

**THE EFFECTS OF COLLABORATIVE
KNOWLEDGE BUILDING AND ANALYTICS-
SUPPORTED REFLECTIVE ASSESSMENT ON
LEARNERS' INTERACTION, COLLABORATION,
CONCEPTUAL UNDERSTANDING AND
LEARNING APPROACH**

SAMAR MOHAMMED ABDULLAH GHAZAL

UNIVERSITI SAINS MALAYSIA

2024

**THE EFFECTS OF COLLABORATIVE
KNOWLEDGE BUILDING AND ANALYTICS-
SUPPORTED REFLECTIVE ASSESSMENT ON
LEARNERS' INTERACTION, COLLABORATION,
CONCEPTUAL UNDERSTANDING AND
LEARNING APPROACH**

by

SAMAR MOHAMMED ABDULLAH GHAZAL

**Thesis submitted in fulfilment of the requirements
for the degree of
Doctor of Philosophy**

January 2024

ACKNOWLEDGEMENT

This thesis is dedicated to the soul of my father; may Allah forgive him and grant him the highest paradise (Ameen). I would like to thank my parents for their unlimited support, encouragement, and love. From my parents, I learned how to respect and appreciate the work and how important are patience and optimism in all matters. I ask Allah to give my mother health and accept her good deeds. I would like to express my appreciation and gratefulness to my supervisor, Prof. Dr. Irfan Naufal Umar for his supervision, advice, encouragement, guidance, influence, and help during my research work and preparation for this project. He has always been there to listen to my doubts and encourage me through hard times. His enthusiasm for my work pushed me to work harder. Without his help, I would not have been able to complete my thesis. Also, I would like to express my special thanks to all faculty and administrative staff of the Centre for Instructional Multimedia, Universiti Sains Malaysia for providing the facilities, advice, and support. My grateful thanks also go to the administrative staff of the Hodeidah University, Yemen, for their assistance and support. To my brother, sisters, relatives, and friends thank you for the constant love and support given to me to complete my studies. Without your love and care, this work can't be done this way. May Allah give you the health and accept your good deeds.

Samar Mohammed Abdullah Ghazal

TABLE OF CONTENTS

ACKNOWLEDGEMENT	ii
TABLE OF CONTENTS.....	iii
LIST OF TABLES	xi
LIST OF FIGURES	xiv
LIST OF ABBREVIATIONS	xvii
LIST OF APPENDICES	xviii
ABSTRAK	xix
ABSTRACT	xxi
CHAPTER 1 INTRODUCTION.....	1
1.1 Introduction	1
1.2 Background of the Study.....	5
1.3 Problem Statement	11
1.4 Preliminary Study.....	15
1.5 Purpose of the Study	18
1.6 Research Objectives	19
1.7 Research Questions	19
1.8 Significance of the Study	20
1.9 Theoretical Framework	21
1.9.1 Social Constructivism Theory.....	22
1.9.2 Knowledge Building Theory	25
1.9.3 Online Learning Theory	26
1.10 Conceptual Framework	27
1.11 Research Framework.....	32
1.12 Operational Definitions	33
1.12.1 Knowledge Building	33

1.12.2	Knowledge Forum.....	33
1.12.3	Collaborative Learning.....	33
1.12.4	Computer Supported Collaborative Learning	34
1.12.5	Learning Approach.....	34
1.12.6	Conception of Collaboration in the Knowledge Building.....	35
1.12.7	Conceptual Understanding	35
1.12.8	Interaction.....	35
1.12.9	Patterns of Interaction	36
1.12.10	Reflective Assessment.....	36
1.12.11	Analytics-Supported Reflective Assessment	36
1.13	Summary	37
CHAPTER 2	LITERATURE REVIEW	38
2.1	Introduction	38
2.2	Theoretical Framework	38
2.2.1	Learning Theories for Online Education.....	39
2.2.1(a)	Community of Inquiry (CoI)	39
2.2.1(b)	Moore’s Model of Interaction.....	40
2.2.1(c)	Online Collaborative Learning (OCL).....	43
2.2.1(d)	Anderson’s Online Learning Model	45
2.2.2	Learning Theories	47
2.2.2(a)	Learning from Behaviorism to Constructivism	47
2.2.2(b)	Social Constructivist Learning Theory	50
2.2.3	Metaphors of Learning.....	56
2.3	Computer-Supported Collaborative Learning (CSCL)	59
2.3.1	The Emerging Paradigm of CSCL	59
2.3.2	Assessment in CSCL Environments	63
2.4	Knowledge Building	65

2.4.1	Definition of Knowledge Building.....	65
2.4.2	Theory of Knowledge Building	66
2.4.3	Principle of Knowledge Building.....	69
2.4.4	Knowledge Building Environments: Knowledge Forum.....	73
2.4.5	The Effects of Knowledge Building Environments	79
2.4.6	Assessing and Describing Knowledge Building Environment	82
2.5	Perspectives of Assessment.....	86
2.5.1	Assessment Paradigm for Different Learning Theories.....	86
2.5.2	Reflective Assessment.....	90
2.5.2(a)	Definitions of Reflective Assessment.....	90
2.5.2(b)	Reflective Assessment Practice and Knowledge Building	92
2.5.2(c)	Analytics-Supported Reflective Assessment.....	97
2.5.2(d)	Measurement of Reflective Assessment in Knowledge Building.....	100
2.6	Alignment of Assessment, Learning, Collaboration, and Instruction	103
2.6.1	Classroom Models of Learning.....	103
2.6.2	Approaches to Learning	105
2.7	Empirical Studies on Knowledge Building.....	109
2.8	Research Gaps based on Reviewed Studies	119
2.9	Summary	122
CHAPTER 3 RESEARCH METHODOLOGY		124
3.1	Introduction	124
3.2	Research Design.....	124
3.3	Research Procedure	126
3.4	Population and Sampling	128
3.5	Instructional Context.....	129
3.5.1	Course Context.....	129

3.5.2	Application of Principled-based Knowledge Building Environment.....	130
3.5.2(a)	Epistemic Agency.....	132
3.5.2(b)	Improvable ideas.....	134
3.5.2(c)	Community knowledge, collective responsibility	136
3.5.2(d)	Constructive use of information	137
3.5.2(e)	Embedded, Concurrent and Transformative Assessment	138
3.5.3	Knowledge Building Environment.....	139
3.5.4	Classroom Processes	142
3.5.4(a)	Phase one: Developing a collaborative Knowledge Building (Week 1- 2).....	143
3.5.4(b)	Phase two: Starting and deepening knowledge building discourse in Knowledge Forum (Week 3-6).....	144
3.5.4(c)	Phase three: Using reflective assessment analytic tools (ITM) for first reflection on KF discourse (Week 7)	146
3.5.4(d)	Phase Four: Continue and Deepening Collaborative Knowledge Building on Knowledge Forum (Week 8-11).....	148
3.5.4(e)	Phase Five: Using reflective assessment analytic tools (ITM) for second reflection on KF discourse (Week 12).	149
3.5.4(f)	Phase Six: Final Collective Knowledge Advances (Week 13-14).	150
3.6	Data Source	152
3.6.1	Questionnaire	152
3.6.1(a)	Questionnaire on Approach to Learning.....	152
3.6.1(b)	Questionnaire on Collaboration (QOC).....	153
3.6.1(c)	Validity and Reliability of Questionnaires (SPQ and QOC).....	154
3.6.2	Conceptual Understanding	157

3.6.2(a)	Validity of Conceptual Understanding Test	158
3.6.2(b)	Reliability of Conceptual Understanding Test	159
3.6.3	Knowledge Forum Log Files	159
3.6.4	Class Videos	159
3.6.5	Class Observations	160
3.7	Threats to the Validity	160
3.7.1	Threats to Internal Validity	160
3.7.1(a)	History	161
3.7.1(b)	Maturation.....	161
3.7.1(c)	Testing	162
3.7.1(d)	Instrumentation	162
3.7.1(e)	Statistical Regression.....	163
3.7.1(f)	Differential Selection of Participants.....	163
3.7.1(g)	Mortality	164
3.7.2	Threats to External Validity	165
3.7.2(a)	Pretest- Treatment Interaction	165
3.7.2(b)	Selection- Treatment Interaction	165
3.7.2(c)	Multiple-Treatment Interference	166
3.7.2(d)	Specificity of Variables	166
3.7.2(e)	Experimenter Effects	166
3.7.2(f)	Reactive Arrangements.....	167
3.8	Data Collection Procedures	168
3.9	Data Analysis	168
3.9.1	Descriptive Statistics	168
3.9.2	Inferential Statistics.....	169
3.9.3	Assessment and Analytical tools.....	170
3.9.3(a)	Analytical Toolkit.....	170

3.9.3(b)	Social Network Analysis – Knowledge Building Discourse Explorer (KBDeX).....	172
3.9.4	Inquiry Thread Analysis.....	174
3.9.5	Narrative Analysis.....	177
3.10	Addressing the Research Goals.....	178
3.11	Summary	181
CHAPTER 4	DATA ANALYSIS AND RESULTS	182
4.1	Introduction	182
4.2	Descriptive Analysis of Participants Characteristics	183
4.3	Inferential Statistics Analysis.....	184
4.3.1	Assumptions of Paired Sample t test.....	185
4.3.1(a)	Level of measurement.....	185
4.3.1(b)	Independence of observations.....	186
4.3.1(c)	Normal distribution.....	186
4.3.1(d)	Outliers	191
4.4	Effects of the Knowledge Building Environment and Analytics-Supported Reflective Assessment on Learners’ Learning Approaches, Collaboration, and Conceptual Understanding	193
4.4.1	Effects of the Knowledge Building Environment and Analytics-Supported Reflective Assessment on the Learners’ Learning Approaches	193
4.4.2	Effects of the Knowledge Building and Analytics-Supported Reflective Assessment on the Conception of Collaboration.....	197
4.4.3	Effects of the Knowledge Building Environment and Analytics-Supported Reflective Assessment on Learners’ Conceptual Understanding	198
4.5	The Patterns of Learners’ Knowledge Forum Participation.....	200
4.5.1	The Assessment and Learning Analytic Tools.....	200
4.5.2	Social Network Analysis - Knowledge Building Discourse Explorer (KBDeX)	203
4.5.2(a)	Network - Learners	205

4.5.2(b)	Network – Discourse Unit	207
4.5.2(c)	Network - Words	210
4.6	Role and Process of Reflective Assessment in Improving Knowledge Building	212
4.6.1	Reflection on Tasks of Inquiry and Social Metacognition.....	213
4.6.2	Reflection on Knowledge Forum Inquiry Using Meta- and Epistemic Talk.....	216
4.6.3	Analytics-Supported Reflection for Collaborative Development	219
4.6.4	Development of reflection as a community norm and social practice	230
4.7	Characterize the Nature of Knowledge Building Discourse	234
4.7.1	Inquiry Threads Analysis	235
4.7.2	Analysis Discourse Patterns	238
4.7.3	Quality of Knowledge-Building Discourse Moves with Inquiry Threads	244
4.7.4	Changes in Discourse Characteristics over Time.....	247
4.8	Relationship between Learners’ KF Interaction, Quality of Productive Discourse, and Conceptual Understanding	250
4.8.1	Correlation Analysis.....	251
4.8.2	Regression Analyses	253
4.9	Summary of Key Findings	258
4.10	Summary	259
CHAPTER 5 DISCUSSION AND FUTURE RECOMMENDATIONS		261
5.1	Introduction	261
5.2	The Effects of the Knowledge Building and Analytics-Supported Reflective Assessment on Learners’ Learning Approaches, Collaboration, and Conceptual Understanding	262
5.2.1	Effects of the Knowledge Building and Analytics-Supported Reflective Assessment on Learners’ Learning Approaches.....	262
5.2.2	Effects of the Knowledge Building and Analytics-Supported Reflective Assessment on Conception of Collaboration.....	266

5.2.3	Effects of the Knowledge Building and Analytics-Supported Reflective Assessment on Conceptual Understanding.....	267
5.3	The Patters of Learners’ Interaction in Knowledge Building Environment	269
5.3.1	Knowledge Forum Assessment analytical Toolkit (ATK).....	270
5.3.2	Social Network Analysis - Knowledge Building Discourse Explorer (KBDeX)	275
5.4	The Role and Process of Reflective Assessment in Improving Learners Knowledge Building	277
5.4.1	Reflective on Tacks of Inquiry and Social Metacognition.....	278
5.4.2	Reflective on Knowledge Forum Inquiry Using Meta- and Epistemic Talk.....	281
5.4.3	Evidence-Based Analytics-Supported Reflection for Collective Growth	284
5.4.4	Reflection Practice Embedded in the Classroom System and Community Norms.....	286
5.5	Characterizing the Nature of Knowledge Building Discourse.....	290
5.5.1	Analysis of Inquiry Threads.....	291
5.5.2	Analyzed Discourse Patterns.....	292
5.5.3	Effects of Knowledge Building and Analytical-Supported Reflective Assessment on Productive Discourse.	293
5.5.4	Progress Productive Discourse of Knowledge Building.....	297
5.6	Relationship between Learners’ KF Interaction and Quality of Productive Discourse on Conceptual Understanding Characterizing.....	299
5.7	Implications of the Study	302
5.8	Limitations and Recommendations for Future Research	307
5.9	Conclusion.....	309
	REFERENCES.....	312

APPENDICES

LIST OF PUBLICATIONS

LIST OF TABLES

	Page
Table 2.1 The 12 Knowledge Building Principles	70
Table 2.2 Knowledge Building Principles and Knowledge Forum Supports: Making Principles Transparent to Teachers and Students (adapted from (Scardamalia, 2002)	78
Table 2.3 Overview of Empirical Studies of Knowledge Building	110
Table 3.1 Reliability coefficients (Cronbach's alpha) for SPQ, QOC Questionnaires.....	156
Table 3.2 Coding Scheme for Conceptual Understanding Test.....	158
Table 3.3 Reliability coefficients (Cronbach's alpha) for Conceptual Understanding	159
Table 3.4 Coding Scheme for Examining Discourse Characteristics in Knowledge Forum Inquiry Threads	176
Table 3.5 Research Questions, Data sources, and Data analysis	180
Table 4.1 Respondents' Demographic Results	183
Table 4.2 Skewness and Kurtosis Results of Learning Approach	187
Table 4.3 Tests of Normality of Learning Approach, Collaboration, Conceptual Understanding	188
Table 4.4 Descriptive Statistics Analysis of Pre-test and Post-test Scores for Learning Approach.....	194
Table 4.5 Paired Samples Test of Learning Approach Scores.....	195
Table 4.6 Descriptive Statistics Analysis of Pre-test and Post-test Scores for Deep and Surface Approach.	196
Table 4.7 Paired Samples Test of Deep and Surface Approach Scores.....	197
Table 4.8 Descriptive Statistics Analysis of Pre-test and Post-test Scores for Conception of Collaboration.....	197

Table 4.9	Paired Samples Test of Conception of Collobration Scores	198
Table 4.10	Descriptive Statistics Analysis of Pre-test and Post-test Scores for Conceptual Understanding.	199
Table 4.11	Paired Samples Test of Conceptual Understanding Scores	199
Table 4.12	Summary of the Analytical Toolkit (ATK)	201
Table 4.13	Means of Degree, Betweenness and Closeness Centrality for Students Network during three Phases.....	207
Table 4.14	Means of Degree, Betweenness and Closeness Centrality for Discource Network during three Phases	209
Table 4.15	Means of Degree, Betweenness and Closeness Centrality for Words Network during three Phases.....	211
Table 4.16	Example of One Small Group Discussion - Journey of Thinking on the ITM	229
Table 4.17	Excerpts of Knowledge Sharing (KS) Discourse.....	239
Table 4.18	Excerpts of Knowledge Construction (KC) Discourse.....	240
Table 4.19	Excerpts of Knowledge Building (KB) Discourse.....	241
Table 4.20	Details of the Inquiry Threads Analysis	244
Table 4.21	Characteristics of Discourse: Frequency in Questioning, Ideas and Community in Inquiry Threads example of Knowledge Building...245	
Table 4.22	Frequency and Percentages of Notes Categorized as Questions, Ideas, and Community in Phase 1, Phase 2, and Phase 3	248
Table 4.23	Person Correlations between KF Interaction, KB Quality Discourse, and Conceptual Understanding	251
Table 4.24	Correlation Coefficients between Post_Conceptual Understanding, Pre_Conceptual Understanding, KF Interaction, KB_Productive Discourse.....	256
Table 4.25	Hierarchical Regression of Pre_Conceptual Understanding, KF Interaction, KB Productive Discourse on Conceptual Understanding	257

Table 4.26	Output of Regression Coefficients and Significance of the Independent Variable	257
Table 4.27	Summary of Findings	258

LIST OF FIGURES

	Page
Figure 1.1 Conceptual Framework (adapted from (Yang, van Aalst, & Chan, 2019)	31
Figure 1.2 Reseach Framework	32
Figure 2.1 Community of inquiry (Garrison & Kanuka, 2004)	40
Figure 2.2 Three Types of Interactions (Moore, 1989)	42
Figure 2.3 Relationship between Interaction and Presence in an Online Environment (adapted from (Swan, 2001).....	43
Figure 2.4 OCL. Three Intellectuall Phases (The process Model)	45
Figure 2.5 Anderson’s Online Learning Model (Anderson, 2008)	46
Figure 2.6 Knowledge Forum View	75
Figure 2.7 Knowledge Forum Scaffolds Embedded within a Note.....	75
Figure 2.8 Example of Idea Thread Mapper (Chen et al., 2013).....	102
Figure 3.1 Research Desgin.....	126
Figure 3.2 Research Procedure	127
Figure 3.3 An Excerpt of Knowledge Forum Progressive Inquiry.....	134
Figure 3.4 An Example of Knowledge Forum View and Note.....	141
Figure 3.5 Assessment and Analytical Tools in Knowledge Forum	142
Figure 3.6 Welcome View in Knowledge Forum.....	145
Figure 3.7 Excerpt from the Knowledge Forum during the First Weeks	146
Figure 3.8 Excerpt from the ITM Wondering Area during the First Session of Reflective Assessment	147
Figure 3.9 Excerpt from the ITM Inquiry Thread during the First Session of Reflective Assessment	147

Figure 3.10	Excerpt from the Knowledge Forum after the First Session of Reflective Assessment	149
Figure 3.11	Excerpt from the ITM Mapping of Inquiry Thread during the Second Session of Reflective Assessment	150
Figure 3.12	Excerpts from the Whole Class Presentations	151
Figure 3.13	Interface of KBDeX	173
Figure 4.1	Histogram for Normality of Learning Approach Score	188
Figure 4.2	Normal Q-Q Plot of Learning Approach Score	189
Figure 4.3	Histogram for Normality of Collaboration Score	189
Figure 4.4	Normal Q-Q Plot of Collaboration Score.....	190
Figure 4.5	Histogram for Normality of Conceptual Understanding Score	190
Figure 4.6	Normal Q-Q Plot of Conceptual Understanding Score.....	191
Figure 4.7	Box plot of Learning Approach Score	192
Figure 4.8	Box plot of Collaboration Score	192
Figure 4.9	Box plot of Conceptual Understanding Score.....	192
Figure 4.10	Daily activity for learners at KF.....	203
Figure 4.11	Snapshots of the Learners Network in the KF (Phase 1 to Phase 3)	205
Figure 4.12	Snapshots of the Discourse Network in the KF (Phase1 to Phase 3)	208
Figure 4.13	Snapshots of the Words Network in the KF (Phase 1 to Phase 3) ...	211
Figure 4.14	Screenshot of Assessment and Analytical Tools in the KF	219
Figure 4.15	Large Tree of Progressive Inquiry in the KF	222
Figure 4.16	Excerpts of ITM Wondering Area Created in the Course	225
Figure 4.17	Excerpt of ITM Inquiry Thread Created in the Course.....	226
Figure 4.18	Excerpt of ITM Multi Inquires Thread Created in the Course.....	228

Figure 4.19	The Inquiry Thread Map (The numbers following the title of each thread show the number of notes and authors involved, respectively)	236
Figure 4.20	The components of the KF interaction, KB Productive Discourse, and Conceptual Understanding	250
Figure 4.21	Normal P-P Plot of Regression Standardized Residuals for Conceptual Understanding	254
Figure 4.22	The Scatterplot of *ZRESID Against *ZPRED of Conceptual Understanding	255

LIST OF ABBREVIATIONS

CSCL	Computer Support Collaborative Learning
KB	Knowledge Building
KF	Knowledge Forum
ITM	Idea Thread Mapper
ATK	Analytical Toolkit
KBDeX	Knowledge Building Discourse Explorer
IS	Instructional Strategies
ID	Instructional Design
SNA	Social Network Analysis
SPQ	Study Process Questionnaire
QOC	Questionnaire on Collaboration

LIST OF APPENDICES

Appendix A	THE TIMELINE OF THE COURSE
Appendix B	DESIGN PEDAGOGICAL PROCESS AND ACTIVITIES
Appendix C	THE STUDY PROCESS QUESTIONNAIRE
Appendix D	THE QUESTIONNAIRE ON COLLABORATION
Appendix E	PRE AND POST CONCEPTUAL UNDERSTANDING TEST
Appendix F	CLASSROOM OBSERVATIONS PROTOCOL
Appendix G	PERMISSION FOR CONDUCTING STUDY

**KESAN PEMBINAAN PENGETAHUAN KOLABORATIF DAN
PENILAIAN REFLEKTIF SOKONGAN ANALITIK TERHADAP
INTERAKSI PELAJAR, KOLABORASI, PEMAHAMAN KONSEP DAN
PENDEKATAN PEMBELAJARAN**

ABSTRAK

Pendidikan perlu mempersiapkan pelajar untuk berkolaborasi, kreatif dan mengamalkan kelestarian terhadap ilmu dalam abad ke 21. Oleh yang demikian, adalah penting bagi tenaga pengajar untuk membantu pelajar membangunkan kompetensi dalam inkuiri kolaboratif dan membina pengetahuan. Berdasarkan teori-teori sosio-konstruktivisme, pembinaan pengetahuan, dan penilaian, kajian ini bertujuan: (1) merekabentuk persekitaran pembinaan pengetahuan yang berpandukan prinsip pembinaan pengetahuan dan penilaian reflektif yang disokong analitik, dan menilai kesannya terhadap pemahaman konsep, pendekatan pembelajaran, dan konsep kolaborasi; (2) menyiasat corak interaksi pelajar dalam persekitaran Forum Pengetahuan; (3) mengkaji peranan dan proses penilaian reflektif dalam meningkatkan pembinaan pengetahuan; (4) mencirikan dinamika pembinaan pengetahuan secara kolaboratif; dan (5) mengkaji peranan interaksi dalam Forum Pengetahuan terhadap pemahaman konsep pelajar. Dalam kajian ini, kaedah campuran (QUAN + QUAL) telah digunakan di mana seramai 24 orang pelajar pasca siswazah telah terlibat. Data dari pelbagai sumber digunakan untuk menjawab matlamat dan persoalan kajian, termasuk soal selidik, pra-ujian, dan pasca-ujian penilaian pemahaman konsep, indeks interaksi Forum Pengetahuan, pemerhatian bilik darjah, dan rakaman video ITM. Lima analisis utama dan dapatan kajian termasuk: (1) analisis inferensi (ujian t-sampel berpasangan) menunjukkan peningkatan signifikan dalam pendekatan pembelajaran

pelajar, konsep kolaborasi, dan pemahaman konsep antara pra-ujian dan pasca-ujian yang dijalankan dalam persekitaran pembinaan pengetahuan, (2) Alat Analitik (ATK) dan analisis Rangkaian Sosial (KBDeX) menunjukkan peningkatan signifikan dan beransur-ansur dalam indeks ATK pelajar dan rangkaian KBDeX apabila mereka terus terlibat dalam inkuiri dan penilaian reflektif untuk membangunkan ilmu yang dikongsi dalam persekitaran pembinaan pengetahuan, (3) Analisis naratif menunjukkan bahawa penilaian reflektif membantu pelajar secara beransur-ansur mengambil kesedaran kolektif dan terlibat dalam wacana yang produktif, (4) Analisis bebenang inkuiri dan analisis kandungan mendapati perkembangan pelajar dalam inkuiri kolaboratif dan pembinaan pengetahuan menunjukkan peningkatan yang semakin pesat dari masa ke masa, (5) Analisis korelasi menunjukkan hubungan yang positif antara corak interaksi dan pemahaman konsep pelajar, manakala analisis regresi menunjukkan corak interaksi adalah penentu yang sangat kuat terhadap pemahaman konsep pelajar. Dapatan kajian ini mempunyai implikasi penting terhadap reka bentuk prinsip pembinaan pengetahuan dan penilaian reflektif untuk meningkatkan pemahaman pelajar dan memberi pencerahan tentang bagaimana instruktur boleh menggunakannya untuk membantu pelajar berinteraksi dalam inkuiri kolaboratif yang produktif. Kajian ini juga memberi implikasi tentang bagaimana inkuiri pembinaan pengetahuan dan dibantu oleh penilaian reflektif yang disokong analitik dapat direka bentuk dalam persekitaran pembelajaran abad ke-21.

**THE EFFECTS OF COLLABORATIVE KNOWLEDGE BUILDING
AND ANALYTICS-SUPPORTED REFLECTIVE ASSESSMENT ON
LEARNERS' INTERACTION, COLLABORATION, CONCEPTUAL
UNDERSTANDING AND LEARNING APPROACH**

ABSTRACT

Education needs to prepare learners for sustained, collaborative, and creative work with the knowledge that is essential to 21st-century society. Helping learners develop competencies in collaborative inquiry and knowledge building is crucial. Premised on socio-constructivism, knowledge building and assessment theories, this study attempts to: (1) design a knowledge building environment, informed by knowledge building principles and analytics-supported reflective assessments, and evaluates its effects on learners' conceptual understanding, approaches to learning, and conceptions of collaboration; (2) investigate the patterns of interaction in Knowledge Forum; (3) examine the role and process of reflective assessment in improving knowledge building; (4) characterize the dynamics of collaborative knowledge building, and (5) examine the role of interaction in Knowledge Forum (KF) on learners' conceptual understanding. A mixed method (QUAN + QUAL) approach was adopted in this study involving 24 postgraduate students. Multiple data sources were used to address the study objectives and questions, including questionnaires, pre-test, and post-test of conceptual understanding assessments, KF interaction indices, classroom observation, and ITM Video recording. Five major analyses and findings include: (1) inferential analysis (paired sample t-test) revealed a statistically significant improvement in the learners' learning approach, conception of collaboration, and conceptual understanding between the pre-test and post-test conducted in the

knowledge building environment, (2) Analytical Toolkit (ATK) and Social Network Networks analysis (KBDeX) indicated a significant and gradual improvement in the learners' ATK indices and KBDeX networks as they continued to engage in inquiry and reflective assessment to develop their shared knowledge in the knowledge building environment, (3) Narrative analysis found that reflective assessment helped the learners to gradually take up collective agency and engage in productive discourse, (4) Inquiry thread analysis and content analysis found that the learners' development in collaborative inquiry and knowledge building shows steeper improvement over time, (5) Correlation analysis indicated a positive relationship between the patterns of interaction and learners' conceptual understanding, while regression analysis found that the patterns of interaction were very strong predictors of learners' conceptual understanding. The study's findings have important implications for the design of knowledge building principles and reflective assessment to promote learners understanding and shed light on how instructors can use them to help learners to interact in productive collaborative inquiry. This study also has implications for how computer-supported knowledge-building inquiry augmented with analytical-supported reflective assessment can be designed in the context of 21st century learners' classrooms.

CHAPTER 1

INTRODUCTION

1.1 Introduction

The recent movement of educational policy makers to encourage learners to participate in effective knowledge creation activities has led to many economic, social, and environmental issues that are still emerging and not well studied (Csikszentmihalyi & Wolfe, 2014; Lai & Campbell, 2018; Li, Huang, Liu, Tseng, & Wang, 2023). Thus, it is important that learners develop their intellectual skills such as critical thinking, creativity, problem-solving, and collaboration in order to effectively deal with these problems (Al-Samarraie & Saeed, 2018; Almerich, Suárez-Rodríguez, Díaz-García, & Orellana, 2021; Lin, Chang, Lin, & Hong, 2017). Since collaborative learning activities are consistent with a sociocultural perspective (where knowledge is socially constructed), individuals can share knowledge and tackle communication losses with other individual group members (Herrera-Pavo, 2021; Ioannou, Demetriou, & Mama, 2014). In the current knowledge society, collaboration between members has become an essential element for ensuring effective knowledge building practices. Veerman (2001) defined collaborative learning as a pedagogical process that encourages learners to discuss problems and viewpoints from different perspectives and to elaborate and refine their understanding to build new knowledge.

One of the most important areas of collaborative learning is the use of advanced technologies to support various collaboration and sharing scenarios (Mohamadi Zenouzagh, 2020; Stahl, Koschmann, & Suthers, 2006). An influential example of an institutional model using Computer Supported Collaborative Learning technology is “knowledge building” which is defined as “the production of knowledge that adds

value to the community” (Scardamalia & Bereiter, 2003, p. 1370). The notion of knowledge building has emerged as one of the promising pedagogical advances for online collaborative learning. Thus, knowledge building is a collaborative process that deals with the production and improvement of ideas in a context specific situation. Within the knowledge building process, learners treat new knowledge or information as something problematic that needs to be explained. Moreover, the literature explained that knowledge advancement is the collective work shared between the members of a group, and that knowledge is improvable through discourse (Scardamalia, 2002; Scardamalia & Bereiter, 2006a). Therefore, knowledge building has been characterized as “knowledge creation”, a third metaphor for learning (Paavola, Lipponen, & Hakkarainen, 2004) that integrates the “knowledge-acquisition” (cognitive) and “participation” (situated) learning metaphors.

Knowledge building in a collaborative setting is currently facing an increasing pressure to provide learners with the abilities to construct meaningful knowledge and become an effective member in the collaborative learning process (Sahni, 2018). To address this issue, knowledge building theory has been constantly used as a promising pedagogical approach in preparing learners for online collaborative learning (Bereiter & Scardamalia, 2003a; Scardamalia & Bereiter, 2006a). This theory asserts the significance of creating knowledge jointly in a society, and describes what learners need to achieve in order to enhance their capacity to learn, mainly through discussion (Scardamalia & Bereiter, 2006a). Thus, it is anticipated that engaging learners in a constructive discourse for the development of new knowledge is important in the collaborative context (Law, Yuen, Wong, & Leng, 2011). Scardamalia and Bereiter (2006a) indicated that the learning that accompanies the process of knowledge building involves sub-skills and socio-cognitive dynamics embedded in the foundation

of other learning approaches. Furthermore, the current conceptualization of the knowledge building process consists of collective cognitive responsibilities and learners' interaction within a community to create and share new knowledge that is supported by online forums (Lee, Lajoie, Poitras, Nkangu, & Doleck, 2017). This understanding has evolved alongside the development of what is referred to as Computer Supported Collaborative Learning (CSCL) and Knowledge Forum. CSCL and Knowledge Forum are networked learning environments designed using socio-cognitive and socio-technological dynamics, particularly to support knowledge advances among members of the group (Balakrishnan, 2015; Stahl, Anderson, & Suthers, 2006; Stahl & Hakkarainen, 2021).

Based on these explanations, it can be said that the primary aim of CSCL is to provide the ability for learners to fully interact in the community, as well as creating a new structure for social communication that is critical for supporting individuals' interaction in the process of knowledge building (Yücel & Usluel, 2016). This might result in different emergent processes and outcomes that may substantially influence the knowledge building process in an online collaborative learning environment. Previous studies on CSCL (e.g., MacLeod & Yang, 2018; Reis et al., 2018) have identified and explained the role of various antecedents to the development of individuals' knowledge building through interaction of learners in certain learning situations. Common aspects that have been studied in the literature usually consists of individuals' interaction (Cacciamani, 2017; Zhang, Yuan, & Bogouslavsky, 2020), participation (Naranjo, Onrubia, & Segué, 2012; Niu & Van Aalst, 2009; Yücel & Usluel, 2016), complex reasoning and level of argumentation (Noroozi, Weinberger, Biemans, Mulder, & Chizari, 2013; Vogel, Kollar, Fischer, Reiss, & Ufer, 2022), metacognitive understanding (Cesareni, Cacciamani, & Fujita, 2016; Ouyang, Chen,

Yang, & Chen, 2022), cognitive learning styles (Balakrishnan, 2015), design processes (Lai, 2015), regulatory processes (Järvelä, Malmberg, & Koivuniemi, 2016), and motivational and scaffolding roles (Radkowsch, Vogel, & Fischer, 2020; Rienties et al., 2012). Despite these, there are still a number of challenges regarding the suitability of current learning and teaching approaches for building learners' knowledge in a university context (So, Seah, & Toh-Heng, 2010; Van Aalst, 2009; Wise & Schwarz, 2017). One of them is the pervasive conception that knowledge building activities are only suitable for learners with higher cognitive abilities (Chan & Lee, 2007; Yang, Yuan, Feng, Li, & Van Aalst, 2022). This common belief has been commonly shared among research communities attempting to promote more learners' agency and responsibility in learning (So et al., 2010). For instance, Zohar and Dori (2003) argue that instructors with these fixed beliefs tend to use higher-order tasks for high-achieving learners more often than for low-achieving learners.

Furthermore, previous literature emphasizes that online interaction is key drivers for the group members in the CSCL environment (Yücel & Usluel, 2016). It can be said that the quality of interaction is a basic component of the knowledge building process.

Within the online learning environment, the main concern of educational researchers is to equip learners with competencies that are relevant to individuals' cognitive skills, social skills, meta-cognitive skills (Almulla & Al-Rahmi, 2023; Noweski et al., 2012), creative problem-solving skills (Aslan & Duruhan, 2021; Barron, 2006), and design thinking skills (Lin et al., 2017; Lin, Hong, & Chai, 2020). Hence, it becomes necessary to examine how metacognitive skills in an online learning environment may influence learners' knowledge-building argumentation and learning outcomes.

The literature also addressed the impact of certain facilitating strategies on learners' learning in CSCL environments. For example, Sánchez-Alonso and Vovides (2007) and Zheng, Niu, Zhong, and Gyasi (2023) found that certain facilitation strategies can help sustain learners' knowledge building in online collaborative learning. The authors found that promoting learners' metacognitive skills may play a key factor in increasing the efficiency of the online collaborative learning environment. Therefore, understanding the application of these dimensions is especially important for fostering online interaction and the cognitive presence of the learners.

1.2 Background of the Study

Recent educational reforms emphasize the importance of engaging learners in authentic and sustained practices in order to prepare them for collaborative and creative work with the knowledge that is vital to 21st-century society (Council, 2012; Martinez, 2022; States, 2013). To meet these needs, researchers have created different educational models that involve learners in collaborative inquiry and knowledge building. In these models, learners work together in a classroom setting, using social technologies to facilitate joint inquiry practices and develop a collective understanding (Bielaczyc, Collins, O'Donnell, Hmelo-Silver, & Erkens, 2006; Scardamalia & Bereiter, 2014). Considerable advancements have been made in comprehending the socio-cognitive procedures involved in learner inquiry and interaction for collaborative knowledge building (Järvelä & Hadwin, 2013; Van Aalst, 2009; Zhang, Scardamalia, Lamon, Messina, & Reeve, 2007a).

CSCL is a research area that investigates how technology-mediated discourse and collaboration contribute to learning and knowledge building (Halavais, 2016;

Stahl & Hakkarainen, 2021; Stahl & Hesse, 2011a). The use of CSCL in higher education is growing, and online discussion forums are frequently used to foster collaborative learning through inquiry and discourse (Bliuc, Ellis, Goodyear & Piggott, 2011; Loncar, Barrett & Liu, 2014).

Knowledge building is a computer-supported educational model that focuses on the idea of learners working collaboratively to take responsibility for advancing their community's knowledge (Scardamalia & Bereiter, 2006b, 2014). The present study uses the term Knowledge Building (KB) to describe an educational model that was developed by Scardamalia and Bereiter (2006b; 2014). In this model, learners engage in authentic and sustained collaborative inquiry with the support of Knowledge Forum® (KF), an online environment. KB also refers to the process by which learners take responsibility for advancing the community's knowledge and work together to do so from their own unique perspective (Scardamalia, 2002). This pedagogical model emphasizes the development of high-level epistemic agency among learners.

Furthermore, the KB model emphasizes important goals related to higher-order learning, including epistemic agency, metacognition, collaboration, and creative work with knowledge (Scardamalia & Bereiter, 2006b, 2014). While some learners may initially struggle with the concept of knowledge building, particularly those with low levels of epistemic agency, the KB approach actually provides a framework for developing this crucial skill through a collaborative effort to improve ideas, community advancement, and embedded and transformative assessment. In classrooms that use the KB model, learners engage in discourse through Knowledge Forum® (KF), which is a computer-supported collaborative environment (Scardamalia & Bereiter, 2014). Within the KB framework, learners work together to

generate questions and develop explanations, utilizing both online and offline discourse to collaboratively pursue a deeper understanding of the subject matter.

In CSCL, collaboration, interactions, and participation during learning are essential. Gaining a comprehensive understanding of how collaborative interactions work is valuable not only for advancing theoretical knowledge but also for implementing CSCL approaches in traditional classrooms (Koschmann, 2012; Rummel, Spada, & Hauser, 2009). Despite the progress made in CSCL, there is still a lack of clear guidance on how to maintain learners' inquiry and collaboration over extended periods of time, which is necessary to bring about transformative change in the classroom (Stahl & Hesse, 2011a; Wise & Schwarz, 2017). In addition, it is crucial to not only sustain long-term inquiry and collaboration in classroom practices but also to cultivate learners' ability to build knowledge. Moreover, research has revealed a significant issue with the implementation of CSCL technology, as it does not effectively enhance the quality of collaborative interactions (Stahl & Hakkarainen, 2021; Wise & Schwarz, 2017). This is supported by data collected from learner discussions held in online forums, which have shown a lack of sustained and on-topic discussions (Guzdial & Turns, 2000; Law, Zhang, & Peppler, 2021), as well as convergent processes and subsequent posts that respond to each other (Palmer, Holt, & Bray, 2008; Peters & Hewitt, 2010; Wise, Hausknecht, & Zhao, 2014). Online discussion forums are becoming more and more popular in classrooms to facilitate collective cognitive activities, but learners frequently rely on sharing their personal viewpoints and disconnected pieces of information instead of engaging in more meaningful discussions (Stahl et al., 2006). The above difficulties and issues stem from a knowledge gap about how to structure and facilitate student-driven inquiry and collaborative activities in a classroom setting. The study aims to design a knowledge

building environment augmented by an analytics-supported reflective assessment that helps learners reflect on their knowledge for the gradual advancement of knowledge building and promote deeper inquiry.

As 21st-century learning programs are being developed, there is a significant challenge to create assessments that can effectively assess the intricate processes included in high-level knowledge work (Gipps, 2005; Zhang et al., 2018). Assessment is a crucial aspect of higher education. Bransford, Brown, and Cocking (2000) recognized assessment as a fundamental element for successful learning. The researchers suggest that processes of teaching and learning should focus on the assessment to provide learners with the chance to showcase their growing abilities and receive guidance to improve their learning. Therefore, it is crucial to recognize that the distinction between formative assessment, which helps learning, and summative assessment, which is for validation and accreditation, is not absolute or rigid although there are tensions between the two types of assessment (William & Black, 1996). Assessment is also integral to pedagogy.

Previous studies reviewed the literature on feedback and found that it is most effective when it is closely tied to specific learning objectives. This kind of feedback helps learners monitor their progress toward their goals and encourages them to develop effective learning strategies. These characteristics of feedback are important components of reflective assessment, which is designed to support learning (Hattie & Timperley, 2007); Nicol & Macfarlane-Dick, 2006).

Therefore, reflective assessment, which includes metacognitive elements, is important to the development of high-level epistemic agency and has been demonstrated to effectively support learners' agency and collaborative inquiry (Toth, Suthers, & Lesgold, 2002; Yang, Van Aalst, Chan, & Tian, 2016). However, there is

a limited amount of research on how reflective assessment supports the development of epistemic agency in learners. The reflective assessment indicates the use of reflective processes that enable learners to develop the agency to consistently trace and reflect on their inquiry processes and outcomes, considering learning objectives and standards, analyzing gaps in learning, providing feedback, and enhancing their learning continuously by addressing broader problems and consistently building knowledge (Lei & Chan, 2018; Yang et al., 2016).

Previous studies have demonstrated the beneficial effects of reflective assessment on learners' knowledge building (KB) practices (Lei & Chan, 2018; Van Aalst & Chan, 2007; Yang et al., 2016). For example, Lei and Chan (2018) investigated the impact of electronic portfolio-supported reflective assessment, where learners were collectively responsible for reflecting on their KB performance. They discovered that reflective assessment supported by portfolios encouraged learners to put more effort into their online inquiries and discussions, resulting in improved KB. Furthermore, in recent research, Yang and colleagues explored how analytics-supported reflective assessment (AsRA) facilitated learners' KB (Lei & Chan, 2018; Yang, Chen, Yu, Feng, & Van Aalst, 2020b; Yang et al., 2016; Yang, Yuan, et al., 2022), and discovered that AsRA aided learners in developing high-order skills, as well as improving their KB and academic understanding. This study aims to expand on this research by investigating the effects of knowledge building and analytics-supported reflective assessment on learners' interaction, productive KB, collaboration, deep learning approach, and conceptual understanding. Therefore, the researcher plans to enhance the knowledge-building discourse of the learners by designing a knowledge building environment augmented by reflective assessment using the analytic tool – Idea Thread Mapper (ITM). The ITM is a collaboration platform that promotes

knowledge building and creative inquiry among classroom communities driven by the learners.

This study seeks to design a framework that addresses challenges faced by learners in knowledge building by exploring the underlying principles, design, and processes involved. The focus is on engaging learners in inquiry-based learning and promoting active participation in the knowledge-building process. Next, the researcher will create a pedagogical strategy that utilizes KB and incorporates reflective evaluation, which will be supported by analytical tools. The processes and dynamics of reflective assessment will then be studied. In this study, KB pedagogy refers to the approach in which learners engage in self-directed inquiry to explore problems they have identified themselves through offline and Knowledge Forum (KF) discussions. This process enables them to develop theories and build knowledge. The study will enhance knowledge building through the use of reflective assessment, where the learners will participate in reflective activities and discussions with the aid of analytical tools. They will collaboratively reflect on their classroom inquiry and knowledge forum conversations to track their progress in building knowledge.

This study will first investigate the effect of knowledge building environment and analytical-supported reflective assessment on learning approaches, conceptual of collaboration, and conceptual understanding. In addition, this research will explore how learners participate in knowledge building and reflective assessment demonstrating productive discourse with metacognitive, social, and epistemic characteristics. The researcher will employ qualitative and quantitative methods, utilizing various data sources to analyze the effect of reflective assessment within knowledge building environments on learners' knowledge building.

1.3 Problem Statement

CSCL is an important research area that examines how technology can facilitate collaborative learning and knowledge building (Stahl & Hesse, 2011a). Online discussions are popular in educational settings that emphasize inquiry and collaborative knowledge Building. Research in this area has shown the potential of online discussion forums to promote learning among learners (Chao, Lai, Liu, & Lin, 2018; Dillenbourg, Järvelä, & Fischer, 2009). Despite the growing popularity of online discussion forums in CSCL, the investigation of online learners' interaction remains a crucial issue, and previous studies have consistently shown unsatisfactory and disappointing results in terms of interaction, inquiry, collaboration, and knowledge building (Hew & Cheung, 2012; Hew, Cheung, & Ng, 2010b; Hewitt, 2005; Van Wart et al., 2020; Wise et al., 2014; Wise, Speer, Marbouti, & Hsiao, 2013; Yang, van Aalst, & Chan, 2021).

For example, Hewitt (2005) revealed that online discussion threads are often brief, fragmented, disjointed, and lack coherence, and sustained inquiry is uncommon and non-existent, and learners' collaboration and interactions often do not lead to fruitful outcomes (Damşa, 2014; Hew, Cheung, Hew, & Cheung, 2012; Hewitt, 2005; Van Wart et al., 2020). Furthermore, Yang et al., (2021) found that although advanced knowledge-building environments demonstrated a high level of interaction, they often end prematurely or abruptly, leading to incomplete discussions and a lack of synthesis across the discussion space (Umar & Ghazal, 2021). In addition, Van Wart et al. (2020) have indicated that while learners can easily exchange ideas and information in online discussion forums, it is challenging for them to engage in in-depth discussions about ideas, concepts, or statements, to negotiate meaning, and even more difficult to create new ideas collaboratively. Moreover, Kirschner, Kreijns, Phielix, and Fransen (2015)

found that online discussion environments are often used for sharing public and superficial opinions rather than collaborative learning to develop knowledge building. In addition, Chan and Chan (2011) investigated how learners' beliefs, conceptions, and approaches may affect the quality of their collaboration and interaction in CSCL environments. Furthermore, Hakkarainen, Lipponen, and Järvelä (2013) indicated that even when online discussions are productive, they tend to focus on facts and lack the conjectures and theories necessary for sustained inquiry. Moreover, interactions may be socially oriented rather than cognitively oriented, which can overshadow more cognitive contributions (Kirschner et al., 2015). This social orientation is important for maintaining social relations that enable collaboration, but it can also prevent discussions from reaching a higher level of collaboration and knowledge building. Consequently, discussions often remain at the knowledge-sharing level without reaching an agreement or solving problems, resulting in little collaborative knowledge building or synthesis (Van Aalst, 2009).

Thus, these problems and challenges become more apparent when there is a significant volume of content in online discussions, it becomes more challenging to distinguish good ideas, leading to the loss of valuable information. Thus, learners may face difficulties in discussing and negotiating ideas, resulting in lost opportunities for collaboration and the building of new ideas (Putri et al., 2020; Yu, 2021; Zurita & Nussbaum, 2004). Additionally, learners may become discouraged if their ideas are not acknowledged or responded to. Although it is recommended to have both individual and collaborative reflection in online discussions, instructors often assess student interaction based on individual contributions rather than community accomplishments (Yang & Chang, 2012). Consequently, a lack of progress and synthesis can give the impression that online discussions do not have educational

value. Research suggests that this is especially true when content productivity is high and a large volume of content is generated (Hew, Cheung, & Ng, 2010; Yang et al., 2021)

Moreover, the core educational mission includes providing learners with the opportunity to enhance their higher-order competencies such as collaboration, metacognition, creation, and epistemic agency (Raes, Schellens, & De Wever, 2014; Zohar & Dori, 2003). These competencies are not only beneficial for enhancing learners' conceptual understanding but also serve as a pathway for ongoing growth and development (Becker & Luthar, 2002; Snell & Lefstein, 2018). In addition to that, one of the most critical obstacles confronted by higher education institutions is ensuring that learners possess the essential tools and possibilities to participate in higher-level learning objectives, such as collaborative inquiry (Yang et al., 2016). Collaborative inquiry is a significant area of research in the field of CSCL that offers several advantages to learners. By engaging in collaborative inquiry, learners can enhance their collaboration skills, foster inquiry, promote knowledge building, encourage critical thinking, facilitate metacognition, and improve regulation (Raes et al., 2014; Zohar & Dori, 2003). Nonetheless, a significant number of instructors are sceptical about the ability of learners to attain higher-order learning objectives (Raes et al., 2014; Zohar & Dori, 2003). Consequently, learners may not be able to interact in collaborative inquiry and may have limited opportunities to reap its benefits (An, 2018; Dubey & Dubey, 2017). According to the findings, learners face challenges in collaborative inquiry not due to their intellectual capacity, but rather because they lack the knowledge and skills needed to collaborate, inquire, reflect, and learn (Bransford et al., 2000; White & Frederiksen, 2005; White & Frederiksen, 1998).

In addition, studies on assessment and analysis of online collective discourse in CSCL usually center on researchers and educators assessing interactions (Puntambekar, Erkens, & Hmelo-Silver, 2011), instead of empowering learners to take the agency of evaluating their own collaboration. Although there have been investigations into learners' interaction in online learning, such as peer assessment (Tenório, Bittencourt, Isotani, & Silva, 2016), the primary focus has been on individual learning and achievement, rather than the advancement of collective knowledge and community building. Further exploration is needed to design student-directed assessment strategies that empower learners to take control of their learning and analyze the meta-discourse processes that foster online learning and collaborative knowledge building. Reflective assessment is a type of student-directed assessment approach where learners engage in a cycle of metacognitive activities, including task analysis, monitoring, reflection, and regulation, to support collaborative inquiry and knowledge (Lee, Chan, & van Aalst, 2006b; Lei & Chan, 2018; Toth et al., 2002; White & Frederiksen, 1998; Yang et al., 2019; Yang et al., 2016) . Various studies have emphasized the significance of reflective assessment, such as Lee, Chan, and Van Aalst (2006a), Yang et al. (2020b), and Yang, Yuan, et al. (2022). However, few studies have explored the impact of reflective assessment approaches on learners' interaction quality, collaboration, metacognition, productive discourse, and collective learning. In addition, many experts believe that learning analytics provides learners with opportunities to engage in reflective assessment processes, especially within a knowledge building community (Yang et al., 2021). Research on learning indicates that analytics-supported reflective assessment is beneficial in encouraging learners to participate in inquiry and knowledge building (Yang et al., 2019; Yang et al., 2016). Analytics-supported reflective assessment is considered a student-directed assessment

approach, and there is empirical evidence supporting its significant impact on various aspects of online learning such as interaction, collaboration, metacognition, productive discourse, and collective learning.

By considering all the above problems and issues, this study aims to address the challenges by designing a knowledge-building environment that incorporates Analytics-supported reflective assessment to investigate the effect of such an environment on enhancing learners' knowledge-building attempts in a CSCL technology-supported collaborative inquiry model.

1.4 Preliminary Study

A preliminary study is an initial investigation or exploration of a research question or topic that is usually conducted before the main study to identify potential problems. The main goal of a preliminary study is to provide researchers with a better understanding of the subject and to lay the foundation for a more comprehensive study.

For this goal, an interview was carried out with four instructors who are using the e-learning portal as an online forum in their teaching and learning processes at a public university in Penang, Malaysia. The purpose of the interview was to gather the instructors' perspectives on the main challenges that could affect the quality of learner interaction in computer-supported collaborative learning. The decision to interview four instructors was methodically grounded in considerations of both practicality and the strength of the research. This sample size was chosen with the aim of achieving a balance between depth and manageability within the given constraints of time and resources. A study by Guest, Bunce, and Johnson (2006) suggests that after a certain point, additional interviews may not yield significantly new information, indicating that saturation—a point where data becomes redundant—can be achieved with a

relatively modest sample size. By interviewing four instructors, this study sought to gather sufficiently rich and diverse perspectives on the subject matter.

The first instructor (Instructor A), who has been teaching Instructional Technology for over eight years, discussed the potential of online discussion forums to enhance learners' knowledge and group work. However, maintaining a high level of interaction and collaboration presents the biggest challenge. According to the instructor, many learners only provide their ideas to meet course requirements without reading others' ideas. Additionally, some learners merely read and write without actively engaging in discussions. Another issue is that some learners only respond to their friends' posts in the forum, while others only read and respond to the latest posts.

Instructor B, with over 12 years of experience in teaching online learning, identified the online discussion forum as a critical element that fosters social interaction among learners and promotes knowledge building. However, the instructor noted that achieving the highest level of asynchronous discussion in the forum presents several challenges, particularly in maintaining a high level of interaction and participation among learners.

The third instructor (Instructor C) teaches online learning classes that use discussion forums and has experience with online learning and instructional technology for over nine years. The instructor found that the learners' interaction and collaboration in an online discussion forum is still at a low level. Also, learners are more likely to focus on specific posts only. It can be argued that learners are more eager to respond to their classmates' inquiries. They are also often scared and anxious when asked about the ideas of their peers. Additionally, the presence of instructors in discussion forums makes learners feel less confident in expressing their ideas.

Furthermore, some learners just read the inquiries in the discussion forum and respond, often not checking other classmates' responses to participate.

Instructor D, who has been teaching Instructional Technology for over five years, noted that the learners do not understand well the relationship between the levels of the discussion forum. For instance, learners find it difficult to know who is responding and how to respond in the discussion forum. In other words, using a complex structure reduces participation, as writing and reading become more complicated and difficult. The interface of the discussion forum also poses difficulties. The instructor also said that although encouragement to use the discussion forum, many learners choose to use social media platforms like WhatsApp and Facebook to interact with each other. Furthermore, some learners respond incorrectly or fail to adhere to the structure established by the discussion forum.

Overall, the interview outcomes indicated that learners have low interaction and contribution in asynchronous online discussions within a computer-supported collaborative learning environment. Furthermore, many learners tend to interact minimally in online discussion forums, often fulfilling course requirements without actively interacting in meaningful discussions or engaging with their peers' ideas. This resulted in a lack of significant interaction and limited knowledge building. Furthermore, instructors highlighted a fundamental issue where certain learners contribute by posting notes or comments without thoroughly comprehending the discussion forum's content or fully engaging with their instructors' or peers' questions. This behavior reflects a lack of in-depth understanding or consideration of the forum's discourse. Moreover, a pattern of selective interaction was observed among learners, as they tended to concentrate solely on particular posts or engage primarily with contributions from their friends. This selective interaction restricted the diversity of

interactions and impeded the development of comprehensive discussions within the online forum. In addition, most of the instructors found that most of the learners had difficulty maintaining and keeping up with the discussions taking place in the forum. Furthermore, sometimes instructors and learners must be able to identify responses that are related to their objectives. However, due to many participants in courses, discussion forums often suffer from cluttered and information overload. On top of this, a substantial proportion of posts are not directly related to the course. As a result, discussion forums become overwhelming and confusing for respondents to navigate. To clarify, since there are often multiple threads involved in discussions, some learners may find it difficult to keep track of all the available topics. As a result, they may shift their thoughts to inconsistent and contradictory ideas without following the suitable thread. In summary, these challenges encompassed issues related to superficial interaction, selective participation, low collaboration, and complex forum structures. Addressing these challenges is critical to fostering more meaningful and robust learner interactions within CSCL environments.

By considering all the above problems and issues, this study aims to design a knowledge-building environment that incorporates Analytics-supported reflective assessment to investigate the effect of such an environment on enhancing learners' interaction, collaboration, and learning approach in a CSCL technology-supported collaborative inquiry model.

1.5 Purpose of the Study

This study aimed to design a knowledge building environment augmented by an analytics-supported reflective assessment that helps learners reflect on their knowledge for the gradual advancement of knowledge building and promote deeper

inquiry. The basis of this study is rooted in social constructivism, knowledge building, and theories of assessment. Thus, this study emphasizes the use of the principles of knowledge building and student-directed reflective assessment in a knowledge building environment to investigate the effect of this environment on collaboration, approach to learning, interaction, and collective knowledge building.

1.6 Research Objectives

The study aims to achieve the following objectives:

- 1- to investigate the effects of the knowledge building and analytics-supported reflective assessment on learners' learning approaches, collaboration, and conceptual understanding.
- 2- to investigate the learners' interaction patterns in knowledge building environment.
- 3- to investigate the role and process of the analytics-supported reflective assessment in improving the knowledge building.
- 4- to investigate the characteristics of the nature and process of inquiry and discourse in the knowledge building.
- 5- to investigate the effects of learners' interaction in the knowledge building environment and analytics-supported reflective assessment on conceptual understanding.

1.7 Research Questions

The research questions of this study are summarized as follows:

- 1- What are the effects of the knowledge building and analytics-supported reflective assessment on learners' learning approaches, collaboration, and conceptual understanding?
- 2- What are the patterns of learners' interaction in knowledge building environment?
- 3- What is the role and process of analytics-supported reflective assessment in improving knowledge building?
- 4- What are the characteristics of the nature and process of inquiry and discourse in the knowledge building?
- 5- What are the effects of learners' interaction in the knowledge building environment and analytics-supported reflective assessment on conceptual understanding?

1.8 Significance of the Study

Despite the significant shift towards a social constructivist approach to learning, there are still crucial questions that need to be addressed. One of these is how to create a social constructivist classroom for the growth of collective knowledge. Another is how to recognize, assess, and facilitate knowledge building. Therefore, this study aims to contribute to design research by identifying how knowledge building principles can be integrated with reflective assessment methods to enhance learners' learning approach, the conception of collaboration, their conceptual understanding, and interaction.

The reflective assessment approach utilized in this study aids in building theory because analytics-supported tools are able to view learners in various levels and contexts, effectively illustrating the development and nature of collaboration. These

tools also provide scaffolding and support for the development of conceptual understanding.

This study's approach to reflective assessment has the potential to provide guidance to instructors on how technology can be used in line with educational principles, and how assessment can be integrated into teaching to benefit the collective aspects of learners' learning. It presents a way of using technology to support and evaluate learners' learning processes that align with the social-constructivist approach to teaching and learning. Additionally, the study aims to investigate the impacts and possible outcomes of transferring the cognitive responsibility of assessment from instructors to learners, by having learners assess their own contributions. Hence, this study will highlight the significance of constructivist theory for building knowledge. Therefore, this study will provide insights into new methods of technology-mediated learning to prepare learners as knowledge builders of the twenty-first century.

This study also utilizes the knowledge building model for the Malaysian context. It has the potential to provide valuable insights to curriculum developers and practitioners in Malaysia regarding the application of socio-constructivist models in their context. This can also guide the design of a more effective learning environment that promotes literacy development and knowledge building, which is crucial in meeting the demands of 21st-century education.

1.9 Theoretical Framework

In this study, the theoretical framework is rooted on the three theories which are: social constructivism, knowledge building and assessment, and online learning. Further discussion of each of these theories is found in Chapter Two.

1.9.1 Social Constructivism Theory

Different theories and perspectives describe how people learn. Collaborative learning is a learning technique that demonstrates the significant effects of learning experiences and knowledge construction (Dillenbourg, 1999; Weinberger & Fischer, 2006), which are supported by technology (Stahl et al., 2006). Furthermore, constructivism must be incorporated into the teaching practice and put emphasis on learners and environments that are supported by the emerging technologies. Collaborative learning is constructivist in nature as learners actively interact, enhancing their knowledge and skills and combining them with one another's ideas (Ossiannilsson & Ioannides, 2017).

Constructivism is a theory of learning that clarify how individuals gain knowledge, learn, and build knowledge and meaning from their experiences. The two primary types of constructivism theories are: (i) cognitive constructivism, which originates from Piaget's theory that highlights the personal process of individuals in constructing ideas, and (ii) social constructivism, which emanates from Vygotsky's theory that emphasizes the interaction with others in the process of constructing ideas (Kalina & Powell, 2009). Both theories emphasize the creation of knowledge through an interactive learning environment. They also share similarities and differences. For instance, both theories focus on interaction in learning environment such as online learning atmosphere. While cognitive constructivism places greater emphasis on facts and the construction of knowledge within an individual's existing mental structures, in contrast, social constructivism involves learners in activities that reinforce relationships and directly influence what they learn. This depiction suggests that constructivism theory can be used to link this study's notations related to cognitive interaction in a CSCL environment.

Furthermore, Vygotsky (1980) explained consciousness and cognitive functions as products of social interactions and suggested that students gradually internalize the externals (i.e., social interactions), which results in continuous changes in their thoughts and behaviour. Therefore, assimilation and accommodation occur between people, in a social context (Duffy, 1996; Wertsch & Tulviste, 1999). Also, Vygotsky (1980) argued that what students can do on their own may not be a good indicator of intellectual development; rather, what they can do with the assistance of others might be a much more suitable indicator for such development. Furthermore, Vygotsky (1980) introduced the Zone of Proximal Development (ZPD), which is the fundamental concept that describes the difference between the actual level of development that can be independently achieved and the potential level of development that can be achieved through guidance by an adult or collaboration with more skilled peers.

Vygotsky's ZPD is similar to what Jerome Bruner and colleagues called instructional scaffolding (Pea, 2004; Wood, Bruner, & Ross, 1976). Bruner's scaffolding encompasses a diverse array of activities in which a knowledgeable adult or peer with more experience supports the learner in attaining objectives that would otherwise be unattainable (Smith, Cowie, & Blades, 2003). Therefore, both Bruner and Vygotsky highlight the social aspect of learning, emphasizing that students require support and guidance from adults or more experienced peers. To put it differently, it can be stated that ZPD can be attained by providing scaffolding in the form of support, direction, or prompts to assist and encourage learners in accomplishing a specific task. Engaging in group discussions enables learners to participate and interact, providing them with the chance to create generalizations and apply their knowledge, combine

the concepts of their peers, and establish comprehension, which facilitates the learning process.

This theory also underscores the significance of feedback and assessment to assist people in constructing their knowledge. In the realm of educational theory, Social Constructivism stands as a pivotal framework emphasizing the active construction of knowledge through social interactions. Central to this theory is the role of feedback and assessment in shaping individuals' cognitive development. Constructive feedback and purposeful assessments, aligned with the principles of Social Constructivism, serve as catalysts for the construction of knowledge. Feedback, whether from peers, instructors, or the learning environment, fosters reflective thinking and encourages learners to engage critically with their ideas and the ideas of others. Assessments, when designed with constructivist principles in mind, become not mere evaluative tools but integral components of the learning process. They provide learners with opportunities to explore, challenge, and refine their understanding collaboratively. Constructivist assessments often involve real-world problem-solving, encouraging learners to actively participate in knowledge construction through experiential learning. Thus, feedback and assessment, within the framework of Social Constructivism, form a dynamic interplay that guides individuals in the active and collaborative construction of their knowledge, fostering a deep understanding of the subject matter and enhancing their overall learning experience. In summary, Social Constructivism centers on the premise that knowledge is actively constructed within the human mind, and it underscores the influence of social forces and interactions on the establishment of formal knowledge (Richardson, 2003). Therefore, drawing from the Social Constructivism Theory of learning, this study