DESIGN, DEVELOPMENT AND EVALUATION OF A WPE MICROWORLD FOR LEARNING PROBABILITY

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A thesis submitted
in fulfillment of the requirement for the degree of Master of Science

Faculty Of computer Science and Information Technology
UNIVERSITI MALAYSIA SARAWAK
2006
ACKNOWLEDGEMENTS

To me, undertaking a master by research is a memorable journey with highs and lows, accompanied by bitterness, hardship, frustration, encouragement, support, trust, enjoyment and kindness of many people. I thank God, the almighty and faithful one, who open the ways, lead me and sustain me along the journey. This is an achievement that never came to my mind, yet a reality before my very own eyes. It will never be enough to express my gratitude in words to all those who have helped me, guided me and walked with me along the journey to this point.

My deepest gratitude must go to Dr. Hong Kian Sam, who not only served as my honorific supervisor but also offered expert advice, insightful comments, continuous support, constant guidance, encouragement, understanding and patience at all levels throughout my study. This research and the writing of the dissertation would not have been completed without him. His prompt and timely feedback has been invaluable in keeping me on the right track and assisting me to complete this thesis on time.

Special thanks and appreciation to the schools, students, teachers, administrative staffs and principals who have offered their valuable time and allowed me to collect necessary data for my study in their schools. Special thanks to Mr. Abang Kok Omar, Mdm. Cheam Chai Fong, Ms. Chin Lee San and students of 4S4 from Kolej Abdillah; Mr. Putit Haji Ped, Mdm. Hii Poh Leh, Ms. Lily Liew, Mr. Habids Muhammad, Ms. Yong Mei Ling and students of 4I and 5G from SMK Green Road; and Mdm. Hii Kwong Ing and students of 5Atom from SMK Arang.

Along the journey, I was supported by the research grant from University Malaysia Sarawak, Skim Zamalah Pascasiswazah Unimas (ZPU). Let me say ‘thank you’ to the committee who have confidence in me and supported my research. My sincere thanks also go to the staff of the Faculty of Cognitive Sciences and Human Development, University of Malaysia Sarawak for providing me with all the assistance required in the process of conducting my research and upon the completion of my thesis.

Finally, I would like to convey my heartfelt thanks to my family: my parents and siblings near and far for their love and support. I thank my friends for their physical and spiritual support. To my husband, Bong Chih How, who has inspired me to start this journey, being unconditionally loving and supportive beside me, I give my everlasting love and gratitude.
ABSTRACT

Many reforms and innovations efforts especially in computer-supported learning have been continuously undertaken in mathematics education. Microworlds have drawn research attention among the educationists and have the potential in creating a constructivist learning environment. This study developed a mathematical microworld (WPE) to investigate the effectiveness of the microworld learning environment in enhancing the learning of probability and improving the students' attitudes toward mathematics. The topic of probability was chosen because students tend to have difficulty in understanding probability. This research also determined the students' satisfaction with the microworlds' features; the relationship between the students' mathematics achievement using the microworld and the students' characteristics; and the relationship between the students' attitudes toward mathematics after using the microworld and the students' characteristics. This research used a quasi-experimental, non-random pre-and post-test static group research design. Samples consisted of 52 students from two Form Four science classes at two secondary schools in Kuching. Students learned probability using the WPE microworld for 12 to 13 periods. Quantitative and qualitative data collection techniques including questionnaires, interviews and observation were deployed to obtain the required data. Among the research instruments were a pre- and post-test for measuring achievements in probability, questionnaire for attitudes toward mathematics and rubric for evaluating the microworld. Findings of this study showed that the students
obtained significantly higher scores in the post-test on probability. The WPE microworld slightly improved students' attitudes toward mathematics. According to the students, WPE as a practical tool helped them to learn and understand probability concepts. Students were satisfied, interested, excited and had fun to explore the microworld while learning the concepts. Generally, they were satisfied with the features of the WPE microworld. Three students who expressed negative reactions on the use of WPE lacked basic computer skills and more comfortable with the traditional rote learning methods. The microworld encouraged interactions among the students and between the students and the instructor. Teachers viewed the WPE microworld as a tool for knowledge construction among the students. Both male and female students learned using technology equally well. However, students with basic computer and Internet skills showed better learning gain, and improved in attitudes toward mathematics after interacting with the WPE microworld. This study also showed the potential of microworlds as a computer-based constructivist learning environment for mathematics learning.
ABSTRAK

# TABLE OF CONTENTS

ACKNOWLEDGEMENTS i
ABSTRACT ii
ABSTRAK iv

TABLE OF CONTENTS vi
LIST OF TABLES xi
LIST OF FIGURES xii

CHAPTER 1 INTRODUCTION

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Overview</td>
<td>1</td>
</tr>
<tr>
<td>1.1</td>
<td>Problem statement</td>
<td>9</td>
</tr>
<tr>
<td>1.2</td>
<td>Research objectives</td>
<td>9</td>
</tr>
<tr>
<td>1.3</td>
<td>Research questions</td>
<td>10</td>
</tr>
<tr>
<td>1.4</td>
<td>Research hypotheses</td>
<td>11</td>
</tr>
<tr>
<td>1.5</td>
<td>Research framework</td>
<td>11</td>
</tr>
<tr>
<td>1.6</td>
<td>Significance of the study</td>
<td>12</td>
</tr>
<tr>
<td>1.7</td>
<td>Limitations of the study</td>
<td>12</td>
</tr>
<tr>
<td>1.8</td>
<td>Definition of terms</td>
<td>13</td>
</tr>
<tr>
<td>1.9</td>
<td>Summary of the chapter</td>
<td>15</td>
</tr>
</tbody>
</table>

CHAPTER 2 REVIEW OF RELATED LITERATURE

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0</td>
<td>Overview</td>
<td>16</td>
</tr>
<tr>
<td>2.1</td>
<td>ICT in mathematics education</td>
<td>16</td>
</tr>
<tr>
<td>2.2</td>
<td>Pedagogical considerations in using ICT in teaching and learning</td>
<td>20</td>
</tr>
<tr>
<td>2.2.1</td>
<td>Teacher’s role in an ICT-based classroom</td>
<td>21</td>
</tr>
<tr>
<td>2.2.2</td>
<td>Student’s role in ICT-based classroom</td>
<td>22</td>
</tr>
<tr>
<td>2.2.3</td>
<td>The role of technology in ICT-based</td>
<td>22</td>
</tr>
</tbody>
</table>
### 2.3 Contributions of computer technology in mathematics learning

**2.3.1 Multimedia and animation**

**2.3.2 Simulation**

**2.3.3 Visualisation and multiple representations**

### 2.4 Model for designing constructivist learning environment (CLE)

### 2.5 Microworlds

**2.5.1 What is microworld?**

**2.5.2 The basic characteristics of microworlds**

**2.5.3 Representations in microworlds**

**2.5.4 Examples of microworld environments**

**2.5.5 Constructivism and microworlds**

**2.5.6 Microworlds versus simulation**

**2.5.7 Microworlds and students’ achievements**

### 2.6 Attitudes toward mathematics

### 2.7 Learning of probability

### 2.8 Summary of the chapter

---

### CHAPTER 3 RESEARCH METHODOLOGY

**3.0 Overview**

**3.1 Research design**

**3.2 Sampling**

**3.3 Research instruments**

**3.3.1 Probability pre-test and post-test**

**3.3.2 Attitudes toward mathematics**

**3.4 Framework for the design of learning environment**

**3.4.1 Design principle and rationale of the microworld**

**3.4.2 The WPE microworld**
CHAPTER 4 FINDINGS

4.0 Overview

4.1 Research Question 1: Could the microworld learning environment enhance the students' learning of probability?

4.2 Research Question 2: Could the microworld learning environment improve the students' attitudes toward mathematics?

4.3 Research Question 3: Would the students be satisfied with the features in the microworld?

4.4 Additional findings from the students' interviews

4.5 Research Question 4: Would there be a relationship between students' mathematics achievements using the microworld and the students' characteristics?

4.6 Research Question 5: Would there be a relationship between students' attitudes toward mathematics and the students' characteristics?

4.7 Summary of the chapter
<table>
<thead>
<tr>
<th>Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.0</td>
</tr>
<tr>
<td>5.1</td>
</tr>
<tr>
<td>5.2</td>
</tr>
<tr>
<td>5.2.1</td>
</tr>
<tr>
<td>5.2.2</td>
</tr>
<tr>
<td>5.2.3</td>
</tr>
<tr>
<td>5.2.4</td>
</tr>
<tr>
<td>5.2.5</td>
</tr>
<tr>
<td>5.2.6</td>
</tr>
<tr>
<td>5.3</td>
</tr>
<tr>
<td>5.3.1</td>
</tr>
<tr>
<td>5.3.2</td>
</tr>
<tr>
<td>5.3.3</td>
</tr>
<tr>
<td>5.4</td>
</tr>
<tr>
<td>5.5</td>
</tr>
</tbody>
</table>

REFERENCES 137
READINGS 151
APPENDICES

Appendix 1A  Letter to obtain information about secondary schools in Kuching district  153
Appendix 1B  Letter from the Jabatan Pelajaran Negeri Sarawak  154
Appendix 2  Approval letter from the Ministry of Education, Malaysia  156
Appendix 3A  Pre-test paper (PREMATH)  158
Appendix 3B  Post-test paper (POSTMATH)  160
Appendix 4A  Pre-test specification table according to Bloom’s taxonomy  162
Appendix 4B  Post-test specification table according to Bloom’s taxonomy  164
Appendix 5A  Questionnaire: Attitudes toward mathematics (ATTMATH)  166
Appendix 5B  Questionnaire: Sikap terhadap matematik (ATTMATH)  168
Appendix 6  WPE microworld evaluation criteria (MWRUBRIC)  170
Appendix 7  Structured interview questions based on MWRUBRIC  172
Appendix 8A  Worksheet to learn probability with WPE microworld (I)  174
Appendix 8B  Worksheet to learn probability with WPE microworld (II)  177
Appendix 8C  Worksheet to learn probability with WPE microworld (III)  180
Appendix 8D  Worksheet to learn probability with WPE microworld (IV)  183
Appendix 9A  Reliability test – mathematics test paper  186
Appendix 9B  Reliability test – attitudes questionnaire  187
Appendix 10  Interview transcript for participants  188
LIST OF TABLES

Table 2.1 Example of microworlds in mathematics teaching and learning 33
Table 3.1 Summary of the selected schools and students involved in the study 45
Table 3.2 Summary of the area of measurements in the questionnaire in its positive or negative statement 49
Table 3.3 Attitudes toward mathematics based on the scoring range, suggested by Liau and Arellano (2003) 50
Table 3.4 Data analysis based on the research objectives 81
Table 4.1 Paired sample t-test on pre- and post-test 84
Table 4.2 Paired sample t-test on attitudes toward mathematics 98
Table 4.3 Students’ attitudes toward mathematics before and after the treatment 100
Table 4.4 Students’ evaluation on the WPE microworld 104
Table 4.5 Achievement’s grading criteria 113
Table 4.6 Students’ achievements in pre- and post-test according to gender 114
Table 4.7 Students’ achievements in post-test according to students’ characteristics 115
Table 4.8 Students’ attitudes toward mathematics in pre- and post-treatment according to gender 118
Table 4.9 Students’ attitudes toward mathematics after treatment according to students’ characteristics 119
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 1.1</td>
<td>Research framework</td>
<td>11</td>
</tr>
<tr>
<td>Figure 2.1</td>
<td>Model for designing CLE</td>
<td>26</td>
</tr>
<tr>
<td>Figure 3.1</td>
<td>Research sampling process</td>
<td>45</td>
</tr>
<tr>
<td>Figure 3.2</td>
<td>Framework for the design of the learning environment</td>
<td>51</td>
</tr>
<tr>
<td>Figure 3.3</td>
<td>The lessons in the WPE microworld</td>
<td>55</td>
</tr>
<tr>
<td>Figure 3.4</td>
<td>Content page of WPE microworld</td>
<td>56</td>
</tr>
<tr>
<td>Figure 3.5</td>
<td>Top menu with common functions of the microworlds in WPE</td>
<td>57</td>
</tr>
<tr>
<td>Figure 3.6</td>
<td>Identical layout in each microworld of WPE</td>
<td>57</td>
</tr>
<tr>
<td>Figure 3.7</td>
<td>Layout in dice microworld</td>
<td>58</td>
</tr>
<tr>
<td>Figure 3.8</td>
<td>Layout in coins microworld</td>
<td>59</td>
</tr>
<tr>
<td>Figure 3.9</td>
<td>Layout in spinner microworld</td>
<td>60</td>
</tr>
<tr>
<td>Figure 3.10</td>
<td>Layout in marbles microworld</td>
<td>61</td>
</tr>
<tr>
<td>Figure 3.11</td>
<td>Various animated colourful 2D and 3D graphics</td>
<td>63</td>
</tr>
<tr>
<td>Figure 3.12</td>
<td>Tree structure representation</td>
<td>64</td>
</tr>
<tr>
<td>Figure 3.13</td>
<td>Dynamic linked data representation in tabular form</td>
<td>65</td>
</tr>
<tr>
<td>Figure 3.14</td>
<td>Dynamic linked bar graphical representation</td>
<td>65</td>
</tr>
<tr>
<td>Figure 3.15</td>
<td>Error message pop-up as feedback to learners</td>
<td>67</td>
</tr>
<tr>
<td>Figure 3.16</td>
<td>Lining up the outcomes in triangle spinner</td>
<td>68</td>
</tr>
<tr>
<td>Figure 3.17</td>
<td>Stacking up the outcomes in round spinner</td>
<td>68</td>
</tr>
<tr>
<td>Figure 3.18</td>
<td>Cognitive resources in WPE – the tree structure</td>
<td>69</td>
</tr>
<tr>
<td>Figure 3.19</td>
<td>Cognitive resources in WPE – the sketchpad</td>
<td>70</td>
</tr>
<tr>
<td>Figure 3.20</td>
<td>Cognitive resources in WPE – the calculator</td>
<td>71</td>
</tr>
<tr>
<td>Figure 3.21</td>
<td>The useful links to other website resources available offline</td>
<td>71</td>
</tr>
<tr>
<td>Figure 3.22</td>
<td>Design and development process of the WPE microworld</td>
<td>73</td>
</tr>
<tr>
<td>Figure 4.1</td>
<td>Enter input to generate tree structure simulation</td>
<td>85</td>
</tr>
<tr>
<td>Figure 4.2</td>
<td>Output of tree structure for n(S) =2 and no of repeating =3</td>
<td>85</td>
</tr>
</tbody>
</table>
Figure 4.3 Table summarising data for two-dice experiment 86
Figure 4.4 Table summarising experiment data for the Five Alphabets Spinner 86
Figure 4.5 Table summarising data for two-coins experiment in 20 trials 87
Figure 4.6 Consistent operations available in every microworld 87
Figure 4.7 Tabular display and graphical elements shown in marbles experiment 89
Figure 4.8 Dynamic multiple representations for marbles experiment 90
Figure 4.9 Probability of getting each side of the coin when n=12 91
Figure 4.10 Probability of getting each side of the coin when n=500 92
Figure 4.11 Probability of getting each side of the coin when n =4500 92
Figure 4.12 Menu in WPE links to the games’ instructions 94
Figure 4.13 Instructions for Game 2 95
Figure 4.14 Instructions for Game 8 96
CHAPTER ONE

INTRODUCTION

1.0 Overview

The world is increasingly dependent on scientific and technological inventions and innovations. In the challenging and global nature of life at the present and in the future, modern communities require a pool of knowledge worker with strong grasp of mathematics and technology (Eighth Malaysia Plan, 2001-2005). Therefore, the education system plays an important role in ensuring that the workers of the future have adequate knowledge and skills of mathematics, science and technology. Hence, research and educational reform activities are constantly required to improve the teaching and learning process in school in general, and the teaching and learning of mathematics and science in particular.

The National Council for Teachers of Mathematics (NCTM) in United States is at the forefront for many of these teaching and learning initiatives. Research activities have been actively pursued to identify difficulties in the teaching and learning of mathematics (Yetkin, 2003), to suggest more effective design of instructional materials and classroom activities (Muellar, 1998), and also to encourage the use of computer in building mathematics understandings (Kaput, 1992). In tandem with the reforms in mathematics initiatives by the NCTM, the
National Integrated Secondary School Curriculum (KBSM) and other initiatives have been put in place in Malaysia with the aims of improving students’ learning in mathematics and their attitudes toward mathematics. KBSM is considered a major educational reform when it was first implemented in the mid of 1980’s. Its goals is to develop students’ logical, analytical, systematic, critical thinking and problem solving abilities. KBSM also emphasises students’ abilities to apply mathematical knowledge and aims to ensure that the students can function effectively and responsibly in their daily lives (Noor Azlan Ahmad Zanzali, 1992).

The impact of KBSM is not very encouraging. Marzita Puteh (2002) expressed her dismay that Malaysian students only learn mathematics because it is a prerequisite for tertiary education and a promise for a better pay, either in the government or private sectors. Generally, Malaysian students are weak in mathematics and the phenomenon of mathematics anxiety is still prevalent among them (Rahmah bt. Murshidi, 1999). Although mathematics and science education are vital for the nation’s productivity and ability to compete in the global marketplace, in general, the students’ mathematical and scientific competencies have fallen below what is required for an increasingly technological world. Recent Western reports have indicated that changes are necessary in the way mathematics is taught and students should develop technological skills in the context of learning and solving problems related to academic content (Baker & O'Neil, 2003).
Furthermore, despite the various curriculum innovations, the teaching and learning methods in the actual classroom have not changed. Teachers still tend to practise the conventional teaching method of “chalk and talk” (Hj. Bhasah b. Hj. Abu Bakar & Rafidah bt. Wahab, 2003; Tian Belawati, 2003). The difficulties to bridge the gap between action and expression are appearing in traditional mathematical pedagogy (Hoyles, 1998). As a result, students become unmotivated and do not learn meaningfully. In the process, they developed negative attitudes toward mathematics, science and technology. Other problems include students having low self-esteem, high mathematics anxiety, low interest and poor attitudes toward mathematics (Olson, 2002). Research also indicates that test anxiety, poor study skills, lack of motivation or concentration, and anxieties toward mathematics may contribute to the lack of mastery in mathematical content (Arvidson, 2001). The negative attitudes must not be allowed to confine the knowledge and creativity of learners, nor the anxiety to interfere the learning process (Juan Fco Coll Garcia, 2001).

Ross, Gray and McDougall (2002) believe that the problems encountered in the teaching and learning of mathematics among others could be due to teachers’ reluctance to adopt new approaches for teaching mathematics. Teachers may be lacking of content and pedagogical knowledge, or their mathematical beliefs are not in line with those reflected in the mathematics reform. Ross et al. (2002) propose that the use of technology could be a potential strategy to overcome this problem. Research such as those conducted by Hoyles and Sutherland (1999), Noss and Hoyles (1996), and Papert (1983, as cited in Godwin & Sutherland,
2000) has shown that the use of computers has tremendous potential to support and enhance mathematics learning. Although some critics believe that educational computing is an accident of corporate marketing, many visionaries, scientists and dreamers responsible for the computer revolution viewed computer as a way to expand intellectual power and human capacity (Stager, 2004). The importance of technology, in particular the computer technology in the teaching and learning of mathematics is illustrated in the technology principle by NCTM which states that, "technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances student’s learning" (NCTM, 2000, p. 3).

In the Malaysian school system, the Ministry of Education had implemented several technology-based classroom innovations to increase students’ interest in learning mathematics and to improve students’ performance in mathematics. Among the initiatives were the use of laptop to support the teaching of Mathematics and Science in English and the Smart Schools project (Malaysia’s Smart School Project Website, 1997; Smart School Project Team, 1997). Mona Masood and Nor Azilah Ngah (2003) reported that computers are increasingly being used for teaching and learning in Malaysian schools.

The Smart School concept was introduced in 1999, involving 90 selected secondary schools nationwide. These schools were chosen to implement multimedia computing and the Internet in the teaching and learning processes. The Malaysian Government aspired to transform all schools into smart schools by the year 2010. It is hoped that this innovation could help to foster the development
of a workforce that is prepared to meet the challenges of the 21st century. The Smart School concept was designed to facilitate the change from memory-based rote learning to one that stimulates thinking and creativity (Muhammad Zaini, Mohd Zain, Hanifi Atan, Ibrahim Jaafar, Saw, & Rozhan, 2003).

In using computers in education, the Malaysian Education System tends to stress on the use of multimedia in the teaching and learning processes (e.g. Abdul Hadi b. Mat Dawi & Toh, 2003; Lee, Noor Shah Mohd. Salleh & Peter Songan, 2004; Toh, 2002; Neo, Neo, & Lim, 2004; Wong & Toh, 2003). Most of these studies focused on applying constructivist and cognitive approaches to produce meaningful learning using Information and Communication Technology (ICT). However, Tian Belawati (2003) reported that the use of ICT in actual teaching and learning processes in Malaysian schools is still limited. Furthermore, studies have shown that although the use of multimedia and graphical presentations could generate students’ interest, its effects on cognitive gains have not been proven (Tversky & Morrison, 2002). Abdul Hadi b. Mat Dawi and Toh (2003) also reported that the effects of animation graphics in multimedia on learning are not consistent. These effects could in fact reduce students’ motivation to learn (Johari b. Surif & Mohammad Yusof Arshad, 2003).

In the Western educational research setting, other than multimedia (Alessi & Trollip, 2001; Davis & Crowther, 1995; Mayer, 2001), “microworlds” has attracted research attention among the educationists such as Edwards (1995, 1998), Hoyles and Noss (1992, 2003), Hoyles and Sutherland (1999), Papert
Papert (1980) uses the term microworld to describe a computer-based learning environment in which the learners do not simply respond to predetermined questions, but actually control when and how events will happen. Microworlds often use images to represent a concept (semantic, icons), which can be directly manipulated by the learner on the screen with a mouse click or point (Kearney, 2001).


\[\textit{incubators for knowledge} \ldots \text{First, relate what is new and to be learned to something you already know. Second, take what is new and make it your own: make something new with it, play with it, build with it. (p. 120)}\]

The microworlds have been touted as having the possibility to create a learning environment, which can encourage and motivate learners to learn through active interaction with real-life experiences. Lawler (1982) suggests that microworlds are successful because they produce "neat phenomena" or "phenomena that are inherently interesting to observe and interact with" (p. 141).

In the microworlds, students learn by doing, instead of just watching or listening to the description of the domain knowledge (Lawler, 1987). Students need to
interact actively with the microworlds to solve real-life problems. Microworlds provide opportunities for students to build a bridge between their prior knowledge and what they are about to learn. Constructivist learning also requires students to interact with their peers and instructor, other than being actively involved in the learning environment (Jonassen, 1994). This could be achieved by incorporating group activities in the microworlds. Thus the key concept of microworlds is to let the user learn by inspecting, exploring, doing and changing the learning environment.

Microworlds are usually associated with Logo, a computer programming language categorised as “discovery learning” (Papert, 1999). However, contrary to these common views, Edwards (1995) argues that microworlds do not necessarily involve Logo programming, modification of Logo code or interaction with programming code. Furthermore, in the design of microworlds, one of the key arguments is whether the microworlds’ mechanism (programming code behind the scene) should be visible to the user and how much of them should be accessible (Hoyles, Noss, & Adamson, 2000). In regard to this, Hoyles et al. (2000) state that programming takes up too much time in a crowded mathematics curriculum and programming is usually difficult for teachers and students. Programming also can divert attention from the underlying knowledge goals. Thus, there is no assertive stand for programming to be highlighted in school educational setting as in the school context, emphasis is on the learning of mathematics rather than programming (Hoyles et al., 2000).
Some researchers had created various microworlds to investigate the effectiveness of mathematics learning in microworlds. Alpers (2002), diSessa (2000), Drier (2000), Edwards (1998), Hoyles (1998), Hoyles and Noss (1992, 2003), Hoyles and Sutherland (1999), Hoyles et al. (2000), Jiang (1992), Kynigos (2001), and Moro (2000), for example, have conducted extensive research on computer-based microworlds that foster the development of the mathematical meanings. They concluded that learners are interested to learn in an exploratory environment and microworld can bridge the gap between knowledge and reality.

Hogle (1995) reported that a well-designed microworld is engaging and motivating, and students enjoy and would like to continue interacting with them if given the chance. Furthermore, the students could abstract the essential properties of the concepts embedded within them (the microworld).

However, a review of the literature in Malaysian context revealed a lack of research on the use of microworlds for the teaching and learning of mathematics in Malaysia schools. Hence, there appear to be a basis for the investigation of the effects of the microworlds on learning mathematics in Malaysia schools based on the positive results reported in the Western studies.
1.1 Problem statement

Generally, mathematics educators believe that probability is an important concept for school mathematics (National Research Council, 1989; NCTM, 2000). However, students tend to have difficulty in understanding probability and have misconception in probability (delMas, 2002; Glencross, 1997). They had problem developing rational number concepts and proportional reasoning.

Microworlds have been suggested as being able to help reduce students’ difficulties in learning of mathematics (Edwards, 1998; Hoyles, 1998; Hoyle & Noss, 1992, 2003; Kynigos, 2001) in general and probability (Drier, 2000; Jiang & Potter, 1992) in particular.

Therefore, this study aimed to investigate the effects of a mathematical microworld in the teaching and learning of mathematics among the secondary students and examined whether the use of the microworld improved students’ attitudes toward mathematics. The study also looked at the students’ satisfaction with the features of the microworld.

1.2 Research objectives

Specifically, the objectives of this research were

(a) developing a mathematical microworld to learn the topic of probability,
(b) investigating the effectiveness of the microworld learning environment in

(i) enhancing the learning of probability,

(ii) improving the students’ attitudes toward mathematics,

(c) determining the students’ satisfaction with the features of the microworld,

(d) determining the relationship between the students’ mathematics achievements
    using the microworld and the students’ characteristics, and

(e) determining the relationship between the students’ attitudes toward
    mathematics and the students’ characteristics.

1.3 Research questions

The research questions of this study were

(a) Could the microworld learning environment enhance the students’ learning of
    probability?

(b) Could the microworld learning environment improve the students’ attitudes
    toward mathematics?

(c) Would the students be satisfied with the features in the microworld?

(e) Would there be a relationship between students’ mathematics achievements
    using the microworld and the students’ characteristics?

(f) Would there be a relationship between students’ attitudes toward mathematics
    and the students’ characteristics?