USER MODELS BASED ON STUDENTS’ MOTIVATION, ACHIEVEMENT, AND PROBLEM-SOLVING SKILLS THROUGH LEARNING ORIENTATIONS PERSONALIZED LEARNING ENVIRONMENT

NORAZRENA ABU SAMAH

A thesis submitted in fulfilment of the requirements for the award of the degree of Doctor of Philosophy (Educational Technology)

Faculty of Education
Universiti Teknologi Malaysia

FEBRUARY 2013
To my beloved mother and father.
Abu Samah Bakar and Jamilah Selamat

To my beloved and understanding husband,
Khairul Anuar Abdul Rahman
ACKNOWLEDGEMENT

Assalamualaikum w. b. t.

In the name of Allah, the Most Gracious, the Most Merciful. First, praise to Allah, the God of all universe. Second, my sincere appreciation goes to my supervisors Dr. Noraffandy Yahaya and Associate Professor Dr. Mohamad Bilal Ali, whose guidance, careful reading and helpful comments were valuable. Their timely and efficient contribution helped me shape this into its final form. I am also deeply indebted to my co-supervisor Professor Dr. Kinshuk for his invaluable advice and supervision alongside my study in Canada.

I am also indebted to Universiti Teknologi Malaysia (UTM) for funding my Ph.D. study. I also wish to thank the Faculty of Education, its leadership and the staff for providing me with an academic base, which has enabled me to take up this study. I am particularly grateful to Professor Dr. Sabine Graf, Professor Dr. Vive Kumar and Professor Dr. Maiga Chang for their worthy contribution. I am also indebted to my colleagues, Noor Dayana Abd Halim, Nurbiha A. Shukor, Dayana Farzeeha Ali and Mohd Shafie Rosli. Special thanks, tribute and appreciation to all of them and to those whose names are not mentioned here who have contributed to the successful completion of this study. Finally, I am grateful to all my family members for their understanding of the importance of this work, to my husband Khairul Anuar Abdul Rahman, my mother Jamilah Selamat and my father Abu Samah Bakar.
The need has arisen for the consideration of individual differences to be taken into account in order to allow learners to engage in and be responsible for their own learning. It is also desirable for learners to be able to acquire the following qualities, namely: to retain information for longer periods, to apply knowledge more effectively, to have positive attitudes towards their respective subjects, to have more interest in learning materials, to score higher grades, and to have higher motivation levels. Therefore, the Learning Orientations Model that covers individual intentions, emotions, social, and cognitive aspects is referred to in attempting to overcome problems involving fractions and motivation in learning fractions. For that reason, learning materials involving fractions are developed by referring to a preferred general learning environment, learning modules, and sequencing methods of each Learning Orientations Profile. In addition, the learning materials are delivered through animation of worked examples in a personalized learning website, called the Fractions Website. The website is developed with the integration of the following functions, namely: learner-self interactive functions, learner-learner/instructor interactive functions, learner-interface interactive functions, and learner-content interactive functions. As a result, the learning through the website was found to be able to improve students' achievements and problem-solving skills in fractions. Moreover, students have been found to be satisfied with, and enjoyed learning using the Fractions Website. Apart from that, Learning Orientations Profiles of some students are found to be not relatively static. Thus, the interactions on the Fractions Website are referred to for use in synthesizing user models for static and non-static Learning Orientations Profile learners.
ABSTRAK

# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>CHAPTER</th>
<th>TITLE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>DECLARATION</td>
<td></td>
<td>ii</td>
</tr>
<tr>
<td>DEDICATION</td>
<td></td>
<td>iii</td>
</tr>
<tr>
<td>ACKNOWLEDGEMENT</td>
<td></td>
<td>iv</td>
</tr>
<tr>
<td>ABSTRACT</td>
<td></td>
<td>v</td>
</tr>
<tr>
<td>ABSTRAK</td>
<td></td>
<td>vi</td>
</tr>
<tr>
<td>TABLE OF CONTENTS</td>
<td></td>
<td>vii</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td></td>
<td>xiii</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td></td>
<td>xviii</td>
</tr>
<tr>
<td>LIST OF ABBREVIATIONS</td>
<td></td>
<td>xxii</td>
</tr>
<tr>
<td>LIST OF APPENDICES</td>
<td></td>
<td>xxiii</td>
</tr>
<tr>
<td><strong>1</strong> INTRODUCTION</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>1.1 Introduction</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>1.2 Background of the Problem</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>1.2.1 Motivation in Mathematics</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>1.2.2 Problems in Learning Fractions</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>1.2.3 Personalized Learning based on</td>
<td></td>
<td>7</td>
</tr>
<tr>
<td>Learning Orientations Model</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.3 Statement of the Problem</td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>1.4 Objective of the Study</td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>1.5 Research Questions</td>
<td></td>
<td>11</td>
</tr>
<tr>
<td>1.6 Scope and Research Delimitation</td>
<td></td>
<td>12</td>
</tr>
<tr>
<td>1.7 Rationale</td>
<td></td>
<td>13</td>
</tr>
<tr>
<td>1.8 Theoretical Framework</td>
<td></td>
<td>14</td>
</tr>
<tr>
<td>1.9 Research Framework</td>
<td></td>
<td>17</td>
</tr>
</tbody>
</table>
1.10 Importance of the Study

1.9.1 Importance for the Education Ministry of Malaysia

1.9.2 Importance for Mathematics Teachers

1.9.3 Importance for Form One Students

1.11 Operational Definition

1.11.1 The Personalized Learning Environment (PLE)

1.11.2 Website

1.11.3 Learning Orientations

1.11.4 Fractions

1.11.5 Form One Students

1.11.6 Database

1.11.7 Data-Logging

1.12 Summary

2 LITERATURE REVIEW

2.1 Introduction

2.2 Motivation in Mathematics

2.3 Problems in Learning Fractions

2.4 Problem-Solving

2.5 Individual Difference

2.6 Personalized Learning Website

2.7 Patterns of Interaction

2.8 User Modelling

2.9 Summary

3 RESEARCH METHODOLOGY

3.1 Introduction

3.2 Research Design

3.3 Research Procedure

3.3.1 Phase 1: Analysis Phase

3.3.2 Phase 2: Design and Developmental Phase
3.3.3 Phase 3: Implementation Phase

3.3.4 Phase 4: Evaluation Phase

3.4 Sample and Population

3.5 Research Instruments

3.5.1 Motivation Questionnaires

3.5.2 Learning Orientations Questionnaires

3.5.3 Pre Test and Post Test on Fractions

3.5.4 System Analysis Questionnaires and System Effectiveness Questionnaires

3.5.5 Problem-Solving Skills Rubric

3.5.6 Fractions Website Development Checklist

3.6 Pilot Study

3.6.1 Pilot Study Results of Pre Test and Post Test

3.6.2 Pilot Study Results of Motivation Questionnaires

3.6.3 Pilot Study Results of Learning Orientations Questionnaires

3.7 Data Analysis

3.7.1 The Effect of Fractions Website towards Achievements in Fractions

3.7.2 The Effect of Fractions Website towards Problem-Solving Skills in Fractions

3.7.3 The Effect of Fractions Website towards Motivation in Fractions

3.7.4 The Effect of Fractions Website towards Learning Orientations

3.7.5 Correlation Analysis between Learning Orientations with Achievement, Problem-Solving Skills and Motivation

3.7.6 Formulation of User Model based on Learning Orientations Profile
4 DESIGN AND DEVELOPMENT OF FRACTIONS WEBSITE

4.1 Introduction 87
4.2 Analysis Phase 88
4.3 Design Phase 90
4.4 Development Phase 95
   4.4.1 Interactive Functions 95
      4.4.1.1 Learner-Self Interactions 96
      4.4.1.2 Learner-Interface Interactions 99
      4.4.1.3 Learner-Content Interactions 103
      4.4.1.4 Learner-Learner/Instructor Interactions 111
   4.4.2 Testing of the Prototype of the Fractions Website 113
4.5 Implementation Phase 114
4.6 Evaluation Phase 115
4.7 Summary 116

5 RESULTS, FINDINGS AND DATA ANALYSIS 117

5.1 Introduction 117
5.2 Findings on the Effect of Fractions Website towards Achievements in Fractions 117
5.3 Findings on the Effect of Fractions Website towards Problem-Solving Skills in Fractions 121
5.4 Findings on the Effect of Fractions Website towards Motivation in Fractions 125
   5.4.1 Statistical Test of the Value of Fractions 127
   5.4.2 Statistical Test of Mathematical Anxiety in Learning Fractions 129
   5.4.3 Statistical Test of Self-Concept of Ability in Fractions 132
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.5</td>
<td>Findings on the Effect of Fractions Website towards Learning Orientations</td>
<td>135</td>
</tr>
<tr>
<td>5.5.1</td>
<td>Statistical Test of Average Learning Orientations</td>
<td>138</td>
</tr>
<tr>
<td>5.5.2</td>
<td>Statistical Test of Self-Motivation</td>
<td>141</td>
</tr>
<tr>
<td>5.5.3</td>
<td>Statistical Test of Self-Directed Strategic Planning</td>
<td>144</td>
</tr>
<tr>
<td>5.5.4</td>
<td>Statistical Test of Learning Autonomy</td>
<td>147</td>
</tr>
<tr>
<td>5.6</td>
<td>Findings on Correlation Analysis between Learning Orientations with Achievement, Problem-Solving Skills and Motivation</td>
<td>150</td>
</tr>
<tr>
<td>5.6.1</td>
<td>Correlation Analysis between Learning Orientations and Achievement</td>
<td>150</td>
</tr>
<tr>
<td>5.6.2</td>
<td>Correlation Analysis between Learning Orientations and Problem-Solving Skills</td>
<td>152</td>
</tr>
<tr>
<td>5.6.3</td>
<td>Correlation Analysis between Learning Orientations and Motivation</td>
<td>153</td>
</tr>
<tr>
<td>5.7</td>
<td>Findings on Formulation of User Modelling based on Learning Orientations</td>
<td>154</td>
</tr>
<tr>
<td>5.7.1</td>
<td>User Modelling of Conforming Learners</td>
<td>155</td>
</tr>
<tr>
<td>5.7.2</td>
<td>User Modelling of Performing Learners</td>
<td>160</td>
</tr>
<tr>
<td>5.7.3</td>
<td>User Modelling of Transforming Learner</td>
<td>165</td>
</tr>
<tr>
<td>5.7.4</td>
<td>User Modelling of Fluctuate Learning Orientations Profile Learners</td>
<td>170</td>
</tr>
<tr>
<td>5.7.5</td>
<td>User Modelling of Positive Learning Orientations Profile Learners</td>
<td>176</td>
</tr>
<tr>
<td>5.7.6</td>
<td>User Modelling of Negative Learning Orientations Profile Learners</td>
<td>181</td>
</tr>
<tr>
<td>5.8</td>
<td>Summary</td>
<td>187</td>
</tr>
</tbody>
</table>
6 DISCUSSIONS, CONCLUSION AND RECOMMENDATIONS

6.1 Introduction 188
6.2 Discussions 188
6.2.1 The Effectiveness of the Fractions Website towards Students’ Achievements 188
6.2.2 The Effectiveness of the Fractions Website towards Students’ Problem-Solving Skills 192
6.2.3 The Effectiveness of the Fractions Website towards Students’ Motivation 194
6.2.4 Changes in Students’ Learning Orientations Profiles after using the Fractions Website 197
6.2.5 User Modelling of Students after using the Fractions Website 199
6.3 Overall Conclusion 202
6.4 Implications of the Research 203
6.4.1 Implications to Teachers 203
6.4.2 Implications to Students 204
6.4.3 Implications to Education Development Centres 205
6.4.4 Implications to Instructional Designers 205
6.5 Limitations of the Study 206
6.6 Recommendations for Further Studies 207
6.7 Summary 208

BIBLIOGRAPHY 210
Appendices A – AE 228 – 299
<table>
<thead>
<tr>
<th>TABLE NO.</th>
<th>TITLE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>The Relationship between the Research Objectives, Questions and Instruments</td>
<td>19</td>
</tr>
<tr>
<td>2.1</td>
<td>Meta-Analysis of Previous Research on Motivation</td>
<td>29</td>
</tr>
<tr>
<td>2.2</td>
<td>Correlations of Value, Self-Concept of Ability and Mathematical Anxiety</td>
<td>32</td>
</tr>
<tr>
<td>2.3</td>
<td>Result of Preliminary Investigation on Students' Answer Scripts on Fractions</td>
<td>34</td>
</tr>
<tr>
<td>2.4</td>
<td>Curriculum Specifications for Fractions</td>
<td>36</td>
</tr>
<tr>
<td>2.5</td>
<td>Meta-Analysis of Previous Research on Problem-Solving</td>
<td>39</td>
</tr>
<tr>
<td>2.6</td>
<td>Meta-Analysis of Previous Research on Individual Differences</td>
<td>42</td>
</tr>
<tr>
<td>2.7</td>
<td>Design Guidelines (Martinez, 2001)</td>
<td>47</td>
</tr>
<tr>
<td>2.8</td>
<td>Meta-Analysis of Previous Research on Online Interactions</td>
<td>53</td>
</tr>
<tr>
<td>2.9</td>
<td>Interactivity Functions on the Fractions Website</td>
<td>55</td>
</tr>
<tr>
<td>3.1</td>
<td>Data Analysis Method corresponding to Research Questions</td>
<td>64</td>
</tr>
<tr>
<td>3.2</td>
<td>Number of Respondents involved in the Pilot Study</td>
<td>66</td>
</tr>
<tr>
<td>3.3</td>
<td>Result of Content Validity for the Pre Test and Post Test</td>
<td>71</td>
</tr>
<tr>
<td>3.4</td>
<td>Difficulty Index of the Pre Test and Post Test Items</td>
<td>72</td>
</tr>
<tr>
<td>Section</td>
<td>Title</td>
<td>Page</td>
</tr>
<tr>
<td>---------</td>
<td>------------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>3.5</td>
<td>Discrimination Index of the Pre Test and Post Test Items</td>
<td>73</td>
</tr>
<tr>
<td>3.6</td>
<td>Result of Content Validity for Motivation Questionnaires</td>
<td>74</td>
</tr>
<tr>
<td>3.7</td>
<td>Case Processing Summary for Motivation Questionnaires</td>
<td>75</td>
</tr>
<tr>
<td>3.8</td>
<td>Reliability Statistics for Motivation Questionnaires</td>
<td>75</td>
</tr>
<tr>
<td>3.9</td>
<td>Principal Component Analysis Matrix for Motivation Questionnaires</td>
<td>76</td>
</tr>
<tr>
<td>3.10</td>
<td>Result of Content Validity for Learning Orientations Questionnaires</td>
<td>77</td>
</tr>
<tr>
<td>3.11</td>
<td>Case Processing Summary for Learning Orientations Questionnaires</td>
<td>77</td>
</tr>
<tr>
<td>3.12</td>
<td>Reliability Statistics for Learning Orientations Questionnaires</td>
<td>78</td>
</tr>
<tr>
<td>3.13</td>
<td>Principal Component Analysis Matrix for Learning Orientations Questionnaires</td>
<td>78</td>
</tr>
<tr>
<td>3.14</td>
<td>Representation of Motivation Factors Data</td>
<td>82</td>
</tr>
<tr>
<td>3.15</td>
<td>Representation of Learning Orientations Constructs Data</td>
<td>84</td>
</tr>
<tr>
<td>4.1</td>
<td>Design of the Learning Materials for Transforming, Performing and Conforming Learners</td>
<td>91</td>
</tr>
<tr>
<td>4.2</td>
<td>The Result of the Validity Test of Developed Learning Materials</td>
<td>92</td>
</tr>
<tr>
<td>4.3</td>
<td>The Result of the Acceptance Test of Developed Learning Materials</td>
<td>93</td>
</tr>
<tr>
<td>4.4</td>
<td>System Specifications of the Fractions Website</td>
<td>94</td>
</tr>
<tr>
<td>4.5</td>
<td>The Result of Alpha Testing</td>
<td>113</td>
</tr>
<tr>
<td>4.6</td>
<td>Minimum Requirements of the Fractions Website</td>
<td>114</td>
</tr>
<tr>
<td>5.1</td>
<td>Descriptive Findings of the Pre Test and Post Test Scores</td>
<td>118</td>
</tr>
</tbody>
</table>
5.2 The Shapiro-Wilk Tests of Normality for the Pre Test and Post Test
5.3 Descriptive Statistics of the Pre Test and Post Test
5.4 Ranks for the Pre Test and Post Test
5.5 Wilcoxon Signed-Ranks Test Statistics of the Pre Test and Post Test
5.6 Descriptive Findings of the Problem-Solving Skills Scores
5.7 The Shapiro-Wilk Tests of Normality for the Problem-Solving Skills Scores
5.8 Descriptive Statistics of the Problem-Solving Skills Scores
5.9 Ranks for the Problem-Solving Skills Scores
5.10 The Wilcoxon Signed-Ranks Test Statistics for the Problem-Solving Skills Scores
5.11 Descriptive Findings of Motivation Factors Scores
5.12 The Shapiro-Wilk Tests of Normality for the Value of Fractions
5.13 Descriptive Statistics of the Value of Fractions
5.14 Ranks for the Value of Fractions
5.15 The Friedman Test Statistics for the Value of Fractions
5.16 The Shapiro-Wilk Tests of Normality for the Value of Fractions
5.17 Within-Subjects Factors of Mathematical Anxiety in Learning Fractions
5.18 Descriptive Statistics of Mathematical Anxiety in Learning Fractions
5.19 Multivariate Tests of the Within Subjects Effect for Mathematical Anxiety in Learning Fractions
5.20 The Shapiro-Wilk Tests of Normality for the Self-Concept of Ability in Fractions
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.21</td>
<td>Descriptive Statistics of the Self-Concept of Ability in Fractions</td>
<td>133</td>
</tr>
<tr>
<td>5.22</td>
<td>Ranks for the Self-Concept of Ability in Fractions</td>
<td>133</td>
</tr>
<tr>
<td>5.23</td>
<td>The Friedman Test Statistics for the Self-Concept of Ability in Fractions</td>
<td>134</td>
</tr>
<tr>
<td>5.24</td>
<td>The Wilcoxon Signed-Ranks Test Statistics of the Self-Concept of Ability in Fractions</td>
<td>134</td>
</tr>
<tr>
<td>5.25</td>
<td>Findings of the Learning Orientations Profile</td>
<td>135</td>
</tr>
<tr>
<td>5.26</td>
<td>Descriptive Findings of the Learning Orientations</td>
<td>137</td>
</tr>
<tr>
<td>5.27</td>
<td>The Shapiro-Wilk Tests of Normality for the Value of Fractions</td>
<td>139</td>
</tr>
<tr>
<td>5.28</td>
<td>Within-Subjects Fractors of Average Learning Orientations</td>
<td>139</td>
</tr>
<tr>
<td>5.29</td>
<td>Descriptive Statistics of Average Learning Orientations</td>
<td>140</td>
</tr>
<tr>
<td>5.30</td>
<td>Multivariate Tests of the Within Subjects Effect for Average Learning Orientations</td>
<td>140</td>
</tr>
<tr>
<td>5.31</td>
<td>The Shapiro-Wilk Tests of Normality for Self-Motivation</td>
<td>141</td>
</tr>
<tr>
<td>5.32</td>
<td>Within-Subjects Fractors of Self-Motivation</td>
<td>142</td>
</tr>
<tr>
<td>5.33</td>
<td>Descriptive Statistics of Self-Motivation</td>
<td>142</td>
</tr>
<tr>
<td>5.34</td>
<td>Multivariate Tests of the Within Subjects Effect for Self-Motivation</td>
<td>143</td>
</tr>
<tr>
<td>5.35</td>
<td>Paired-Samples T-Test of Self-Motivation</td>
<td>143</td>
</tr>
<tr>
<td>5.36</td>
<td>The Shapiro-Wilk Tests of Normality for Self-Directed Strategic Planning</td>
<td>144</td>
</tr>
<tr>
<td>5.37</td>
<td>Within-Subjects Fractors of Self-Directed Strategic Planning</td>
<td>145</td>
</tr>
<tr>
<td>5.38</td>
<td>Descriptive Statistics of Self-Directed Strategic Planning</td>
<td>145</td>
</tr>
<tr>
<td>5.39</td>
<td>Multivariate Tests of the Within Subjects Effect for Self-Directed Strategic Planning</td>
<td>146</td>
</tr>
</tbody>
</table>
5.40 Paired-Samples T-Test of Self-Directed Strategic Planning
5.41 The Shapiro-Wilk Tests of Normality for Learning Autonomy
5.42 Within-Subjects Factors of Learning Autonomy
5.43 Descriptive Statistics of Learning Autonomy
5.44 Multivariate Tests of the Within Subjects Effect for Learning Autonomy
5.45 Paired-Samples T-Test of Learning Autonomy
5.46 Pearson's Correlation between Learning Orientations and Achievement Scores in Fractions
5.47 Pearson's Correlation between Learning Orientations and Problem-Solving Skills Scores in Fractions
5.48 Pearson's Correlation between Learning Orientations and Motivation Factors
## LIST OF FIGURES

<table>
<thead>
<tr>
<th>FIGURE NO.</th>
<th>TITLE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Theoretical Framework</td>
<td>15</td>
</tr>
<tr>
<td>1.2</td>
<td>Research Framework</td>
<td>18</td>
</tr>
<tr>
<td>3.1</td>
<td>One-Group Pre Test-Post Test Design (Campbell &amp; Stanley, 1963)</td>
<td>61</td>
</tr>
<tr>
<td>3.2</td>
<td>Formula of Difficulty Index (Legg, 1991)</td>
<td>72</td>
</tr>
<tr>
<td>3.3</td>
<td>Formula of Discrimination Index (Legg, 1991)</td>
<td>73</td>
</tr>
<tr>
<td>3.4</td>
<td>Formula of the mean scores of achievement, problem-solving skills, motivation factors and frequencies of interactions on the Fractions Website</td>
<td>86</td>
</tr>
<tr>
<td>4.1</td>
<td>Flowchart of the Fractions Website</td>
<td>95</td>
</tr>
<tr>
<td>4.2</td>
<td>Update Profile Function (Function 1-1)</td>
<td>97</td>
</tr>
<tr>
<td>4.3</td>
<td>Calendar Function (Function 1-2)</td>
<td>98</td>
</tr>
<tr>
<td>4.4</td>
<td>Individualized Record Function (Function 1-3)</td>
<td>98</td>
</tr>
<tr>
<td>4.5</td>
<td>Learning Objectives Function (Function 1-4)</td>
<td>99</td>
</tr>
<tr>
<td>4.6</td>
<td>Home Page (Function 2-1)</td>
<td>100</td>
</tr>
<tr>
<td>4.7</td>
<td>Language Choice Function (Function 2-2)</td>
<td>100</td>
</tr>
<tr>
<td>4.8</td>
<td>Lessons Menu Function (Function 2-3)</td>
<td>101</td>
</tr>
<tr>
<td>4.9</td>
<td>Online Comment Function (Function 2-4)</td>
<td>102</td>
</tr>
<tr>
<td>4.10</td>
<td>Discussion and Relaxation Page (Function 2-5)</td>
<td>102</td>
</tr>
<tr>
<td>4.11</td>
<td>Learning-Status Tracking Function (Function 2-6)</td>
<td>103</td>
</tr>
<tr>
<td>4.12</td>
<td>Example of a Positive Feedback Page (Function 3-2)</td>
<td>104</td>
</tr>
<tr>
<td>4.13</td>
<td>Example of a Negative Feedback Page (Function 3-2)</td>
<td>104</td>
</tr>
</tbody>
</table>
4.14 Example of an Online Test Attempt Summary (Function 3-3) 105
4.15 Further Learning Function (Function 3-4) 106
4.16 Transformance Learning Sequence (Function 3-5) 107
4.17 Performance Learning Sequence (Function 3-5) 108
4.18 Conformance Learning Sequence (Function 3-5) 109
4.19 Games Function (Function 3-6) 110
4.20 Music Function (Function 3-7) 110
4.21 Messaging Function (Function 4-1) 111
4.22 Forum Function (Function 4-2) 112
4.23 Chat Function (Function 4-3) 112
5.1 Graph of Interactions of Conforming Learners on the Fractions Website 156
5.2 Graph of Achievement of Conforming Learners 157
5.3 Graph of Problem-Solving Skills of Conforming Learners 157
5.4 Graph of Value of Fractions of Conforming Learners 158
5.5 Graph of Self-Concept of Ability in Learning Fractions of Conforming Learners 158
5.6 Graph of Mathematical Anxiety on Fractions of Conforming Learners 159
5.7 Vier Model of Conforming Learners 160
5.8 Graph of Interactions of Performing Learners on the Fractions Website 161
5.9 Graph of Achievement of Performing Learners 162
5.10 Graph of Problem-Solving Skills of Performing Learners 162
5.11 Graph of Value of Fractions of Performing Learners 163
5.12 Graph of Self-Concept of Ability in Learning Fractions of Performing Learners 163
5.13 Graph of Mathematical Anxiety on Fractions of Performing Learners

5.14 \textit{Vier} Model of Performing Learners

5.15 Graph of Interactions of Transforming Learner on the Fractions Website

5.16 Graph of Achievement of Transforming Learner

5.17 Graph of Problem-Solving Skills of Transforming Learner

5.18 Graph of Value of Fractions of Transforming Learner

5.19 Graph of Self-Concept of Ability in Learning Fractions of Transforming Learner

5.20 Graph of Mathematical Anxiety on Fractions of Transforming Learner

5.21 \textit{Vier} Model of Transforming Learner

5.22 Graph of Interactions of Fluctuate Learning Orientations Profile Learners on the Fractions Website

5.23 Graph of Achievement of Fluctuate Learning Orientations Profile Learners

5.24 Graph of Problem-Solving Skills of Fluctuate Learning Orientations Profile Learners

5.25 Graph of Value of Fractions of Fluctuate Learning Orientations Profile Learners

5.26 Graph of Self-Concept of Ability in Learning Fractions of Fluctuate Learning Orientations Profile Learners

5.27 Graph of Mathematical Anxiety on Fractions of Fluctuate Learning Orientations Profile Learners

5.28 \textit{Vier} Model of Fluctuate Learning Orientations Profile Learners
5.29 Graph of Interactions of Positive Learning Orientations Profile Learners on the Fractions Website

5.30 Graph of Achievement of Positive Learning Orientations Profile Learners

5.31 Graph of Problem-Solving Skills of Positive Learning Orientations Profile Learners

5.32 Graph of Value of Fractions of Positive Learning Orientations Profile Learners

5.33 Graph of Self-Concept of Ability in Learning Fractions of Positive Learning Orientations Profile Learners

5.34 Graph of Mathematical Anxiety on Fractions of Positive Learning Orientations Profile Learners

5.35 Vier Model of Positive Learning Orientations Profile Learners

5.36 Graph of Interactions of Negative Learning Orientations Profile Learners on the Fractions Website

5.37 Graph of Achievement of Negative Learning Orientations Profile Learners

5.38 Graph of Problem-Solving Skills of Negative Learning Orientations Profile Learners

5.39 Graph of Value of Fractions of Negative Learning Orientations Profile Learners

5.40 Graph of Self-Concept of Ability in Learning Fractions of Negative Learning Orientations Profile Learners

5.41 Graph of Mathematical Anxiety on Fractions of Negative Learning Orientations Profile Learners

5.42 Vier Model of Negative Learning Orientations Profile Learners

6.1 Simplification of the Vier Model
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADDIE</td>
<td>Analysis, Design, Develop, Implement and Evaluate</td>
</tr>
<tr>
<td>AEHA</td>
<td>Adaptive Educational Hypermedia Applications</td>
</tr>
<tr>
<td>AHA!</td>
<td>Adaptive Hypermedia Architecture</td>
</tr>
<tr>
<td>CL</td>
<td>Conforming Learner or Conformance</td>
</tr>
<tr>
<td>FW</td>
<td>Fractions Website</td>
</tr>
<tr>
<td>LO</td>
<td>Learning Orientations</td>
</tr>
<tr>
<td>LOM</td>
<td>Learning Orientations Model</td>
</tr>
<tr>
<td>LOQ</td>
<td>Learning Orientations Questionnaire</td>
</tr>
<tr>
<td>MQ</td>
<td>Motivation Questionnaire</td>
</tr>
<tr>
<td>PL</td>
<td>Performing Learner or Performance</td>
</tr>
<tr>
<td>PLE</td>
<td>Personalized Learning Environment</td>
</tr>
<tr>
<td>PS</td>
<td>Problem-Solving</td>
</tr>
<tr>
<td>RL</td>
<td>Resistant Learner or Resistance</td>
</tr>
<tr>
<td>SILPA</td>
<td>System for Intentional Learning and Performance Assessment</td>
</tr>
<tr>
<td>TANGOW</td>
<td>Task-based Adaptive Learner Guidance On the WWW</td>
</tr>
<tr>
<td>TL</td>
<td>Transforming Learner or Transformation</td>
</tr>
</tbody>
</table>
## LIST OF APPENDICES

<table>
<thead>
<tr>
<th>APPENDIX</th>
<th>TITLE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Motivation Questionnaire</td>
<td>228</td>
</tr>
<tr>
<td>B</td>
<td>Rubric of Problem-Solving Skills</td>
<td>231</td>
</tr>
<tr>
<td>C</td>
<td>Translation of Learning Orientations Questionnaire</td>
<td>232</td>
</tr>
<tr>
<td>D</td>
<td>Preliminary Study on Learning Orientations Profiles Questions</td>
<td>235</td>
</tr>
<tr>
<td>E</td>
<td>System Analysis Questionnaire</td>
<td>236</td>
</tr>
<tr>
<td>F</td>
<td>Pre Test</td>
<td>241</td>
</tr>
<tr>
<td>G</td>
<td>Answer Scheme of Pre Test</td>
<td>247</td>
</tr>
<tr>
<td>H</td>
<td>Post Test</td>
<td>253</td>
</tr>
<tr>
<td>I</td>
<td>Answer Scheme of Post Test</td>
<td>259</td>
</tr>
<tr>
<td>J</td>
<td>System Effectiveness Questionnaire</td>
<td>265</td>
</tr>
<tr>
<td>K</td>
<td>Fractions Website Development Checklist</td>
<td>268</td>
</tr>
<tr>
<td>L</td>
<td>Research Instrument Validity Form</td>
<td>269</td>
</tr>
<tr>
<td>M</td>
<td>Validation of Pre Test 1</td>
<td>270</td>
</tr>
<tr>
<td>N</td>
<td>Validation of Pre Test 2</td>
<td>271</td>
</tr>
<tr>
<td>O</td>
<td>Validation of Pre Test 3</td>
<td>272</td>
</tr>
<tr>
<td>P</td>
<td>Validation of Post Test 1</td>
<td>273</td>
</tr>
<tr>
<td>Q</td>
<td>Validation of Post Test 2</td>
<td>274</td>
</tr>
<tr>
<td>R</td>
<td>Validation of Post Test 3</td>
<td>275</td>
</tr>
<tr>
<td>S</td>
<td>Validation of Motivation Questionnaires 1</td>
<td>276</td>
</tr>
<tr>
<td>T</td>
<td>Validation of Motivation Questionnaires 2</td>
<td>279</td>
</tr>
<tr>
<td>U</td>
<td>Validation of Learning Orientations Questionnaires 1</td>
<td>282</td>
</tr>
</tbody>
</table>
V Validation of Learning Orientations Questionnaires 2
W Learning Materials Validity Form 291
X Validation of Learning Materials 1 292
Y Validation of Learning Materials 2 293
Z Validation of Learning Materials 3 294
AA Acceptance Test Questions 295
AB Alpha Testing Questions 296
AC Letter of Approval on Research by Ministry of Education Malaysia 297
AD Letter of Approval on Research by Department of Education Johor 298
AE Letter of Confirmation Status of Student in Universiti Teknologi Malaysia 299
1.1 Introduction

Currently, we are rapidly approaching an era in which technology is widely used in the field of education. The difference between the use of technology in education and its use in general is that technology in education is only concerned with its impact on the teaching and learning process. For example, it is involved in the following areas, namely: in delivering learning materials and contents, evaluating students' achievements, providing feedback and encouraging collaborative learning among students; in the education system (Hanna & de Nooy, 2003). Furthermore, the use of technology in education only differs in how much the technology is used in each subject and how the technology is applied in it. This includes different kinds of learning environments, such as online learning, blended learning and the use of electronic hardware as a teaching aid. Moreover, the use of technology in education will involve the use of computers, projectors, or other kinds of electronic hardware and software in the teaching and learning process (Goodwin, 2008).

In addition, broadening the use of technology in education has attracted many researchers to study its effectiveness on students' achievement, performance, cognition, emotions, intentions, etc. (Hanna & de Nooy, 2003; Liu et al., 2008; Morrison & Guenther, 2000; Trinidad, 2003). They found that technology in education supports the students' construction of knowledge (Morrison & Guenther, 2000), supports learner-centred learning (Trinidad, 2003) and improves learning and
educational outcomes (Hanna & de Nooy, 2003). In addition, Liu, et al. (2008) found that the use of technology in mathematics learning concentrates on learners’ differences, reduces misconceptions and hence, also improves students’ performance. Furthermore, research carried out into the topic of fractions shows positive results in the use of technology when learning fractions (Abdul Rahman & Abu Samah, 2011; Goodwin, 2008). Goodwin (2008) found that students’ learning outcomes were accelerated after learning whilst using technology. On the other hand, results from the research done by Abdul Rahman and Abu Samah (2011) showed a positive result in relation to students’ achievements in fractions and an increase in their satisfaction. In addition, clearly defined educational objectives are the beginning of any successful use of technology (Gagné et al., 2005).

Furthermore, there is a need to consider individual differences in order to ensure that learners are engaged, take responsibility for their own learning development, and are provided with the necessary challenges and opportunities for self-development and learning (Abdul Rahman & Abu Samah, 2011; Aviram et al., 2008; Jung & Graf, 2008; Keller, 2010; Kim, 2009; Thompson, 2008). This is aligned with the term of “personalized learning environment”, in which personalized instruction emphasizes individual differences and needs, while providing a student-centred approach (Alias, Jamaluddin, & Hashim, 2005; Capuano et al., 2009; Gilbert & Han, 2002; Kim, 2009; F. Liu, 2007). The personalized learning environment is found to be most suitable in an online medium, since online learning provides individualized learning and offers personalization in learning (Abdul Rahman & Abu Samah, 2011; Abu Samah, Yahaya, & Bilal Ali, 2011; Alias, Jamaluddin, & Hashim, 2005; Martinez, 1999, 2002).

Apart from that, many researchers found online learning to be more beneficial to students. Research by Gagné, et al. (2005) found that, through online learning, students are able to diagnose their strengths and limitations, make effective decisions, create new ideas and take responsibility for their own learning. Moreover, students’ motivation could easily be measured through their interactions in online learning (Muñoz-Organero, Muñoz-Merino, & Kloos, 2010). Werby (2009) and Chyung (2007) also found that online learning supports meaningful learning and
improves motivation. Subsequently, there are researchers who have developed learner or user models based on learners' interactions in online learning in order to help teachers understand the learning process from the perspective of learners (Fouad, Harb, & Nagdy, 2011). The model mainly included learners' cognitive development or interest in learning (Qiu & Zhao, 2009). The synthesisization of a user model specifically based on a personalized learning environment was also focused on by Fouad, Harb and Nagdy (2010) and Qiu and Zhao (2009). However, the model did not consider the impact of PLE towards motivation, achievement and problem-solving skills.

Therefore, user modelling in a personalized learning environment, representing students' interactions in the learning environment and the effect of the learning environment on motivation, achievements and problem-solving skills has been synthesized in this research. The changes of motivation factors included in the user modelling have had an influence on students' motivation to learn. Therefore, the user modelling is used to analyze the relationship between motivation factors with students' achievements and problem-solving skills after learning through the personalized learning environment. Further explanation on motivation, achievements, problem-solving skills, personalized learning environments and a user model will be detailed in the following section.

1.2 Background of the Problem

This research was carried out to enhance motivation in the study of mathematics and overcoming problems in fractions, by considering individual differences based on the Learning Orientations Model. Therefore, this section will discuss the background of the problems, which are namely: motivation in mathematics, problems with learning fractions and personalized learning based on the Learning Orientations Model, as follows:
1.2.1 Motivation in Mathematics

The diversity of mathematics' usage in the real world has confirmed the importance of mathematics as a body of knowledge. However, there is a belief that mathematics has no connection with the real world and also that it is a difficult subject to learn (Smith, 1995; Usiskin, 2007). This phenomenon has resulted in high anxiety among learners in relation to the study of mathematics (Uusimaki & Nason, 2004). They tend to feel less confident in mathematics and have no interest in learning the subject. What is more, motivation to learn is influenced by an individual's beliefs, interest and emotions (Gagné, et al., 2005). Therefore, a negative belief in mathematics, entertaining a low value of mathematics, high mathematical anxiety and a low self-concept of one's ability in mathematics become the factors behind low motivation levels towards mathematics (Alsup, 2005; Ball, 1990; Hembree, 1990; Newton, 2008, 2009; Stipek, 2002; Swars, Daane, & Giesen, 2006; Tirosh, 2000; Turner et al., 2003; Vinson, 2001; A. Wigfield & Eccles, 2000).

Motivation has an important role to play in students' achievements in mathematics. If students are not motivated to learn mathematics, they tend to place less value on the knowledge of mathematics (Newton, 2009). These problems were found have a relationship with the low achievement rate in mathematics among learners (Woolf et al., 2010). These may also lead to a low self-concept of ability towards the learning because it is related to current belief in the learner's own ability, together with expectations of success in the future (Newton, 2009). As a result, a student can have a low self-concept of his/her ability, become a low achiever, place less value on mathematics and have high mathematical anxiety. In addition to that, motivation is important in problem-solving generally (Jonassen, 2011) and is therefore important in solving mathematical problems. In addition, students with a high self-concept of ability in learning are found to have high problem-solving skills, an ability to perform better and to be a high achiever (Adeyemo, 2010). Therefore, in order to tackle problems with mathematics, the motivation level of students in learning mathematics needs to be taken into account and must be increased.
Accordingly, motivation can be observed through students’ behaviour (Gagné, et al., 2005), and online learning is able to capture the behaviour through students’ interactions and the total time spent interacting with the system (Muñoz-Organero, Muñoz-Merino, & Kloos, 2010). In addition to that, online behaviour could be observed through students’ participation in online learning activities and social activities, such as messaging, chatting and using forums (Chyung, 2007). Chyung (2007) also found that interactive and social activity options motivate students more to log in frequently to the system and, thus, to learn. However, there is still a lack of research into the use of technology that specifically considers investigating the following: students’ motivation in terms of how they value mathematics; their mathematical anxiety and, also, their self-concept of ability in mathematics. Therefore, this research is carried out to investigate the effectiveness of technology towards these motivational aspects, which were introduced by Newton (2009). These motivational aspects also are investigated regarding mathematics learning, specifically on the topic of fractions. Further explanation on fractions will be discussed in the following subsection.

1.2.2 Problems in Learning Fractions

Specifically, fractions is a topic in mathematics, which is the continuity of the topic of proportionality and also fundamental to the topic of algebra (Adjiage & Pluvinage, 2007). In the topic of fractions, students learn operations involving the following, namely: proper and improper fractions with the same, or different, numerators or denominators; equivalent fractions that involve simplification and sequencing of fractions and interpretation of fractions using graphical methods or set notations. The knowledge of fractions is important for use in daily life. As an example, a whole cake needs to be distributed equally to six children. In this matter, a knowledge of fractions is needed to be applied for a fair distribution of cake slices to the six children. However, difficulties involving fractions are found among students (Fandiño Pinilla, 2007). In addition, many researchers (e.g. Gould, 2005; Peng & Idris, 2008; Tengku Zainal, Mustapha, & Habib, 2009; Tirosh, 2000) have found mistakes and misconceptions involving fractions.
In addition, unfamiliarity or not having much experience in solving problems involving fractions could be the cause of errors or an inability to solve the multi-step problems of fractions (Ya-Amphan, 2002). Moreover, students’ inability to solve multi-step problems in fractions can be attributed to the lack of problem-solving skills, prior knowledge of mathematical concepts and language-based misconceptions (Amen, 2006). In addition, there are mistakes found from the preliminary investigation towards students’ answer scripts on fractions. These are, namely: mistakes in the last answer, mistakes in calculation and mistakes in copying information from the questions. Inaccurate computational skill will also contribute to poor problem-solving skills (Zentall & Ferkis, 1993). What is more, low skills in problem-solving will contribute to low motivation in learning fractions and hence a reduced desire to learn more about them (Gearhant et al., 1999; Jonassen, 2010, 2011; Malloy & Jones, 1998; Pantziara & Philippou, 2007). Mathematics performance was also found to be involved with students’ problem-solving processes. As found by Gagatsis, Elia, and Mousoulidis (2006), students need to master the basic knowledge of problem-solving to be able to answer complex problems in mathematics.

Therefore, there is a need to develop students’ problem-solving skills to overcome the following, namely: their mistakes and misconceptions involving fractions, increasing their desire to learn fractions, improve their cognitive development in fractions and then encourage them to become good, or better, problem solvers (Gagné, et al., 2005; Jacob & Sam, 2008; Tripathi, 2009). According to Jonassen (2011), problem-solving requires intentional learning. Students must have the intention to learn and be responsible for their own learning in order to solve multi-step problems involving fractions. This is aligned with the Intentional Learning Theory presented by Martinez (1999), which not only considered students’ cognitive style in learning but also deliberated further on their intentions and emotions for better and more effective learning. However, there is still a lack of research using the Intentional Learning Theory in improving the learning of mathematics, especially fractions.
On the other hand, it has been found that the animation of worked examples could aid in the understanding of problem-solving steps (Scheiter, Gerjets, & Schuh, 2010). Moreover, technology enables the development of an interactive environment that increases achievement, and encourages problem-solving and motivation in mathematics (Jacob & Sam, 2008; Serin, 2011). Therefore, the learning of fractions in this research is delivered through the animation of worked examples by Jonassen (2011) in order to familiarize students with problem-solving steps in fractions. Moreover, the sequence of observation, interpretation and application helps students better understand the process of problem-solving (Vat, 2009). In addition to that, this research emphasized the importance of individual intention in learning, and the preference of a problem-solving approach as suggested by Martinez (2001), since an individual has different preferences in solving problems (Treffinger & Selby, 2004). Further elaboration on personalized learning based on individual differences by Martinez (2001) will be discussed in the following subsection.

1.2.3 Personalized Learning based on Learning Orientations Model

Several studies have related the importance of students' individual differences being taken into account when preparing learning (Aviram, et al., 2008; Jung & Graf, 2008; Kim, 2009). Accordingly, the Intentional Learning Theory by Martinez (1999) (which focused on students' conative, affective, social and cognitive aspects) is referred to in this research in order to design the learning modules of fractions learning. The consideration of the conative aspect is found to be able to connect knowledge and feelings to actions (Schoeman, 2005). The Learning Orientations Model introduced in the theory categorized students into four Learning Orientations Profiles, which are namely: Transforming Learner, Performing Learner, Conforming Learner and Resistant Learner. Therefore, in order to emphasize individual differences and needs (Capuano, et al., 2009; Kim, 2009; F. Liu, 2007), personalized learning modules have been developed for students with different Learning Orientations Profiles. This also assists to fill in the gap of "no such personalized learning" that is considered on the Learning Orientations Profiles introduced by Martinez (1999). This is aligned with a suggestion by Vat (2009),
stating that the learning design must place emphasis on students' own learning orientations, since teaching and learning are ongoing processes. Besides that, there is a need for a formulation of a user model, based on a personalized learning environment, which will give overall information as to how students learn and if they benefitted from the learning.

Subsequently, research on user modelling in individualized and personalized learning has blossomed in recent years. The user model is designed to represent characteristics of users or students, including preferences, knowledge, competencies, tasks and objectives (Aroyo et al., 2006; Choi & Kang, 2012; Qiu & Zhao, 2009). The user model helps teachers to monitor students' learning processes and to see clearly the outcome and effectiveness of the learning (Fouad, Harb, & Nagdy, 2011). Therefore, it is necessary to fill in the gap of no research done on user modelling for each Learning Orientations Profile with regard to achievement, problem-solving skills and motivation. Accordingly, a user model is synthesized for each learner's profile based on students' motivation before, during and after learning through a personalized learning website, called "Fractions Website". It is also based on their performance in learning fractions and problem-solving skills.

1.3 Statement of the Problem

As explained previously, motivation plays an important role in students' achievements in mathematics. Therefore, an individual's beliefs, interests and emotions should be considered in the preparation of learning since these are the factors that influence students' motivation. These also have an effect on students' performance and motivation to learn (Pantziara & Philippou, 2007). Specifically, the topic of fractions is the continuity of the topic of proportionality and the basis of the topic of algebra (Adjiage & Pluvinage, 2007). There are students who believe that fractions have no meaning in their lives. For that reason, many mistakes and misconceptions with regard to fractions are found by researchers among students. These involve operations of addition, subtraction, multiplication and division
involving the following, namely: fractions, equivalent fractions (which includes comparing fractions and line intervals), interpretation of fractions, simplification of fractions, sequential fractions, reasoning and the concept of fractions as a whole. Furthermore, the lack of problem-solving skills will contribute to a low performance in fractions, since it contains multi-step problems.

Therefore, in order to improve students’ performance and motivation in fractions, a personalized learning website, called the Fractions Website, has been developed on the topic of Fractions for Form One students. The website emphasizes individual differences in order to increase learner motivation towards learning (Aviram, et al., 2008; Lim, Morris, & Yoon, 2006). A website is the learning medium chosen by the researcher since it is found to be perfect for individualized learning (Alias, Jamaluddin, & Hashim, 2005; Martinez, 1999, 2002). In addition, it enables instructors to monitor students’ progress easily, present content specifically, identify learners’ differences easily and increase students’ satisfaction, which will also increase their motivation levels (Lim, Morris, & Yoon, 2006). In addition, the website is developed by referring to Intentional Learning Theory, since this theory covers individually cognitive aspects, intention, as well as social and emotional aspects, which have an effect on students’ problem-solving (Jonassen, 2010, 2011).

Furthermore, the worked examples approach in learning fractions by Jonassen (2011) is referred to in order to enhance students’ problem-solving skills. Students’ engagement in problem-solving activities could improve their problem-solving abilities (Adeyemo, 2010; Zentall & Ferkis, 1993). This study is expected to improve students’ achievements and motivation in fractions and enhance their problem-solving skills in mathematics, especially regarding fractions. In addition, this study is expected to synthesize a user model for each Learning Orientations Profile in regard to students’ participation in the Fractions Website, achievement, problem-solving skills and motivation in learning fractions.
1.4 **Objective of the Study**

This research is conducted with objectives aiming to:

a) Design and develop a personalized learning website for Form One's topic of fractions (called the Fractions Website) by including Interactivity Functions.

b) Design and develop learning modules by referring to the Learning Orientations Model.

c) Investigate the effect of the Fractions Website towards students':
   i. Achievements in fractions.
   ii. Problem-solving skills in fractions.
   iii. Motivational factors (which are the value of fractions, mathematical anxiety on fractions and self-concept of ability in learning fractions).
   iv. Learning orientations..

d) Analyze students' learning orientations, namely, self-motivation, self-directed strategic planning and learning autonomy in correlation to their:
   i. Achievement scores in fractions.
   ii. Problem-solving skills scores in fractions.
   iii. Motivational factors (which are the value of fractions, mathematical anxiety about fractions and self-concept of ability in learning fractions).

e) Synthesize a user modelling system based on Learning Orientations Profiles in relation to students':
   i. frequency of interactions on the Fractions Website;
   ii. achievement scores in fractions;
   iii. problem-solving skills scores in fractions;
iv. motivational factors (which are the value of fractions, mathematical anxiety about fractions and self-concept of ability in learning fractions).

1.5 Research Questions

This research is conducted with regard to corresponding questions, which are namely:

a) Does Fractions Website have an effect on students':
   i. Achievements in fractions?
   ii. Problem-solving skills in fractions?
   iii. Motivational factors (which are the value of fractions, mathematical anxiety about fractions and self-concept of ability in learning fractions)?
   iv. Learning orientations?

b) What is the correlation between students' learning orientations, namely: self-motivation, self-directed strategic planning and learning autonomy with their:
   i. Achievement scores in fractions?
   ii. Problem-solving skills scores in fractions?
   iii. Motivational factors (which are the value of fractions, mathematical anxiety about fractions and self-concept of ability in learning fractions)?

c) What is the user modelling based on Learning Orientations Profiles in relation to students’:
   i. frequency of interactions on Fractions Website;
   ii. achievement scores in fractions;
   iii. problem-solving skills scores in fractions;
iv. motivational factors (which are the value of fractions, mathematical anxiety about fractions and self-concept of ability in learning fractions)?

1.6 Scope and Research Delimitation

The scope of this study is a focus solely on 35 Form One students from a school in Johor, chosen using purposive sampling, whereby special needs students and students from Fully Residential Schools are excluded from this research. Further explanation on purposive sampling will be discussed in Chapter 3, Section 3.3. This research is focused on the following, namely: students’ achievements in fractions; problem-solving skills in fractions; learning orientations profiles and motivational aspects of self-concept of ability in learning fractions, the value of fractions and mathematical anxiety about fractions before and after learning through a personalized learning website, called the Fractions Website. In addition to that, students’ interactions on the website are analyzed in order to synthesize a user model for static and non-static learning orientations profiles. It discusses the effect of the website on their achievements, problem-solving skills and motivations. Other demographic factors such as gender, family background, race and students’ interest in online learning are not considered in this research. The Fractions Website is integrated with five interactivity functions, namely: learner-learner, learner-self, learner-instructor, learner-interface and learner-content interactive functions, as recommended by Chou, Peng and Chang (2010).

Further, learning modules of fractions are constructed by referring to the Curriculum Specifications for Mathematics Form One for the topic of fractions, provided by Curriculum Development Centre of the Ministry of Education Malaysia (Ministry of Education Malaysia, 2002). Moreover, the learning modules are designed for Transforming Learners, Performing Learners and Conforming Learners, based on the Intentional Learning Theory by Martinez (1999). This includes the Learning Orientations Model, the Learning Orientations Questionnaire and Website
Design Guidelines for each learning orientations profile. There are no specific learning modules designed for Resistant Learners, since it has been found that this category of learner will avoid using learning to achieve academic goals set by others (Chapman, 2006). Moreover, the learning modules are delivered through the Fractions Website using a worked examples approach, as suggested by Jonassen (2011).

1.7 Rationale

This research is conducted to develop a personalized learning website for the topic of Fractions for Form One students. A Personalized Learning Environment (PLE) is chosen since many studies have proven its effectiveness towards learning, involving differences in each student (Aviram, et al., 2008; Gilbert & Han, 2002; Görgün et al., 2005; Retalis et al., 2004). The content is best delivered through the web, because of the practicality of the medium. which has the following qualities: it enables non-linear structures and navigation, contains multimedia presentations, distributes cross-platform systems and allows for immediate updates, responses and feedback (Wang & Yang, 2005). In addition, online learning encourages students to learn more, since the learning provides interactive and social options (Chyung, 2007). This could help in improving value placed by students' on mathematics knowledge (Newton, 2009). This could then lead to their becoming better achievers (Woolf, et al., 2010).

Additionally, the Intentional Learning Theory by Martinez (1999) is referred to in the construction of the learning modules, since this theory not only focuses on cognitive aspects, but also emphasizes students’ conative, affective and social aspects (Chapman, 2006) that connect their knowledge and feelings to action (Schoeman, 2005). The learning modules are delivered through worked examples as suggested by Jonassen (2011) in order to enhance students’ problem-solving skills. Problem-solving was found to have correlation with motivation in learning and the desire to learn more (Jonassen, 2010, 2011; Pantziara & Philippou, 2007). Therefore,
students need to master problem-solving in order to be able to answer complex mathematical problems in the future (Gagatsis, Elia, & Mousoulidis, 2006).

1.8 Theoretical Framework

Figure 1.1 is the theoretical framework of this research. In analysing the needs of students in learning, differences in students’ individual ways of learning have to be taken into account to conduct better and more effective learning (Aviram, et al., 2008; Jung & Graf, 2008; Kim, 2009; Retalis, et al., 2004; Weber, Martin, & Cayanus, 2005). After conducting the needs analysis; students’ intentions and their emotional, social and cognitive styles play an important role in an effective learning process. For that reason, the Intentional Learning Theory by Martinez (2001) that covers the whole-person perspectives, namely: conative or intentional, affective or emotional, social and cognitive, is used in this research. Therefore, the Learning Orientations Model is used to categorize students based on the Learning Orientations Profiles of the following categories: Transforming Learner or Transformance, the Performing Learner or Performance, the Conforming Learner or Conformance and the Resistant Learner or Resistance. The design guidelines on the preferences of each learner profile, as constructed by Martinez (2001), are then referred to in the development of learning modules for each learner profile on the Fractions Website. These are specifically for Transforming, Performing and Conforming Learners. Alternatively, the Resistant Learner learns through their own choice of learning module selected from the provided list.
Fractions Learning Modules of Fractions Website

Design based on Learning Orientations Profiles by Martinez (2001a)

<table>
<thead>
<tr>
<th></th>
<th>Transforming Learners</th>
<th>Performing Learners</th>
<th>Conforming Learners</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>Prefer loosely structured of mentoring</td>
<td>Prefer semi-complex structured of coaching</td>
<td>Prefer simple structured of guiding</td>
</tr>
<tr>
<td>Learning Module</td>
<td>Prefer short, compact, big picture with links to more detail</td>
<td>Prefer medium, brief overview, focus on application</td>
<td>Prefer long, guided, step-by-step learning</td>
</tr>
<tr>
<td>Problem Solving</td>
<td>Prefer complex and whole-to-part problem solving</td>
<td>Prefer part-to-whole problem solving</td>
<td>Prefer scaffolded and simple problem solving</td>
</tr>
</tbody>
</table>

Problem Solving Framework by Jonassen (2011)

- Identify the elements in the problem
- Identify the relationship among those problem elements
- Explain why and how the process is used

Resistant Learners

Learning Orientations Profile

Learning Performance

Interactions on Fractions Website
- Learner-Self
- Learner-Learner
- Learner-Instructor
- Learner-Content

User Model based on Learning Orientations Profile

Motivation Aspects
- Self-concept of ability
- Value
- Mathematical anxiety

Achievement
- Problem-Solving Skills

Figure 1.1: Theoretical Framework
In addition, students learn fractions by using worked examples, as suggested by Jonassen (2011) and based on their preferred general environment of learning, overview of modules and problem-solving approach, as shown in Martinez's design guidelines. Steps in the worked examples are, namely: identifying the elements in the problem, identifying the relationship between those problem elements and explaining why and how the process is used. This learning approach will be applied differently based on students' learning orientations. Since Transforming Learners prefer complex and whole-to-part problem-solving, a holistic problem-solving approach will be used for them. Conversely, Performing Learners prefer part-to-whole problem-solving, which is also called an analytical approach. At the same time, Conforming Learners prefer scaffolded and simple problem-solving. Therefore, the problem-solving approach for them is analytical and fully guided. On the other hand, Resistant Learners are given the freedom to choose any problem-solving approach since they resist both learning and following instructors' educational goals.

Consequently, the effectiveness of learning fractions through the Fractions Website is then investigated through analysis of students' achievements in Pre Test and Post Test results. In addition, students' problem-solving skills before and after learning through the website are measured using the Problem-Solving Rubric. This contains the following: problem-solving skills scores for accuracy of problems classification, identification of initial conditions, accuracy of equation, accuracy of answer estimate, unit consistency and accuracy of answers. In addition, students' motivational aspects regarding the value of fractions as well as anxiety generally relating to mathematics, fractions and self-concept of ability in learning fractions are analyzed before, during and after learning through the website. Finally, a user model is synthesized based on students' achievements, motivation and problem-solving skills for each Learning Orientations Profile. This is performed together with monitoring the frequencies of their interactions between themselves, other learners, instructors and learning content on the Fractions Website.
1.9 Research Framework

The research framework of this research is divided into four phases, which are namely: the Analysis Phase, the Design and Developmental Phase, the Implementation Phase and the Evaluation Phase, as shown in Figure 1.2. In the Analysis Phase, problems are analysed and identified after thorough reading of previous studies. The sample of this research is also determined in this phase using the purposive sampling method. The research instruments, namely: Pre Test, Post Test, System Analysis Questionnaires, System Effectiveness Questionnaires and Fractions Learning Modules for Transforming, Performing and Conforming Learners, are then constructed in the Design and Developmental Phase. These instruments are subsequently validated and tested for reliability, together with the Learning Orientations Questionnaires. The other research instruments, namely the Motivation Questionnaires and Problem-Solving Rubric, are used for data analysis purposes. In addition to that, the personalized learning website called Fractions Website is developed in this phase.

The Implementation Phase of this research is then divided into three stages, which are the Pre Test, Treatment and Post Test stages. In the Pre Test Stage, the Pre Test and the Motivation Questionnaires are distributed to the samples undertaking this study. The learning orientations profile of each student is subsequently determined through online Learning Orientations Questionnaires. After that, in the Treatment Stage, students learn through the particular learning environment on the Fractions Website that suits their learning orientations profile. In the middle of the implementation period, another Learning Orientations Questionnaires and Motivations Questionnaire will be administered to the samples of this study. Students will then learn in a different learning environment that suits their new learning orientations profile. However, if their profile remains the same, the student will stay in the same learning environment until the end of the Treatment Stage. Finally, in the Post Test Stage, another Motivation Questionnaire and Learning Orientations Questionnaire will be administered, together with the Post Test and a System Effectiveness Questionnaire.
Analysis Phase
1. Analyses of problems in Mathematics, especially in the topic of Fractions from previous studies.
2. Sample of this study is determined.

Design and Developmental Phase
1. Construction, validation and reliability testing of research instruments.
2. Design and development of Fractions Website

Implementation Phase

Pre Test
1. The first Motivation Questionnaires are administered to the sample of this study, together with Pre Test.
2. Then, the first Learning Orientations Questionnaires are answered online by the sample of this study to determine their learning orientations profiles.

Treatment
1. The sample of this study is asked to enter the learning environment that suits their learning orientations profiles provided in the Fractions Website.
2. In the middle of implementation period, the second Motivation Questionnaires are administered to the sample of this study.
3. Then, the second Learning Orientations Questionnaires are answered online by the sample of this study to determine their learning orientations profiles.
4. Afterwards, the sample will change the learning environment if their learning orientations profiles are changed on the second Learning Orientations Questionnaires. Otherwise, they stayed in the same learning environment until the end of the implementation period.

Post Test
1. The third Motivation Questionnaires are administered to the sample of this study, together with Post Test.
2. Then, the third Learning Orientations Questionnaires are answered online by the sample of this study to determine their learning orientations profiles.

Evaluation Phase
Data analysis based on Research Questions

Figure 1.2: Research Framework

Finally, in the Evaluation Phase, data collected in the Implementation Phase will be analyzed corresponding to the research questions. Table 1.1 simplifies the following information, namely: the research instruments involved in the data collection, the development of the Fractions Website and the design of the learning modules for Transforming Learners, Performing Learners and Conforming Learners that correspond to the objectives and questions of this research. The research procedure, data analysis and research instruments will be detailed in Chapter 3.
### Table 1.1: The Relationship between the Research Objectives, Questions and Instruments

<table>
<thead>
<tr>
<th>Research Objectives</th>
<th>Research Questions</th>
<th>Research Instruments</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Design and develop a personalized learning website for Form One’s topic of Fractions (called the Fractions Website) by including Interactivity Functions.</td>
<td>Does Fractions Website have an effect upon students’?: i. Achievements in fractions? ii. Problem-solving skills in fractions? iii. Motivational factors (which are the value of fractions, mathematical anxiety about fractions and self-concept of ability in learning fractions)? iv. Learning orientations?</td>
<td>i. System Analysis Questionnaires ii. Interactivity Functions Documents iii. System Development Checklist</td>
</tr>
<tr>
<td>Design and develop learning modules by referring to the Learning Orientations Model.</td>
<td>i. Fractions Learning Modules for Transforming, Performing and Conforming Learners</td>
<td>i. Pre Test ii. Post Test iii. Problem-Solving Skills Rubric on Pre Test and Post Test iv. Motivation Questionnaires during Pre Test, in the middle of learning and during Post Test v. Learning Orientations Questionnaires during Pre Test, in the middle of learning and during Post Test vi. System Effectiveness Questionnaires</td>
</tr>
<tr>
<td>Analyze students’ learning orientations, which are self-motivation, self-directed strategic planning and learning autonomy in correlation to their: i. Achievement scores in fractions. ii. Problem-solving</td>
<td>What is the correlation between students’ learning orientations, which are self-motivation, self-directed strategic planning and learning autonomy with their: i. Achievement scores in fractions?</td>
<td>i. Motivation Questionnaires during Post Test ii. Post Test iii. Problem-Solving Skills Rubric on Post Test iv. Learning Orientations Questionnaires during Post Test</td>
</tr>
<tr>
<td>Synthesize a user modelling based on Learning Orientations Profiles in relation to students':</td>
<td>What is the user modelling based on Learning Orientations Profiles in relation to students':</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>i. frequency of interactions on Fractions Website;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ii. achievement scores in fractions;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>iii. problem-solving skills scores in fractions;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>iv. motivational factors (which are the value of fractions, mathematical anxiety about fractions and self-concept of ability in learning fractions).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>i. Online data logging database of Fractions Website</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ii. Pre Test</td>
<td></td>
<td></td>
</tr>
<tr>
<td>iii. Post Test</td>
<td></td>
<td></td>
</tr>
<tr>
<td>iv. Problem-Solving Skills Rubric on Pre Test and Post Test</td>
<td></td>
<td></td>
</tr>
<tr>
<td>v. Motivation Questionnaires during Pre Test, in the middle of learning and during Post Test</td>
<td></td>
<td></td>
</tr>
<tr>
<td>vi. Learning Orientations Questionnaires during Pre Test, in the middle of learning and during Post Test</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 1.10 Importance of the Study

The importance of this study is very relevant for Malaysia’s Ministry of Education, mathematics teachers and Form One students, as follows:
1.10.1 Importance for the Education Ministry of Malaysia

The development of a personalized learning website on the topic of Fractions for Form One students will be one of the strategies of Malaysia’s Ministry of Education in accomplishing the mission in developing individual with high mathematical thinking and problem-solving skills by using educational technology (Curriculum Development Centre, 2011). This is in line with the effectiveness of the website in delivering knowledge and learning contents to students of all ages (Bull & Bell, 2008; Hu & Webb, 2009; Kilday & Kinzie, 2009; Wegerif, 2007). Therefore, it is hoped that the website can be a tool by which to enhance students’ problem-solving skills in mathematics, especially in the topic of fractions, and to produce students who are able to face future challenges and master the basic knowledge of mathematics. In addition to that, the findings of this research could be used in planning and designing an instructional medium that will be able to improve students’ motivation to learn and achieve in the study of mathematics.

1.10.2 Importance for Mathematics Teachers

The development of the website is hoped to help mathematics teachers in delivering the contents of fractions in an easy to understand format to Form One students at all lower secondary schools in Malaysia. This website also helps teachers to deliver the learning of fractions through a problem-solving approach. In addition, teachers can observe students’ achievements and performances through the website instantly and easily, from the online assessment provided in the website. These will decrease teachers’ respective burdens and help them to deliver an effective knowledge of fractions that will be used widely in higher levels of education. Moreover, the findings of this research could be used in designing teaching aids that are able to improve students’ motivation, achievements and problem-solving skills in mathematics.
1.10.3 Importance for Form One Students

The use of the website in learning fractions is hoped to help Form One students to understand and master the basic knowledge of fractions. Furthermore, this will improve their problem-solving skills in fractions. Mastering the basic concepts of fractions, and the problem-solving skills involved, will help them survive and to easily accommodate their new knowledge of fractions, as well as the further subjects involving fractions, at a higher level of education. In addition, the findings of this research could expose students to the learning medium that is able to motivate them to learn more and improve their achievement and problem-solving skills in mathematics.

1.11 Operational Definition

This research uses a few terms relating to technology or variables that may be difficult to understand. Hence, this operational definition could be referred to for further understanding of this study, as follows:

1.11.1 The Personalized Learning Environment (PLE)

Personalized instruction can be defined as instruction that is tailored to the learner's learning preferences and needs (Gilbert & Han, 2002). On the other hand, the learning environment is the setting for the learning to take place (Newby et al., 2006). Therefore, Personalized Learning Environment in this research refers to learning modules of fractions learning that are tailored to each Learning Orientations Profile. The learning modules are referred to in the guidelines by Martinez (2001) in designing a problem-solving approach, general environment of the learning and overview of the modules.
1.11.2 Website

A website offers an ideal technological environment for personalized learning, where learners can be uniquely identified, content can be specifically presented and progress can be individually monitored (Alias, Jamaluddin, & Hashim, 2005). The term of website in this research is used to refer to the personalized learning website for the topic of Fractions for Form One students, named the Fractions Website. The website was developed by referring to the ADDIE Model and contains five interactivity functions, which are namely: learner-self, learner-learner, learner-content, learner-instructor and learner-interface interactive functions, as recommended by Chou, Peng and Chang (2010). These functions are included to promote interactive and social options in order to motivate students to learn and increase their desire to learn more (Chyung, 2007).

1.11.3 Learning Orientations

Learning Orientations describes the disposition of an individual in approaching, managing and achieving their learning intentionally and differently from others. Also, Learning Orientations focuses on the whole-person perspective and can be used as a framework to examine the following, namely: the dynamic flow between deep-seated psychological factors, past and future learning experiences, subsequent choices about cognitive learning preferences, styles, strategies and skills and responses to treatment and, lastly, learning and performance outcomes (Martinez, 1999). There are four Learning Orientations Profiles included in this research, which are namely: Transforming Learner, Performing Learner, Conforming Learner and Resistant Learner as follows:

a) Transforming Learner refers to a highly self-motivated learner, who uses holistic thinking and prefers exploratory learning. The learner will maximize efforts to reach their goals. In addition, they are responsible for
their own learning and are easily frustrated if given little learning autonomy.

b) Performing Learner is a self-motivated and focused learner situationally. The learner will minimize efforts and prefer coaching and interaction to reach their goals, and may give up control in lower interest areas.

c) Conforming Learner is a low-risk and extrinsically motivated learner. The learner will maximize efforts in supportive environments and needs continual guidance to achieve short-term goals.

d) Resistant Learner is either an actively or passively resistant learner. The learner will avoid using learning in order to achieve academic goals set by others, but may situationally improve, perform or resist in response to positive or negative learning situations.

1.11.4 Fractions

The topic of fractions that will be learned on the website is specified for Form One students in Malaysia. The subtopic of fractions includes, namely: fractions as part of a whole, equivalent fractions, mixed numbers, proper and improper fractions, as well as the operation of addition, subtraction, multiplication and division of all types of fractions.

1.11.5 Form One Students

The Form One students involved are 13-year-old students at a lower secondary school in Malaysia. 35 students were selected from a lower secondary school in Malaysia, excluding special needs students and Fully Residential Schools.
1.11.6 Database

The database in this research refers to a collection of information, activities and interactions (Newby, et al., 2006) on the Fractions Website. The collection of information includes learning contents, online quizzes and tests, and extra learning from other fractions websites. The activities on the website include a forum, chat, music and games. The database was developed based on five types of interaction, which are namely: learner-self interaction, learner-learner interaction, learner-instructor interaction, learner-interface interaction and learner-content interaction.

1.11.7 Data-Logging

Data Logging refers to logging the activities of students on the developed website, named the Fractions Website. The logging activities are referred to in synthesizing a user model based on students’ achievement, problem-solving skills and motivation in learning fractions.

1.12 Summary

This chapter discussed the use and advantages of a personalized learning environment and online learning in education. However, there are problems when learning fractions that need to be mastered in early education. Either one or a combination of factors might cause the problems found, including motivation, mistakes, misconceptions and problem-solving skills. Therefore, a personalized learning website on the topic of fractions, called the Fractions Website, is developed for Form One students. The learning modules on the website emphasizes learners’ differences by referring to the Learning Orientations Model proposed by Martinez (1999) and by using worked examples in delivering the learning contents, as suggested by Jonassen (2011). Students’ interactions on the Fractions Website are
BIBLIOGRAPHY


at the Second International Conference of E-learning and Distance Education (eLi 2011), Riyadh.


at the 8th IEEE International Conference on Advanced Learning Technologies (ICALT08), Santander.


