

## DECLARATION

I declare that the thesis entitled “An Integrated Framework for Students’ Academic Performance Prediction Based on Affective and Cognitive State Using Mixed Numeric and Categorical Data” submitted by me for the degree of Doctor of Philosophy (Ph.D.) is the record of work carried out by me during the period from July 2019 to March 2023 under the guidance of Dr.I.Elizabeth Shanthi and has not formed the basis for the award of any Degree, Diploma, Associateship, Fellowship, Titles in this University or any other University or other similar institution of Higher Learning.



Signature of the Supervisor



Signature of the Candidate

**Dr. I. ELIZABETH SHANTHI**  
Professor Dept. of Computer Science  
Avinashilingam Institute for Home Science  
and Higher Education for Women  
Coimbatore - 641 043

## CERTIFICATE FROM THE SUPERVISOR

I certify that the thesis entitled “An Integrated Framework for Students’ Academic Performance Prediction Based on Affective and Cognitive State Using Mixed Numeric and Categorical Data” submitted for the degree of Doctor of Philosophy (Ph.D.) by Ms.M.Amala Jayaanthi is the record of research work carried out by her during the period from July 2019 to March 2023 under my guidance and supervision and that this work has not formed the basis for the award of any Degree, Diploma, Associateship, Fellowship or other Titles in this University or any other University or institution of Higher Learning.



Signature of the


Head of the Department

**Dr.(Mrs)S.N.GEETHALAKSHMI, MCA., Ph.D**  
Professor and Head  
Department of Computer Science  
Avinashilingam Institute for Home Science  
and Higher Education for Women  
Coimbatore - 641 043



Signature of the Supervisor

**Dr. I. ELIZABETH SHANTHI**  
Professor Dept. of Computer Science  
Avinashilingam Institute for Home Science  
and Higher Education for Women  
Coimbatore - 641 043



Signature of the Dean

**Dr. G.PADMAVATHI**  
M.Sc., M.Phil., Ph.D., MISTE, MCSI.,  
Dean, School of Physical Science and  
Computational Sciences  
Avinashilingam Institute for Home Science  
and Higher Education for Women  
(Deemed to be University)  
Coimbatore - 641 043

## ACKNOWLEDGEMENT

First and foremost, I would like to thank God Almighty for giving me the strength, knowledge, ability and opportunity to undertake this research study and to persevere and complete it satisfactorily. Without his blessings, this achievement would not have been possible.

I express my heartfelt gratitude to former chancellors **Shri Dr.P.R.Krishnakumar and Professor S.P. Thyagarajan**, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore, for giving me the consistent motivation during the research work.

I record my heartfelt gratitude to **Dr.T.S.K.Meenakshisundaram M.A., M.Phil., Ph.D.**, Chancellor, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore, for giving me the provision to do the research work.

I express my sincere thanks to former vice chancellor **Dr. (Mrs.) Premavathy Vijayan**, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore, for giving me the opportunities to take up the research work.

I express a deep sense of gratitude to **Dr. (Mrs.) V. Bharathi Harishankar**, Ph.D., FRSA., Vice Chancellor, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore, for providing the entire facilities essential to carry out and complete the study.

I thank **Dr. (Mrs). S. Kowsalya, Registrar**, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore, for all the amenities provided for the conduct of study.

My special acknowledgement and thanks to **Dr. (Mrs).K. Manimozhi, Controller of Examinations**, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore, for her continuous support throughout the research work.

My special thanks to **Dr. (Mrs.) P.Lalitha, M.Sc., M.Phil., Ph.D. Dean In-charge, (Research & Consultancy), Assistant Dean, Student Research,** Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore, for her continuous support and guidance throughout the research work.

I express my sincere thanks to **Dr. (Mrs). G.Padmavathi , M.Sc., M.Phil., Ph.D. Professor, Dean, School of Physical Sciences and Computational Sciences,** Avinashilingam Institute for Home Science and Higher Education for women, Coimbatore, for her spontaneous and timely help and amenities provided for the successful completion of this research.

I extend my gratitude, **Dr. (Mrs.) S.N.Geethalakshmi , MCA. M.Phil , Ph.D., Professor and Head, Department of Computer Science,** Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore for her constant encouragement, motivation, positive attitude, timely help, care and advice throughout the research.

My sincere and whole hearted gratitude to my guide **Dr. I.Elizabeth Shanthi, M.Sc., M.Phil., Ph.D.,** Professor, Department of Computer Science, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore. I would like to express my thanks to her for being a great mentor with great concern in me with her knowledge and intelligence in providing unwavering support and constructive feedback that has enabled me to move ahead in the right direction of my research. Her acumen towards planning and executing the research in order to ensure a timely completion has provided me an absolute drive throughout the research work.

I owe special thanks to all the staff members of our Department of Computer Science and research scholars of the department who rendered their help whenever I needed it.

I express my special thanks to my husband, parents, and my children and all my family members, friends and everyone else who have blessed me with their prayers to succeed in this Endeavour.

**M. Amala Jayanthi**

## LIST OF TABLES

<b>TABLE NO.</b>	<b>TITLE</b>	<b>PAGE NO.</b>
1.1	Components of Education Quality	3
1.2	Emotional Intelligence Attributes	14
2.1	Research gap identified	62
3.1	Example Questions	70
3.2	Polarity Score	73
3.3	Questionnaire details	75
3.4	EIQ Results	77
3.5	EIQ Results - MAE and accuracy	78
3.6	EPI Results	78
3.7	EPI Results - MAE and accuracy	79
3.8	SDS Results	80
3.9	SDS Results - MAE and accuracy	81
3.10	GSE Results	81
3.11	GSE Results - MAE and accuracy	82
3.12	RSE Results	83
3.13	RSE Results - MAE and accuracy	84
3.14	PANAS Results	84
3.15	PANAS Results - MAE and accuracy	85
3.16	OHQ Results	86
3.17	OHQ Results - MAE and accuracy	87
4.1	Pros and Cons of Mixed Data Clustering	93
4.2	Sample Dataset with Missing Value	95
4.3	Dataset after missing value imputation	95
4.4	Summary of Dataset	101
4.5	Classes to Cluster Assignment Table	102
4.6	RI Comparison	107

---

<b>TABLE NO.</b>	<b>TITLE</b>	<b>PAGE NO.</b>
4.7	Precision Comparison	108
4.8	Recall Comparison	109
5.1	AC algorithms merits and demerits	119
5.2	MIR - Student Data	124
5.3	LIR - Student Data	124
5.4	Dataset Details	125
5.5	Assessment Metrics for dataset	126
5.6	UCI Dataset Description	126
5.7	Assessment Metrics for the UCI dataset	127
5.8	Number of Generated Rule Comparison	127
5.9	Accuracy (%) Comparison	128
5.10	Execution Time (Sec) Comparison	129
6.1	Questionnaire Details with proposed score calculation	136
6.2	Polarity Result	139
6.3	Comparing Assessment Metrics for Clustering	141
6.4	Evaluation Metrics for ARM	142

---

## LIST OF FIGURES

FIGURE NO.	TITLE	PAGE NO.
1.1	Process of EDM	6
1.2	Bloom's Cognitive, Affective and Psychomotor Domain	11
1.3	Open-Ended Questionnaire Categories	19
1.4	Varieties of Closed-Ended Questionnaire	21
1.5	Graphical representation of the Recommender system	28
1.6	Overall Workflow of the Proposed System	33
3.1	Sentiment Analysis Architecture	65
3.2	Architecture of Quest_SA	69
3.3	EIQ Scale(standard vs polarity)	77
3.4	EPI Scale (standard vs polarity).	79
3.5	SDS Scale (standard vs polarity).	80
3.6	GSE Scale (standard vs polarity).	82
3.7	RSE Scale (standard vs polarity).	83
3.8	PANAS Scale (standard vs polarity).	85
3.9	OHQ Scale (standard vs polarity).	86
4.1	Heatmap for EI	103
4.2	Heatmap for EP	103
4.3	Heatmap for GSE	104
4.4	Heatmap for OHQ	104
4.5	Heatmap for PANAS	105
4.6	Heatmap for RSE	105
4.7	Heatmap for SDS	106
4.8	Heatmap for evaluation metrics	106
4.9	Comparison of Rand Index	107
4.10	Comparison of Precision	108
4.11	Comparison of Recall	109

---

<b>FIGURE NO.</b>	<b>TITLE</b>	<b>PAGE NO.</b>
5.1	ARMpred Workflow	121
5.2	No of Generated Rules Comparison	128
5.3	Accuracy Comparison for UCI Dataset	129
5.4	Execution Time Comparison	130
6.1	System Architecture	135
6.2	Sample Rules Mined	138
6.3	MAE Comparison	140
6.4	Accuracy Comparison	140
6.5	Comparison of Assessment Metrics for Clustering	141
6.6	Student Home Page	142
6.7	EI Questionnaire Page	143
6.8	EP Questionnaire Page	143
6.9	SDS Questionnaire Page	144
6.10	GSE Questionnaire Page	144
6.11	RSE Questionnaire Page	145
6.12	PANA Questionnaire Page	145
6.13	EH Questionnaire Page	146
6.14	Clustering Page	146
6.15	Clustering Result Page	147
6.16	Association Rule Mining Page	147
6.17	ARM Result Page	148
6.18	Student Affective State and Academic Performance	148

---

## LIST OF SYMBOLS AND ABBREVIATIONS

---

AC	-	Associative Classification
APR	-	Active Pruning Rules
ARM	-	Association Rule Mining
CAR	-	Class Association Rules
CBA	-	Classification based Association
CCA	-	Classes to Cluster Assignment
CF	-	Collaborative Filtering
CMAR	-	classification based on Multiple Association Rules
CR-Tree	-	Cosine R-Tree
DM	-	Data Mining
DL	-	Deep Learning
ECARG	-	Efficient Class Associative Rule Generation
eMCAC	-	Enhanced Multi-label Classifier-based Associative Classification
EI	-	Emotional Intelligence
EIQ	-	Emotional Intelligence Questionnaire
EDM	-	Educational Data Mining
EPI	-	Eysenck Personality Inventory
EH	-	Emotional Happiness
FACA	-	Fast Associative Classification
FP-tree	-	Frequent Pattern Tree
GSE	-	General Self-Efficacy
LIR	-	Less Important Rule
MAE	-	Mean Absolute Error

---

---

ML	-	Machine Learning
MPS-KM	-	Modified Probability and Similarity-based K-Means
MSOM	-	Modified-Self-organizing Map
MIR	-	More Important Rule
NLP	-	Natural Language Processing
NMI	-	Normalized Mutual Information
OHQ	-	Oxford Happiness Questionnaire
PANAS	-	Positive and Negative Affect Schedule
PCAR	-	Predictability-based collective class association rule
RI	-	Rand Index
RS	-	Recommender System
RSE	-	Rosenberg's self-esteem
SDS	-	Self-Determination Scale
SA	-	Sentiment Analysis
SOM	-	Self-Organizing Map

---