

Table of Contents

Abstract.....	i
Acknowledgement.....	iii
Table of Contents.....	v
List of Figures.....	viii
List of Tables.....	x
Chapter 1 – Introduction.....	1
1.1 Research Overview.....	4
1.2 Research Motivations	5
1.3 Research Objectives.....	6
1.4 Research Scopes	7
1.5 Research Methodology	8
1.6 Thesis Organization	10
Chapter 2 – Collaborative Learning	12
2.1 Collaborative Learning Definition.....	12
2.2 Benefits of Collaborative Learning	13
2.3 Limitations of Collaborative Learning	15
2.4 Collaborative Learning Techniques.....	15
2.4.1 Circles of Learning (Learning Together).....	16
2.4.2 Student Teams-Achievement Division (STAD).....	16
2.4.3 Teams-Games-Tournaments (TGT)	16
2.4.4 Team-Assisted Individualization or Team-Accelerated Instruction (TAI) ...	17
2.4.5 Group Investigation (GI)	17
2.4.6 Co-op- Co-op.....	18
2.4.7 Cooperative Integrated Reading and Composition (CIRC).....	18
2.4.8 Jigsaw Classroom	19
2.5 Computer Supported Collaborative Learning (CSCL).....	19
2.5.1 CSCL Applications.....	20
2.6 CSCL in Malaysian Schools.....	27
2.7 WebCL Workshop.....	30
2.7.1 The Workshop’s Brainstorming Sessions.....	31
2.7.2 The Workshop Formative Evaluation.....	31
2.7.3 The Workshop Outcomes and Proposal	33
2.8 The Proposed G-Jigsaw Module.....	33
2.9 Chapter Summary	35
Chapter 3 – G-Jigsaw (Group Jigsaw) Process Model	36
3.1 Jigsaw Classroom	36
3.2 An Example of Jigsaw Classroom Activities	39
3.3 The advantages and limitation of Jigsaw Classroom.....	41
3.4 The proposed G-Jigsaw versus Jigsaw Classroom	43
3.5 The G-Jigsaw Process Model	46
3.5.1 Initial Level of Collaboration	47
3.5.2 Expert Level of Collaboration	49
3.5.3 Jigsaw Level of Collaboration	51
3.6 Summary of Aronson’s Jigsaw Classroom and G-Jigsaw Process Model	52
3.7 Tools to support jigsaw technique	54
3.8 G-Jigsaw Prototype.....	55
3.9 Chapter Summary	57
Chapter 4 – Web Agents for Supporting Collaborative Learning	58
4.1 Agent Definitions.....	58
4.2 Agent Classifications	60

4.2.1 Nwana's Agent typology	60
4.2.2 Different Agent Types Identified by Nwana	63
4.2.2.1 Collaborative Agents	64
4.2.2.2 Interface Agents	64
4.2.3.3 Mobile Agents	64
4.2.2.4 Information Agents	65
4.2.2.5 Reactive Agents	65
4.2.2.6 Hybrid Agents	66
4.2.2.7 Heterogeneous Agents	66
4.3 Web Agent	67
4.3.1 The Potentials of Web Agents	68
4.3.2 Types of Web Agents	69
4.4 Agent Architectures for Educational Applications	72
4.4.1 Existing Educational Applications with Agent Architectures	73
4.4.2 Summary on reviewed Agent Architectures	80
4.5 Web Agents in Supporting Collaborative Learning	83
4.6 Web Agents in supporting G-Jigsaw Collaborative Learning	85
4.7 Review Summary	86
Chapter 5 – G-Jigsaw Analysis and Design	87
5.1 G-Jigsaw Analysis	87
5.1.1 Requirement Analysis	87
5.1.1.1 G-Jigsaw Functional Requirements	88
5.1.1.2 G-Jigsaw Non-functional requirements	91
5.1.2 Object-Oriented Analysis	91
5.1.2.1 G-Jigsaw's Use Case Diagrams	92
5.1.2.2 G-Jigsaw Class Modeling	95
5.1.3 Summary of Web Agents Requirements in G-Jigsaw	96
5.2 G-Jigsaw Design	97
5.2.1 Architecture Design	97
5.2.2 Object-Oriented Design	102
5.2.2.1 G-Jigsaw's Sequential Diagrams	102
5.2.2.2 G-Jigsaw's Activity Diagrams	107
5.2.3 G-Jigsaw Graphical User Interface Design	109
5.3 Chapter Summary	111
Chapter 6 – G-Jigsaw Implementation and Execution	112
6.1 The implementation of G-Jigsaw's Agents	112
6.2 The Implementation of G-Jigsaw's Internal Multi-Agent Architecture	114
6.2.1 G-Jigsaw's Multi-Agent Communication	118
6.3 The Implementation of G-Jigsaw Security Aspects	128
6.4 Scenarios of G-Jigsaw Execution	128
6.4.1 Jigsaw Task Module	129
6.4.2 Initial Group Module	131
6.4.3 Expert Group Module	133
6.4.4 Jigsaw Group Module	136
6.5 Chapter Summary	138
Chapter 7 – G-Jigsaw Evaluation and Result	139
7.1 G-Jigsaw Evaluation	139
7.2 Pilot Test for Primary Schools Teachers	139
7.2.1 Experimental Material	140
7.2.2 Environment	140
7.2.3 Methodology	141
7.2.4 Activities Performed in the Task Scenarios	141

7.2.5 Designed Questionnaire.....	143
7.2.6 Pilot Test Results	145
7.3 Hands-On Testing for Primary School Students	154
7.3.1 Experimental Material	155
7.3.2 Environment	155
7.3.3 Methodology.....	155
7.3.4 Designed Questionnaire.....	156
7.3.5 Student Hands On Testing Results	156
7.4 Discussion on G-Jigsaw's Achievement	158
7.5 Chapter Summary	161
Chapter 8 – Conclusion and Future Enhancements.....	162
8.1 Research Summary	162
8.2 Research Contributions.....	163
8.3 Future Enhancements.....	165
References.....	167
Appendix A: G-Jigsaw Object-Oriented Analysis and Design	175
Appendix B: G-Jigsaw Evaluation Task Scenarios	203
Appendix C: G-Jigsaw Questionnaires.....	210
Appendix D: G-Jigsaw Web Agents' Algorithm.....	217

List of Figures

Figure 1-1 Research Methodology	10
Figure 3-1 Aronson's Jigsaw Classroom Process Model	38
Figure 3-2 The Forming of Initial Groups	47
Figure 3-3 Initial Level of Collaboration.....	48
Figure 3-4 The Forming of Expert Groups.....	49
Figure 3-5 Expert Level of Collaboration	50
Figure 3-6 The Forming of Jigsaw Group	51
Figure 4-1 Nwana's Agent Typology (from Nwana, 1996)	62
Figure 4-2 A Summary of Nwana's Different Agent Types (from Nwana, 1996).....	63
Figure 4-3 Various Types of Web Agents with Different Roles on the Internet.....	72
Figure 4-4 EduBots' Internal Architecture (Adapted from Andoh et. al., 2001)	74
Figure 4-5 Agent Architecture (Adapted from Olguin et. al. 2000).....	76
Figure 4-6 A Proposed Architectural Scheme of a Multi-Agent System (Adapted from Fenton-Kerr et. al., 1998)	79
Figure 5-1 Use Case Diagram For Jigsaw Task Module.....	93
Figure 5-2 Use Cases Diagram For Initial Group Module	94
Figure 5-3 Use Cases Diagram For Expert Group Module	94
Figure 5-4 G-Jigsaw Class Model	95
Figure 5-5 G-Jigsaw Environment.....	98
Figure 5-6 Domino Web Server Architecture	100
Figure 5-7 G-Jigsaw's Multi-tier Client/Server Architecture.....	101
Figure 5-8 G-Jigsaw Successful Login Scenario.....	103
Figure 5-9 Jigsaw Task Module's Create New Jigsaw Task Scenario.....	105
Figure 5-10 Initial Group Module's Compose Response Scenario	106
Figure 5-11 Expert Group Module's View Summaries Scenario.....	106
Figure 5-12 Jigsaw Group Module's Integrate All Reports Scenario.....	107
Figure 5-13 Activity Diagram Showing Students' Jigsaw Activity Process	108
Figure 5-14 G-Jigsaw's Homepage GUI Design.....	109
Figure 5-15 G-Jigsaw's Page GUI Design	110
Figure 6-1 G-Jigsaw Internal Agent Architecture	116
Figure 6-2 The Multi-agent Internal Architecture's Communication in G-Jigsaw	117
Figure 6-3 The Sharing Agent Execution.....	121
Figure 6-4 The Navigation Agent Execution.....	125
Figure 6-5 The Integration Agent Execution.....	127
Figure 6-6 G-Jigsaw Homepage	129
Figure 6-7 G-Jigsaw's Question Templates	129
Figure 6-8 Creating a Jigsaw Task	130
Figure 6-9 Jigsaw Tasks View.....	131
Figure 6-10 Questions to be responded in Initial Group	131
Figure 6-11 Giving Responses in Initial Group.....	132
Figure 6-12 The Summary View and Form.....	132
Figure 6-13 Expert Group View	133
Figure 6-14 Providing comments and feedback to the Summary.....	134
Figure 6-15 The Report View	135
Figure 6-16 The Report Form.....	135
Figure 6-17 Jigsaw Group Report View.....	136
Figure 6-18 Integrate Report View.....	137
Figure 6-19 Completed Task View.....	137
Figure 7-1 Comparison Results on the significant differences of web agents in simplifying the jigsaw activities	147

Figure 7-2 Comparison Results on the level of difficulties in learning to use G-Jigsaw	148
Figure 7-3 Web Agents in supporting G-Jigsaw Activities.....	152
Figure A-1-1 Accessing G-Jigsaw Use Case Diagram.....	176
Figure A-1-2 Accessing Jigsaw Task Module Use Case Diagram.....	176
Figure A-1-3 Accessing Initial Group Module Use Case Diagram.....	177
Figure A-1-4 Accessing Expert Group Module Use Case Diagram.....	177
Figure A-1-5 Accessing Jigsaw Group Module Use Case Diagram	178
Figure A-2-1 G-Jigsaw Class Diagram.....	179
Figure A-3-1 Successful Login Sequential Diagram.....	180
Figure A-3-2 Login Failure Sequential Diagram.....	181
Figure A-3-3 Navigate to other Task Modules Sequential Diagram.....	181
Figure A-3-4 Read/View Jigsaw Tasks Sequential Diagram	182
Figure A-3-5 Compose New Jigsaw Task Sequential Diagram	183
Figure A-3-6 Preview and Select Templates Sequential Diagram	184
Figure A-3-7 Retrieve Jigsaw Task Questions Sequential Diagram	184
Figure A-3-8 Edit Jigsaw Task Sequential Diagram	185
Figure A-3-10 Submit Jigsaw Task Sequential Diagram	186
Figure A-3-11 Set Profile Sequential Diagram	187
Figure A-3-12 Compose Response Sequential Diagram.....	187
Figure A-3-13 Submit Response Sequential Diagram.....	188
Figure A-3-14 Read/View Responses Sequential Diagram	188
Figure A-3-15 Compose Summary Sequential Diagram.....	189
Figure A-3-16 Retrieve Responses Sequential Diagram	189
Figure A-3-17 Submit Summary Sequential Diagram	190
Figure A-3-18 Read/View Summaries Sequential Diagram	190
Figure A-3-19 Respond to Summaries Sequential Diagram	191
Figure A-3-20 Compose Report Sequential Diagram	191
Figure A-3-21 Retrieve Summary Sequential Diagram	192
Figure A-3-22 Submit Report Sequential Diagram.....	192
Figure A-3-23 Read/View Reports Sequential Diagram	193
Figure A-3-24 Edit Report Sequential Diagram.....	194
Figure A-3-25 Delete Report Sequential Diagram	194
Figure A-3-26 Integrate Reports Sequential Diagram.....	195
Figure A-3-27 Switch Group Sequential Diagram.....	195
Figure A-4-1 Create New Jigsaw Task Activity Diagram	196
Figure A-4-2 Read and/or Edit Jigsaw Task Activity Diagram	197
Figure A-4-3 Respond to Group Members Activity Diagram.....	198
Figure A-4-4 Compose Summary Activity Diagram.....	199
Figure A-4-5 Provide Comments and Compose Report Activity Diagram.....	200
Figure A-4-6 Read, Edit and Integrate Group Reports Activity Diagram.....	201
Figure A-4-7 The Entire Jigsaw Session Activity Diagram	202

List of Tables

Table 2-1 CSCL Applications that support Children's Collaborative Learning	25
Table 3-1 The advantages and limitation of Jigsaw Classroom	43
Table 3-2 Jigsaw Classroom and G-Jigsaw Requirements Comparison	43
Table 3-3 Steps for Aronson's Jigsaw Classroom and G-Jigsaw Process Model.	52
Table 4-1 Summary of Web Agents' Implementation in Educational Applications.....	80
Table 4-2 Web Agents Roles in Supporting Collaborative Learning Activities	84
Table 6-1 Activity Agency's Reactions Towards User's Requests.....	118
Table 6-2 Sharing Agent's Communication	119
Table 6-3 Pseudo-codes for Sharing Agent's Algorithm	120
Table 6-4 Navigation Agent's Communication.....	122
Table 6-5 Map Profile Agent's mapping table	122
Table 6-6 Pseudo-codes for Navigation Agent's Algorithm	123
Table 6-7 Integration Agent's Communication.....	125
Table 6-8 Pseudo-codes for Integration Agent's Algorithm	126
Table 7-1 Summary of Pilot Test Designed Questionnaire	144
Table 7-2 The Average Time Spent in Performing Each Jigsaw Activity	145
Table 7-3 Group Report Integration Steps (with and without web agents) Comparison	147
Table 7-4 (a) Results on the Usefulness of G-Jigsaw's Facilities	149
Table 7-4 (b) Results on the Collaboration among the Teachers and Students.....	149
Table 7-4 (c) Results on the helpfulness of G-Jigsaw's Quick Helps and Instructions	150
Table 7-4 (d) G-Jigsaw's Performance Evaluation Results.....	150
Table 7-4 (e) G-Jigsaw Ease-of-use Results.....	151
Table 7-5 G-Jigsaw's Usability Test Results.....	152
Table 7-6 Summary of Questionnaire Evaluation Categories	156
Table 7-7 Student Hands-On Testing Results	156