, working cooperatively and collaboratively with one another. During performing some of the SPicE sections, the children were observed working cooperatively where each member performed different parts of the task with a common aim. This was particularly obvious while they were performing the “Pendulum Experiment”, where one was seen taking the measurements of the thread, while another was setting-up the retort stand and the other member of the group was checking on the stop watch. It was interesting to note that each member knew which role to play as illustrated in the following video transcript:

> *“Only one member of each group went over to the front to take the materials and equipment for the experiment. Afiqah represented Group E, Zack represented Group F, Said represented Group A and Halimah represented Group D. They first took the retort stand and brought it back to their work station.”*

They were also seen working collaboratively, aiding each other in accomplishing the given tasks. This can be illustrated in one of the video episodes, “Said and Fahmi were setting up the retort stand. Said raised the height of the clamp, while Fahmi was holding the stand and later helped tightened up the screw”. This episode illustrates that both the children were trying to accomplish the same task, which was preparing the retort stand for the experiment, and each performed the same role. In contrast to the previous episode, which portray the children working cooperatively where they carried different roles in accomplishing the same task.

In addition to physical interaction, the children also interacted in cyberspace through the *Forum sectio*n. The *Forum section* gave them the opportunity to interact with their peers as written in Aimi’s dairy, “The *Forum* gave me the opportunity to post question and help my friends”. The children posted queries related to the activities they

had just done and responded to any questions posted by their friends. Therefore, based on the processes mentioned above, the second theme that emerged from the data was interpersonal dimension. In this context, interpersonal dimension refers to the interaction between children, either inter groups or within their own group members. Four interpersonal processes were prevalent in the study and they are cooperation, collaboration, peer coaching and competition.

4.3 Intrapersonal Dimension

The learning process that emerged in the present study also involved the intrapersonal dimension. For instance, Rizal's expression, "I want to try again!" while performing one of the activities in *Hubungan* section: "Fossweb", captures what can be described as the intrapersonal processes. This learning dimension involves the inner feelings of oneself or the affective domain. In the present study, children portrayed the sense of improving oneself. They were also intrinsically motivated and self-determined in pursuing their tasks, and evidently portrayed in the following video transcript:

> *"Although most of the groups that were performing the "hands-on" activity have completed their tasks, Halimah's group continued doing the experiment without much problem and distraction. They continued doing it even when the bell rang for recess (break)."*

"Determination", "striving for improvement" and "intrinsic motivation" were the three processes that were found prominent in this.

4.4 Interrelatedness of the Learning Process

Further analysis of the data reveal that the three dimensions of learning occurred in the present web-based learning environment are intertwined within themselves as one process occurred within the other process. Thus, the processes did not occur in isolation. These processes too did not occur in a linear manner as the analysis of the data suggest that one process occurred did not follow by another since there was no certain sequence or pattern of these processes. For example, taking a situation where Rizal of Group B called upon Said from Group A to assist him. Members in Rizal's group were unsure of the way to form relationships between the variables in the second Level of the Persaingan activity. Said then tutored them on formulating the hypothesis. Thus, two processes of different dimensions were involved in this situation. Peer tutoring or coaching under the Interpersonal Dimension occurred simultaneously with formulating hypotheses, which was categorized under the Cognitive Dimension. This situation is best demonstrated in the following excerpt:

> Rizal: Said! Eh..help me Said!
> Said: Uh?
> Rizal: How do you form relationships (between the variables)?
> Said: "If..then…" that's hypothesis …
> Rizal: Yes…how did you do it?
> Said: If…if…the size of sail is big, then the distance it travel aa…short!

To further illustrate, examine the excerpt below.

> Illana: Wait…wait…will the beaker cracks if left under the hot sun for a long time…?
> Halimah: I'm not sure…but flower pots do not crack (when placed under the sun).

Illana: That's right! (So) it is not a factor or the manipulated variable!
Halimah: It's not the factor …I think, this is probably the one! [Referring to the other options].
Illana: Let's try!

In this scenario, Group C was trying to answer one of the questions in *Cabaran SPicE* section. The question reads, "In *Panas! Panas!* activity, why is the duration of the beaker exposed to the sun kept constant?" Before solving this problem, they first had to determine which the manipulated variable is. Based on their past experience, they observed that flower pots do not crack when placed under the sun for a long time. Therefore, applying this experience to the present situation, they figured out that the duration was kept constant because duration was not the independent or the manipulated variable, and was not the factor to be studied in this activity. Thus, this situation portrays that children were involved in the process of controlling variables. Nevertheless, this process also occurred within the Intrapersonal Dimension as the children were determined in getting the correct answer, as Halimah excitedly uttered, "Let's try!". Both examples presented above suggest that the learning process did not occur separately. Instead, they occurred simultaneously. One process occurred within the other learning process, but there was not enough evidence to show that all three dimensions occurred simultaneously. This phenomenon can be represented in the schematic diagram in Figure 1.

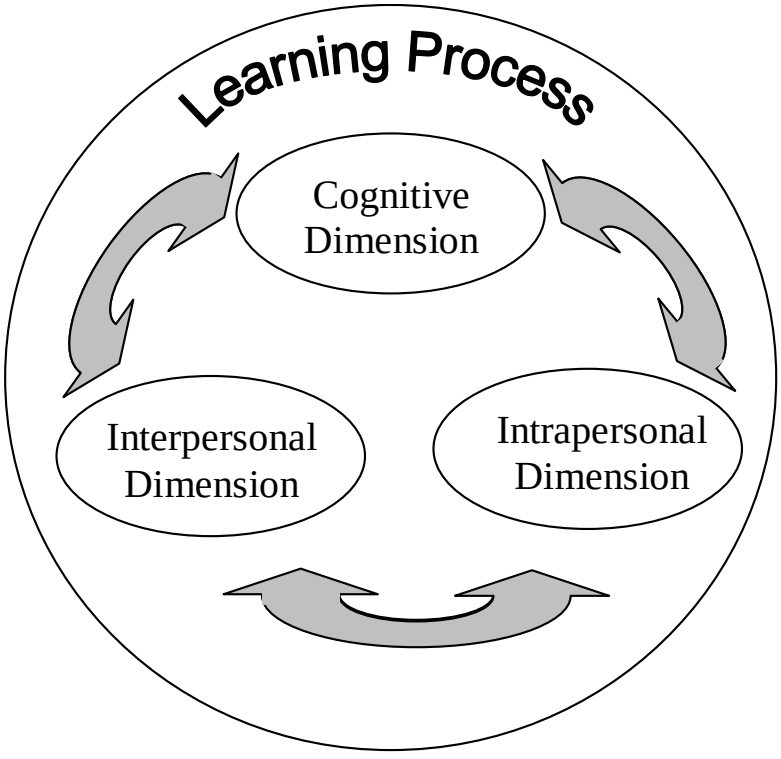

Figure 1
Interrelatedness between Learning Dimensions

4.5 The Connections between the Learning Process and Instructional

Design of SPicE

As mentioned earlier, basically the SPicE program was subdivided into five main sections. Each section was designed with certain features. For example, the "Hands-on" section was designed in order to provide users with hands-on experience. In this study, children were involved in manipulation of apparatus and materials. They took real measurements and got real data. The *Simulasi* section, on the contrary, adopted the direct manipulation approach where carrying out so-called "experiments" were done virtually. Children were able to observe the effect of any manipulation made immediately. The very pertinent feature in *Cabaran SPicE* was the immediate or synchronous feedback. Feedback was instantaneously given to the responses executed by the children. The *Forum* section on the other hand, emphasized on social interactivity. It gave the children the opportunity to interact in cyberspace. They posted questions and also replied their friends' questions. However, the responses were in the form of delayed feedback. The features available in the *Hubungan* section varied depending on the nature of the links. For example the link "Fossweb" had simulation and synchronous feedback while other links were more of content oriented where the sites provided lots of science content.

Based on the analysis, processes of the Cognitive Dimension occurred predominantly in "Hands-on" and *Simulasi* sections. While children were performing the "Hands-on" activities, they were engaged in seven out of eight of the Cognitive Processes. The children"s behavior was much regimented in that they followed strictly to the experiment procedures as prescribed in the program. The children had a direct contact with the apparatus. They took measurements, set up the pendulum and manipulated the variables. They observed the effects of the manipulated variables and then formed connections of such occurrences. This led them into processes such as making observation, making prediction, and controlling variables. At the end of the experiment, they drew conclusions. While completing the *Log Pemerhatian,* they were involved in making predictions, controlling variables, formulating hypotheses and drawing conclusions. However, there was no evidence of any utterances that reflected that they were making any inferences.

Similar processes occurred while the children were exploring the *Simulasi* section. In this section the children observed immediate effect of their manipulation of the variables and they engaged in cognitive processes such as making observations, making inferences, making predictions and drawing conclusions. In this section, children were also involved in seven out of eight of the cognitive processes. The only process that they were not involved was measuring and using numbers. This was quite obvious since this section had no real manipulation of the experiments since the experiments were done virtually. The experiments did not involve any measurements as all values were predetermined by the program. The children chose the desired variables such as the weight, sizes, shapes or types of ramp from the icons provided. Graphs were computer-generated based on the input provided by the children.

Interpersonal or social interactions occurred highly in the "Hands-on" section and the *Simulasi* section. Three social processes occurred when children were engaged in the activities in the *Simulasi* section and another three processes occurred while the children performed the "Hands-on" activities. This could be related to the nature of the activities in these sections. Both sections supported cooperative and cooperative learning. They cooperated and collaborated with each other by each member performing different tasks,

they peer coached each other, either within their own group or between other group members. They had a common goal to accomplish and each member had a role to play. Social processes also occurred moderately in the other sections. The intrapersonal processes occurred moderately while children were interacting with all the sections. "Intrinsic motivation" occurred in all the sections, followed by the process of "striving for improvement" and "determination". Children expressed their sense of determination and they were motivated in getting the right answer. They were determined to do as many activities as they could in exploring SPicE.

The learning processes that occurred while children interacted with linkages depend on the nature of the links that they went to, as each link provided different emphasis. The link "Fossweb" had lots of activities and was very much related to science process skills. It had simulated activities as well as elaboration of the science content. This link was the popular site since most groups had visited and explored this site. Surprisingly, the analysis reveals that only cognitive processes of observation and making inferences were involved in this link. However, interpersonal processes on the other hand occurred highly during their exploration with this link. They coached each other; they collaborated and competed with one another. Intrapersonal processes were also prominent in this section. They seemed motivated in exploring the links and they tend to explore as many activities as they could.

5.0 Conclusions and Recommendations

One major conclusion of this study is that this technology-mediated environment seemed to advocate learning processes favorable for science learning. The children exhibited competencies in science process skills and manipulative skills, which are components of the scientific skills vital in science learning (Harlen 1999; 2000). The children observed in this study also perceived the present environment conducive for learning science as indicated in Ramli's diary , "I feel learning science is easier for these past four weeks.", and Ally's diary, "I gained a lot of science knowledge using the computer (SPicE Programme)".

The findings of this study concur with the studies by Rio Sumarni Sharifuddin (1996) and Salomon, Globerson and Guterman (1989). Rio Sumarni Sharifuddin (1996) reported that students perceived that the use of computers in science learning helped to improve learning (69.1%) and helped to teach abstract and difficult concepts (49.2%). In a study which focused on language development, Salomon, Globerson and Guterman found that the computer programme (Reading Partner) facilitates the development of reading and writing competencies, which actually are skills.

Based on the data analysis, three main dimensions of learning emerged from this study. They are the cognitive dimension, interpersonal dimension and the intrapersonal dimension. These learning dimensions intertwined with each other and occurred simultaneously. This finding supports the aspiration of the National Philosophy of Education (Curriculum Development Centre, 1999), which advocates the development of an individual in a holistic and integrated manner so as to produce learners who are intellectually, spiritually, emotionally and physically balanced. Education is no longer seen as the development of the intellect or the cognitive domain solely but also the development of other faculties. Based on the National Philosophy of Education, individuals who are well balanced will be able to contribute to the harmony of the family,

the society and the nation at large. Initially the study focused on the cognitive domain, which is the science process skill. The study, being exploratory in nature also uncovered that the interpersonal and intrapersonal dimensions were also involved in the learning process. Both these dimensions were as important as the cognitive dimension as they contributed to the learning of science. For example, the children in the study interacted socially with peers which in turn facilitated intellectual discourse in knowledge building. This led to the acquisition of cognitive skills or the science process skills. In view of this, Web-based learning could be regarded as one of the means to uphold the aspiration of the National Philosophy of Education.

The findings of the study are also in-line with the current paradigm of instructional-design theory which focuses on learning that supports a variety of learning dimensions or domains. The cognitive dimension has always been emphasized in most types of learning. Bloom (1956) and Gagne (1985) categorize these processes as the cognitive domain. Reigeluth (1999) argues that cognitive learning is no longer the primary focus of education. He sees that other types of learning, such as learning for psychomotor development as well as learning for affective development, are equally vital in this information age.

In summary, learning science in the present learning environment facilitates the acquisition of the integrated science process skills, with all the three dimensions of learning interplay with one another. These findings could provide some guidance to educators who may want to embark on developing science process skills in such learning environment. Some limitations of the present study may call for further investigations. Further study should consider other science process skills and as well as other components of science learning. One of the project that is in progress at the University of Malaya is the 'Crafting Science Instruction Using Learning Objects' or in short the CSILO Project. CSILO is an extension of SPicE where it includes the scientific knowledge, scientific skills and assessments, and it is being developed using the concept of reusable Learning Objects.

References

Allen, L. (1973). An examination of the ability of third grade children from the Science Curriculun Improvement Study to identify experimental variables and to recognize change. *Science Educatio*n, *5*7, 123-151.

Almekinders, R., Thijs, G. &Lubben, F. (1998). Development of procedural understanding among South African science students at pre-tertiary education level. *Journal of Biology Education, 3*3(1), 33-38.

Anderson, J.R. (1982). Acquisition of cognitive skills. *Psychological Review, 8*9, 369-406.

Bloom, B.S. (Ed.). (1956). *Taxonomy of educational objectives. Handbook1: Cognitive domain.* New York: David McKay.

Blundell, C. (1994). *Computer-assisted, cognitive apprenticeship in mineral identification.* R e t r i e v e d J u l y 2 0 , 2 0 0 0 , f r o m http://www.redlands.qld.edu.au/eartnsci/CALReport.html

Brotherton, P.N. & Preece, P.F.W. (1995). Science process skills: Their nature and interrelationships. *Research in Science and Technological Education, 1*3(1), 5-11.

Chiapetta, E.L., Kobala Jr., T.R. & Collette (1998). *Science instruction in the*

middle and secondary schools (4 th . ed.). New Jersey: Prentice Hall.

Eilam, B. (2002). Phases of learning: Ninth graders skill acquisition. *Research in Scienceand Technological Education, 2*0(1), 5-24.

FOSS. (2000). *Teacher guide: Variable*s. Nashua, NH: Delta Education, Inc.

Gagne, R.M. (1965). The psychological basis of science - a process approach. *AAAS Miscellaneous Publicatio*n, 65-68.

Huppert, J, Lomask, S. & Lazarowitz, R. (2002). Computer simulations in high school: Students' cognitive stages, science process skills and academic achievement in microbiology. *International Journal of Science Education, 2*4(8), 803-821.

Johnson, R. (1997). *How can computers be used to promote metacognition in primary school students?* Unpublished doctoral dissertation, Monash University, Australia.

Khan, B. H. (1997). *Web-based instructio*n. New Jersey :Educational Technology Publications

Klahr, D. (1998). *Carnegie Mellon Researchers say direct instruction, rather than "Discovery Learning" is the best way to teach process skills in scienc*e. Retrieved July 15, 1999, from http://.eurekalert.org/releases/direct-sciskill.html.

Klahr, D, Chen, Z., & Toth, E. E. (1999) From Cognition to Instruction to Cognition: A Case Study in Elementary School Science Instruction . In Crowley, K., Schunn, C.D., & Okada, T. (Eds.) *Designing for Science: Implications from Professional, Instructional, and Everyday Scienc*e. Mahwah, NJ: Erlbaum.

Kulik, C.C. & Kulik, J.A. (1991). Effectiveness of computer-based instruction: An updated analysis. *Computers in Human Behaviour,* 7, 75-94

Lawson, A.E., Blake, A.J.D., & Nordland, F.H. (1975). Training effects and generalization of the ability to control variables in high school biology students. *Science Education, 5*9(3), 387-396.

Lazarowitz, R. & Huppert, J. (1993). Science process skills of 10 th -grade biology students in a computer-assisted learning setting. *Journal of Research on Computing in Education, 2*5(3), 367382.

Merriam, S. (1998). *Qualitative research and case study applications in education: Revised and expanded from case study research in educatio*n. California: Jossey-Bass Inc.

Nakhleh, M.B. & Krajcik, J.S. (1993). A protocol analysis of the influence of technology on students' actions, verbal commentary, and thought processes during the performance of acid-base titrations. *Journal of Research in Science Teaching, 3*0(9), 1149-1168.

Niemiec, R. & Walberg, H.J. (1987). Comparative effects of computer-assisted instruction: A synthesis of reviews. *Journal of Educational Computing Research.* 3(1), 19-37.

Nor Aziah Alias, Haziah Jamaludin, Salemah Ismail & Rosmawati Abdul Halim. (1998). *Faktor ransangan yang mempengaruhi minat belajar pelajar sekolah menengah dalam mata pelajaran sains: Kajian terhadap penggunaan ciri (facet) utama teknologi WWW (World Wide Web*).[The effect of stimulus on secondary students' motivation in learning science: A study of the main facet of WWW]. (PIER Research Project No.KP(BPPP)2/44. Jld. XXI(65)6000-BRC/PIER/5/4). Shah Alam: Pusat Sains, MARA Institute of Technology.

Quinn, M.E. & George, K.D. (1975). Teaching hypothesis formation. *Science Education, 5*9(3), 289-296.

Ramli Atan. (1994). *The effects of a special tutoring program on the achievement of form 4 and form 5 secondary school students with respect to the acquisition of integrated science process skill*s. Unpublished M.Ed. Dissertation, University of Houston, Texas.

Ramsey, G.A. & Howe, R.W. (1969). An analysis of research related to instructional procedures in elementary school science. *Science and Children,* 6(7), 25-26.

Reigeluth, C.M. (1999). What is instructional-design theory and how is it changing?. In C.M. Reigeluth (Ed.) *Instructional Theories and Models: A New Paradigm of Instructional Theory, Volume I*I. (pp.5-29). Mahwah, NJ: Lawrence Erlbaum Associates, Publishers

Rio Sumarni Sharifudin (1996). *The use of computers in Malaysian schools and the effectiveness of computer-assisted instruction for the learning of some science concept*s. Unpublished Doctoral Dissertation , Universiti Teknologi Malaysia, Skudai, Johor.

Rohaida Mohd. Saat & Kamariah Abu Bakar (2000, October). *Development of a Web-based Instruction for Primary School: SPic*E, Paper presented at the International Conference Education & ICT in the New Millennium, Kuala Lumpur.

Rohaida Mohd. Saat (2001). *SPicE Project: Web-based Instruction in Acquiring Science Process Skills.* In C. Montgomery & J. Vitelli (Eds.) Proceedings of the International Conferenxe “ED-Media: World Conference on Educational Multimedia, Hypermedia and Telecommunications” (pp. 1339-1340). USA: Association for the Advancement of Computing in Education (AACE).

Salomon, G., Globerson, T. & Guterman, E. (1989). The computer as a zone of proximal development: Internalizing reading-related metacognitions from a reading partner.*Journal of Educational Psychology, 8*1(4), 620-627.

Screen, P. (1986). *Warwick process science. Section One : Controlling variable*s. Hampshire : Ashford Press Publishing.

Settlage, J.J. (1995). Children’s conceptions of light in the context of a technology-based curriculum. *Science Education, 7*9(5), 535-553.

Shuell, T.J. (1990). Phases of meaningful learning. *Review of Educational Researc*h, 60, 531-547.

Strauss, A.L. & Corbin, J. (1990). *Basics of qualitative research: Grounded theory procedures and techniques*. Thousand Oaks: Sage Publication.

Appendices