A COMPUTATIONAL MODEL FOR RECOGNISING STUDENTS EMOTIONS IN E-LEARNING SYSTEMS

Thanuja Chandani Sandanayake

(08/8032)

University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk

Degree of Master of Philosophy

Department of Interdisciplinary Studies
Faculty of Information Technology

University of Moratuwa
Sri Lanka

February 2013

A COMPUTATIONAL MODEL FOR RECOGNISING STUDENTS EMOTIONS IN E-LEARNING SYSTEMS

Thanuja Chandani Sandanayake

(08/8032)

Thesis submitted in partial fulfilment of the requirements for the degree of Master of Philosophy

University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk

Department of Interdisciplinary Studies
Faculty of Information Technology

University of Moratuwa
Sri Lanka

February 2013

DECLARATION

I declare that this is my own work and this thesis does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

Also, I hereby grant to University of Moratuwa the non-exclusive right to reproduce and distribute my thesis, in whole or in part in print, electronic or other medium. I retain the right to use this content in whole or part in future works (such as articles or books).

Signature: Date:

University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations

The above candidate has carried out research for the M.Phil thesis under my supervision.

Supervisor: Dr. A. P. Madurapperuma

Signature of the supervisor: Date:

ABSTRACT

Online learning is a support tool for educators as well as a medium of delivery of any-time, any-where delivery of a content to a dispersed learner community. Web-based learning environments are a relatively new medium of learning to Sri Lankan universities. Like any learning process, online learning depends on effective communication of human knowledge, whether this occurs in a face-to-face classroom or across the Internet. The effectiveness of online learning also depends on establishing two-way communication between facilitators and learners, and among learners themselves. Although both emotions and interest can increase learners' likelihood to engage in traditional learning, little is known about the influence of emotions and interest in learning activities in a digital environment. Emotions play an essential role in decision making, managing, perceiving and learning and influence the rational thinking process of humans. Emotions are also important in teaching and learning and often find expression in particular ways, such as interactions with others and motivation in learning. The influence of emotions on e-learning is still not emphasized. Continuous and increasing exploration of the complex set of parameters surrounding online learning reveals the importance of the emotional states of learners and especially the relationship between learning and affective behaviour. Previous research have identified that emotions occur while individuals assess events in their environment that are related to the needs, goals and well-being. Moreover, recent research on the emotional response to online learning has focused on the importance of learners' feelings in relation to the community of learning.

The aim of the research is to develop a model to recognize leaner emotions in online learning environment. Through a critical literature review on affective computing, the study has identified several models and selected Barry Kort's Learning Spiral Model as the prototype model of the research study. The learning spiral model is a four quadrant learning model in which emotions change while the learner moves through quadrants and up the spiral. This study will be presenting a model which describes the relationship between the online learners learning performances and emotions that occur during online learning process. The research study has built a high-level architecture which consists of three sub modules representing the current context on online learning and two sub modules representing the novel approach of affective learning. Experiments were conducted based on the sub modules developed. The research was focused on identifying a suitable tool to recognise the online learner's emotions. During the comprehensive literature survey, different tools enabling recognising learner emotions were identified and the study has selected Achievement of Emotions Questionnaire (AEQ) by Pekrun *et al.* to be applied in recognising learner emotions. Therefore, the study has developed Online AEQ based on the AEQ which is suited for the online learning environment. The study has identified six parameters which represent the learner's level of learning during the learning experience. These parameters are analysed using multiple regression analysis and a model equation was developed to compute the online learner's level of learning. Finally the study has analysed and evaluated the correlation between the learner emotions and the observed behaviour. This research study therefore developed a novel model of affective online learning which can be use as a tool to recognise online learner's emotions with regard to the performance in learning.

Keywords: E-Learning, E-Learners, Emotions, Affective Learning, Learner Performances

University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk

DEDICATION

I dedicate this thesis to my parents, sister, husband and my son with love simply because they all are part of it.

University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk

ACKNOWLEDGEMENTS

I am indebted to many people who supported me throughout this study. Firstly, I would like to extend my profound gratitude to my supervisor, Dr. Ajith P. Madurapperuma. I have been honoured to work with such an enlightened individual. I could not have imagined having a better advisor and a mentor for my research study. Without his support, perseverance and perceptiveness, I would never have finished this research.

Thanks are also due to my second supervisor, Prof. (Mrs.) Dileeka Dias for all the support given throughout the period of research study. I owe special thanks to Mr. D.K Withange, Dean, Faculty of IT, Prof. A. S. Karunananda, Mr. P. M. Karunaratne, Head of the Department of Interdisciplinary Studies who provided valuable support during research studies. In particular, I would like to thank Mr. P. Dias from the University of Sri Jayawardenapura for support given in the final data analysis. Very special thank goes to Mrs. Champika Manel for all the help and encouragement provided during the study period.

University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations

I am also grateful to Dr. P. B. Dissanayake, Dr. D. Uduwawala from University of Peradeniya, Dr. I. A. M. Leena University of Colombo and Dr. Ranathunga from University of Ruhuna for the support given in data collection. I would like to thank Dr. Lochandaka, Mr. Channa, Mr. Malaka, Mrs. Malathy, Mrs. Mufitha, Mrs. Chandini, Mrs. Sumudu Mr. Susantha, and Mr. Nalin for the help given throughout the study. Very special thanks to Ms. Maheshika for proof reading the thesis by spending her valuable time. I would also like to extend my thanks to all my friends at the University of Moratuwa,

I owe special thanks to my parents who went through so many hardships to get me to where I am now. Without them, I would not be here. I also express my deepest gratitude to my sister Dr. Yasangika Sandanayake. Finally, I am so grateful to my dear husband, Nandika and my little son Hirun, for encouraging me throughout the study period.

TABLE OF CONTENTS

DECLARATION ..... **I**

ABSTRACT ..... **II**

DEDICATION ..... **III**

ACKNOWLEDGEMENTS ..... **IV**

TABLE OF CONTENTS ..... **V**

LIST OF FIGURES ..... **VIII**

LIST OF TABLES ..... **IX**

LIST OF ABBREVIATIONS ..... **X**

CHAPTER 1: INTRODUCTION **1**

1.1 BACKGROUND TO RESEARCH 1
1.2 PROBLEM STATEMENT AND RATIONALE BEHIND THE STUDY 3
1.3 RESEARCH AIM AND OBJECTIVES 5
1.4 THE RESEARCH APPROACH 5
1.5 THESIS CHAPTER BREAKDOWN 8
1.6 SUMMARY OF CHAPTER 10

CHAPTER 2: ONLINE LEARNING IN HIGHER EDUCATION **11**

2.1 INTRODUCTION 11
2.2 DEEP AND SURFACE LEARNING IN ONLINE LEARNING ENVIRONMENT 12
2.3 PEDAGOGICAL PERSPECTIVES OF ONLINE LEARNING 14
2.4 THE CHALLENGES OF E-LEARNING AND THE LIMITATIONS OF THE CURRENT APPROACHES 16
2.5 THEORETICAL FRAMEWORK OF ONLINE LEARNING 18
2.5.1 Active learning vs. passive learning in online learning 18
2.5.2 Learning reflections – Kolb's cycle 21
2.5.3 SOLO taxonomy 23
2.5.4 Bloom's taxonomy 25
2.5.5 Connectivity of the three domains described in Blooms' taxonomy with the online leaning 28
2.6 SUMMARY 29

CHAPTER 3: AFFECTIVE E-LEARNING – A REVIEW ON THE IMPACT OF LEARNER EMOTIONS IN E-LEARNING **30**

3.1 INTRODUCTION 30
3.2 DETECTING AND RECOGNISING EMOTIONAL INFORMATION IN LEARNING 30
3.3 EMOTIONS ASSOCIATED WITH LEARNING PROCESS 32
3.4 AFFECTIVE E-LEARNING MODELS 33
3.4.1 Picard's view on affective learning 33
3.4.2 Kort's learning spiral model 35
3.4.3 Multidimensional model of the emotions (MME) by Robert Plutchik 37
3.4.4 Russell's circumplex model of affect 38

University of Moratuwa, Sri Lanka.
Institutional Repository

3.4.5 Affective e-learning model *41*
3.4.6 Approaches to measure emotion *43*
3.4.6.1 Achievement emotions 44
3.4.6.2 Recognising the role of emotions in online learning 45
3.4.6.3 Importance of addressing learner emotions 47
3.4.7 Tools of recognising emotions *51*
3.4.7.1 Motivated Strategies for Learning Questionnaire (MSLQ) 51
3.4.7.2 Positive And Negative Affects Scale (PANAS) 52
3.4.7.3 Achievement Emotions Questionnaire (AEQ) 52
3.5 SUMMARY 53

CHAPTER 4: THE CONCEPTUAL MODEL AND THE SYSTEM ARCHITECTURE OF THE RESEARCH 55

4.1 INTRODUCTION 55
4.2 DEVELOPING A CONCEPTUAL MODEL TO RECOGNISE LEARNER EMOTIONS IN E-LEARNING 57
4.3 HIGH-LEVEL ARCHITECTURE OF THE PROPOSED RESEARCH SYSTEM 58
4.3.1 E-learning activity module *60*
4.3.2 Performance measure module *61*
4.3.3 Teacher evaluation module *63*
4.3.4 Emotion library module *65*
4.3.5 Recognising emotions - learner emotion identification module *66*
4.4 CHAPTER SUMMARY 67

CHAPTER 5: RESEARCH METHODOLOGY 68

5.1 INTRODUCTION 68
5.2 RESEARCH METHODOLOGY OF EXISTING ONLINE LEARNING ENVIRONMENT 69
5.2.1 E-learning activity module *70*
5.2.2 Performance measure module *71*
5.2.3 Teacher evaluation module *72*
5.3 METHODOLOGY OF THE AFFECTIVE E-LEARNING MODEL 73
5.3.1 Measuring learner emotions *73*
5.3.2 Rationale for selecting Achievement Emotions Questionnaire (AEQ) *75*
5.3.3 Designing of online AEQ *77*
5.4 MEASURING THE ONLINE LEARNERS' LEVEL OF LEARNING 79
5.4.1 Defining parameters *79*
5.4.2 Parameters measuring the level of learning *81*
5.5 METHODOLOGY OF THE FINAL USER STUDY 85
5.5.1 Experimental design on Moodle of final user study *86*
5.5.2 Designing of assessment activities *87*
5.6 SUMMARY 88

CHAPTER 6: IMPLEMENTATION, TESTING AND FINAL RESULTS OF THE AFFECTIVE E-LEARNING MODEL 90

6.1 INTRODUCTION 90
6.2 IMPLEMENTATION, TESTING AND FINAL RESULTS OF THREE SUB MODULES OF EXISTING ONLINE LEARNING ENVIRONMENT 90
6.2.1 E-learning activity module *91*
6.2.2 Performance measure module *96*

University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations

6.2.3 Teacher evaluation module 101
6.3 IMPLEMENTATION, TESTING AND FINAL RESULTS OF NOVEL APPROACH OF AFFECTIVE E-LEARNING MODEL 106
6.3.1 Measuring the online learners level of learning 107
6.3.2 Data analysis and final results of measurements of level of learning 108
6.3.3 Multiple regression analysis to derive the model of level of learning 109
6.3.4 Validation test of the regression model..... 115
6.3.4.1 Relative error in between the estimated and actual Y_i value 117
6.3.5 Measuring the online learners' emotions..... 118
6.3.6 Internal consistency or reliability test of online AEQ 119
6.3.7 Relationship between learning activities under X_1 and emotions..... 125
6.4 CHAPTER SUMMARY 126

CHAPTER 07: CONCLUSIONS 128

7.1 INTRODUCTION 128
7.2 RESEARCH APPROACH AND CONCLUSIONS.....128
7.3 LIMITATIONS AND FUTURE WORK.....132
7.4 CHAPTER SUMMARY OF THE THESIS 133

REFERENCES..... 135

APPENDIX I: PEDAGOGY REVIEW REPORT..... 143

APPENDIX II: MARKING SCHEME OF DISCUSSION FORUM 144

APPENDIX III: MARKING CRITERIA OF THE MINI PROJECT 145

APPENDIX IV: PEER REVIEW REPORT OF MINI GROUP PROJECT..... 146

APPENDIX V: ONLINE ACHIEVEMENT EMOTION QUESTIONNAIRE (OLAEQ) 147

APPENDIX VI: PUBLICATIONS AND PRESENTATIONS..... 150

Electronic Theses & Dissertations

LIST OF FIGURES

FIGURE 2.1: A MODEL OF ACTIVE LEARNING 20
FIGURE 2.2: KOLB'S CYCLE 21
FIGURE 2.3: SOLO TAXONOMY 24
FIGURE 2.4: BLOOM'S TAXONOMY 26
FIGURE 3.1: AN EXAMPLE OF THE BASIC LEARNING EMOTION SPACE 34
FIGURE 3.2: EMOTION SETS POSSIBLY RELEVANT TO LEARNING 36
FIGURE 3.3: PROPOSED MODEL RELATING PHASES OF LEARNING TO EMOTIONS 36
FIGURE 3.4: MULTIDIMENSIONAL MODEL OF THE EMOTIONS (MME) 38
FIGURE 3.5: EIGHT AFFECT CONCEPT IN A CIRCULAR ORDER (CIRCUMPLEX STRUCTURE) 40
FIGURE 3.6: DIRECT CIRCULAR COORDINATES FOR 28 AFFECT WORDS 41
FIGURE 3.7: AFFECTIVE LEARNING MODEL 42
FIGURE 3.8. BASIC DIDACTICAL ISSUES OF E-LEARNING COURSE 47
FIGURE 3.9: CUBIC EMOTIONAL MODEL: 3-DIMENSIONAL EMOTION MODEL 49
FIGURE 3.10: HIGH LEVEL STRUCTURE OF ACE STUDENT MODEL 50
FIGURE 4.1: CONCEPTUAL MODEL OF THE RESEARCH 57
FIGURE 4.2: HIGH-LEVEL ARCHITECTURE OF THE PROPOSED RESEARCH 59
FIGURE 4.3: ONLINE LEARNING ACTIVITIES 60
FIGURE 4.4: PERFORMANCE MEASURE MODULE IN EXISTING ONLINE LEARNING ENVIRONMENT 61
FIGURE 4.5: TEACHER EVALUATION MODULE 64
FIGURE 4.6: EMOTION LIBRARY MODULE 65
FIGURE 4.7: LEARNER EMOTION IDENTIFICATION MODULE 66
FIGURE 6.1: LEARNER PREFERENCES ON DIFFERENT LEARNING MODES 92
FIGURE 6.2: USER HANDLING OF ONLINE LEARNING 93
FIGURE 6.3: QUIZ AND ASSIGNMENT MARKS DISTRIBUTION OF E-LEANING ACTIVITY MODULE 95
FIGURE 6.4: AVERAGE TIME SPENT ON THE LESSON 98
FIGURE 6.5: DISTRIBUTION OF THE ASSESSMENT ACTIVITIES OF PERFORMANCE MEASURE MODULE 99
FIGURE 6.6: TEACHER'S LEVEL OF CONCERN ABOUT LEARNERS EMOTIONS 103
FIGURE 6.7: POSITIVE AND NEGATIVE EMOTIONS RECOGNISED BY THE TEACHER 104
FIGURE 6.8: NORMAL PROBABILITY PLOT OF THE RESIDUALS OF X_1 TO X_6 109
FIGURE 6.9: CORRELATION BETWEEN INDEPENDENT AND DEPENDENT VARIABLES 111
FIGURE 6.10: OUTCOME OF THE MULTIPLE REGRESSION ANALYSIS 112
FIGURE 6.11: OUTCOME OF THE MULTIPLE REGRESSION MNALYSIS AFTER REMOVING UNUSUAL OBSERVATIONS 113
FIGURE 6.12: DISTRIBUTION OF ESTIMATED Y VALUES OBTAINED THROUGH THE MODEL EQUATION VS. THE ACTUAL Y VALUE OBTAINED 118
FIGURE 6.13: PROBABILITY PLOT OF EMOTIONS OF ONLINE AEQ 121
FIGURE 6.14: CORRELATIONS BETWEEN THE EMOTIONS AND MEASURED PARAMETERS OF LEVEL OF LEARNING 122
FIGURE 6.15: THE RELATIONSHIP BETWEEN THE EMOTIONS AND MEASURED PARAMETERS OF LEVEL OF LEARNING 123
FIGURE 6.16: RELATIONSHIP BETWEEN LEARNING ACTIVITIES OF X_1 AND EMOTIONS 125

University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk

LIST OF TABLES

TABLE 2.1: TEACHING ACTIVITIES THAT SUPPORT DIFFERENT ASPECTS OF THE LEARNING CYCLE 23
TABLE 2.2: LEVELS OF BIGGS'S SOLO TAXONOMY.....25
TABLE 2.3: EDUCATIONAL OBJECTIVES OF BLOOM'S TAXONOMY 27
TABLE 5.1: CATEGORIES OF EMOTIONS IN ONLINE AEQ.....76
TABLE 5.2: EXPECTED TIME TO BE SPENT ON EACH ACTIVITY 86
TABLE 6.1: COMPOSITION OF THE USERS OF THE SURVEY IN TEACHER EVALUATION MODULE 102
TABLE 6.2: USER SUMMARY OF THE VALIDITY TEST OF REGRESSION MODEL 116
TABLE 6.3: EMOTIONS GROUPS IN AEQ.....119
TABLE 6.4: RELIABILITY TEST RESULTS OF ONLINE AEQ 120

University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk

LIST OF ABBREVIATIONS

AEQ	Achievement of Emotions Questionnaire
ICT	Information and Communication Technology
ITS	Intelligent Tutoring System
KSA	Knowledge, Skills and Attitude
LMS	Learner Management System
LSM	Learning Spiral Model
MIS	Management Information System
MME	Multidimensional Model of the Emotions
MSLQ	Motivated Strategies for Learning Questionnaire
NA	Negative Affect
OLAEQ	Online Achievement of Emotions Questionnaire
PA	Positive Affect
PANAS	Positive and Negative Affects Scale
SOLO	Structure Observed Learning and Outcomes
VL	Virtual Learning

University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk