UNIVERSITI PUTRA MALAYSIA

IMPACT OF LESSON STUDY ON MATHEMATICS LECTURERS' CONTENT KNOWLEDGE AND PEDAGOGICAL CONTENT KNOWLEDGE AND STUDENTS' PROBLEM SOLVING ABILITY, MOTIVATION AND ANXIETY

HOSSEINALI GHOLAMI

IPM 2021 4

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By

HOSSEINALI GHOLAMI

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

June 2020

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DEDICATION

This thesis is dedicated to:
My dearest wife, Massoumeh,
for her boundless love, support and encouragement

My lovely daughters, Haniyeh and Shiva,
Whom I can't force myself to stop loving

My beloved parents and darling parents-in-law,
With all my love and gratitude

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Doctor of Philosophy

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June 2020

Chairman : Professor Aida Suraya Md. Yunus, PhD
Faculty : Institute of Mathematical Research

Mathematics lecturers who are teaching at the foundation level, which is one of the pre-university programmes in Malaysia, play an essential role in preparing students for higher-level mathematics or courses that extend mathematics knowledge beyond what was covered in secondary school. A lecturer with a limited grasp of mathematical content knowledge and pedagogical content knowledge has little room for progress or novelty in the classroom or the ability to fuel students' interest in the mathematics subject. The results of international assessments in mathematics showed that students in countries such as Singapore and Japan are very successful in mathematics at the school level. This indicates that the students have high potential in their ability to do problem solving and higher order thinking when they pursue mathematics learning in higher education. In these countries, mathematics teachers work together and research about lesson plans collaboratively. They improve their content knowledge and pedagogical content knowledge through teamwork using a method of mathematics teaching which originated from Japan, which is called Lesson Study. This study was conducted in a Foundation Center of a public university in Malaysia. The study which employed the mixed method was aimed to explore the impact of Lesson Study on mathematics lecturers' content knowledge (common content knowledge and specialized content knowledge) and pedagogical content knowledge (knowledge of content and teaching as well as knowledge of content and students) and students' outcomes in mathematical problem solving, motivation in mathematics and mathematics anxiety. A group of nine lecturers (seven mathematics lecturers, a physic lecturer and the researcher) contributed in developing research lessons through Lesson Study and two foundation classes with 95 students participated in the experimental part of the study. The researcher adopted the qualitative case study method to understudy the Lesson Study group and quasi-experimental method for the two foundation classes which were assigned as control

and experimental groups. The lecturers collaboratively planned, discussed and designed five research lessons and following that, the students underwent five weeks of learning based on the lessons developed. Data collection methods which comprised of interviews, observations and mathematics tests were used to collect data of the lecturers. Data for the quantitative part were collected using tests to determine the students' mathematical problem solving ability, as well as a motivation questionnaire (Butler, 2016) and an anxiety questionnaire (Bai, 2011). The results of this study showed that mathematics lecturers through collaborative work and sharing of knowledge and experiences greatly improved their content knowledge and pedagogical content knowledge. Furthermore, there were significant differences between the experimental and control groups in scores for mathematics problem solving tests, motivation and anxiety but there is no statistical significant interaction between treatment groups and gender on problem solving tests, motivation and anxiety scores. In summary, the results of this study showed that Lesson Study is a dynamic teaching method for pre-university programme and it has potentials in improving mathematics lecturers' content knowledge (common content knowledge and specialized content knowledge) and pedagogical content knowledge (knowledge of content and teaching as well as knowledge of content and students) in order to enhance student learning in mathematics through use of research lessons based on problem solving approach and higher order thinking skills.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

KESAN *LESSON STUDY* KE ATAS PENGETAHUAN KANDUNGAN DAN PENGETAHUAN PEDAGOGI KANDUNGAN PENSYARAH MATEMATIK DAN KEBOLEHAN MENYELESAIKAN MASALAH, MOTIVASI DAN KERISAUAN PELAJAR

Oleh

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Pensyarah matematik yang mengajar di peringkat asasi, yang merupakan salah satu daripada program pra-universiti di Malaysia, memainkan peranan penting dalam menyediakan pelajar untuk matematik aras tinggi atau kursus yang memperluas pengetahuan matematik melebihi apa yang diajarkan di sekolah menengah. Pensyarah yang mempunyai penguasaan yang terhad tentang pengetahuan isi kandungan dan pengetahuan pedagogi kandungan dalam matematik mempunyai kekangan untuk memajukan diri atau membuat pembaharuan di dalam bilik darjah dan kebolehan untuk meningkatkan minat pelajar terhadap subjek matematik. Keputusan pentaksiran antarabangsa dalam matematik menunjukkan pelajar dari negara seperti Singapura dan Jepun sangat berjaya dalam matematik pada peringkat sekolah. Ini menunjukkan pelajar mereka mempunyai potensi tinggi dalam kebolehan menyelesaikan masalah dan pemikiran aras tinggi apabila mereka meneruskan pembelajaran matematik di peringkat pendidikan yang lebih tinggi. Di negara tersebut, guru matematik berkolaborasi dalam merancang dan mengkaji tentang rancangan pengajaran. Mereka menambah baik pengetahuan kandungan dan pengetahuan pedagogi kandungan melalui usaha kumpulan menggunakan kaedah pengajaran matematik yang dipelopori di Jepun, yang dikenali sebagai *Lesson Study*. Kajian ini telah dilaksanakan di sebuah Pusat Asasi di sebuah universiti awam di Malaysia. Kajian yang menggunakan kaedah campuran ini bertujuan untuk meneroka kesan *Lesson Study* ke atas pengetahuan kandungan (pengetahuan kandungan umum dan pengetahuan kandungan khusus) dan pengetahuan pedagogi kandungan (pengetahuan tentang kandungan dan pengajaran serta pengetahuan tentang kandungan dan pelajar) dan hasil pelajar dalam menyelesaikan masalah matematik, motivasi dalam matematik dan kerisauan dalam matematik. Sekumpulan sembilan orang pensyarah (tujuh orang pensyarah matematik, seorang pensyarah fizik dan penyelidik) menyumbang dalam membangunkan *research lessons* melalui

Lesson Study dan dua kelas asasi dengan 95 orang pelajar terlibat dalam bahagian eksperimen kajian ini. Penyelidik menggunakan kaedah kualitatif kajian kes bagi menyelidik kumpulan *Lesson Study* dan kaedah eksperimen kuasi bagi dua kelas asasi yang di rencanakan sebagai kumpulan kawalan dan kumpulan eksperimen. Para pensyarah secara kolaboratif merancang, membincang dan merancang lima *research lessons* dan selepas itu, pelajar mengikuti pembelajaran selama lima minggu berdasarkan pelajaran yang dibangunkan. Kaedah pengumpulan data yang merangkumi temu bual, pemerhatian dan ujian matematik digunakan untuk mengumpulkan data bagi pensyarah. Data bagi bahagian kuantitatif dikumpul menggunakan ujian bagi mengenalpasti kemampuan pelajar dalam menyelesaikan masalah matematik, soal selidik motivasi (Butler, 2016) dan soal selidik kebimbangan (Bai, 2011). Keputusan kajian menunjukkan bahawa pensyarah matematik melalui usaha kolaboratif dan perkongsian ilmu dan pengalaman telah dapat meningkatkan pengetahuan kandungan dan pengetahuan pedagogi kandungan mereka. Tambahan pula, terdapat perbezaan signifikan antara kumpulan kawalan dan eksperimen dalam skor bagi pencapaian matematik, motivasi dan kerisauan, tetapi tiada perbezaan signifikan dikesan bagi skor min bagi kumpulan berdasarkan jantina. Sebagai rumusan, dapatan kajian menunjukkan *Lesson Study* merupakan satu kaedah pengajaran yang dinamik bagi pengajian peringkat pra-universiti dan ia berpotensi meningkatkan pengetahuan kandungan (pengetahuan kandungan umum dan pengetahuan kandungan khusus) dan pengetahuan pedagogi kandungan (pengetahuan kandungan dan pengajaran serta pengetahuan kandungan dan pelajar) pensyarah bagi membolehkan peningkatan pembelajaran pelajar melalui penggunaan *research lesson* berasaskan pendekatan penyelesaian masalah dan kemahiran berfikir aras tinggi.

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May Allah bless all of you.

This thesis was submitted to the Senate of the Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

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TABLE OF CONTENTS

		Page
ABSTRACT		i
ABSTRAK		iii
ACKNOWLEDGEMENTS		v
APPROVAL		vi
DECLARATION		viii
LIST OF TABLES		xv
LIST OF FIGURES		xx
LIST OF APPENDICES		xxi
LIST OF ABBREVIATIONS		xxiii
CHAPTER		
1	**INTRODUCTION**	1
	1.1 Background of the Study	1
	1.2 Professional Development for Mathematics Teachers	1
	1.3 Lesson Study	2
	1.4 Mathematics Problem Solving Ability among Students	3
	1.5 Statement of the Problem	4
	1.6 Objectives of the Study	6
	1.7 Research Questions	7
	1.8 Research Hypotheses	7
	1.9 Significance of the Study	9
	1.10 Limitation of Study	10
	1.11 Operational Definitions	10
	1.11.1 Mathematical Problem Solving	10
	1.11.2 Mathematics Exercise	10
	1.11.3 Lesson Study and Research Lesson	11
	1.11.4 Professional Development	11
	1.11.4.1 Content Knowledge (CK)	11
	1.11.4.2 Pedagogical Content Knowledge (PCK)	11
	1.11.5 Mathematics Anxiety	13
	1.11.6 Motivation in Mathematics	13
2	**LITERATURE REVIEW**	15
	2.1 Introduction	15
	2.2 Education System in Malaysia	15
	2.3 Mathematics Teachers' Knowledge	16
	2.4 Mathematics Teachers' Professional Development	16
	2.4.1 Mathematics Teachers' Content Knowledge (CK)	18
	2.4.1.1 Studies Related to Educators' Content Knowledge (CK)	19

2.4.2 Mathematics Teachers' Pedagogical Content Knowledge 22
2.4.2.1 Studies Related to Pedagogical Content Knowledge 25
2.4.3 Teachers' Technological Pedagogical Content Knowledge (TPACK) 26
2.5 Lesson Study as a Mathematics Educators Professional Development 28
2.5.1 Stages of Lesson Study Execution 30
2.5.2 Lesson Study in Malaysia 31
2.5.3 Lesson Study Challenges and Benefits 31
2.5.4 Studies Related to the Lesson Study 32
2.6 Student Problem Solving 34
2.6.1 Memorization in Mathematics Teaching and Learning 36
2.6.2 Higher Order Thinking Skills (HOTs) 38
2.6.3 Studies Related to Problem Solving Abilities 39
2.7 Mathematics Anxiety 39
2.8 Motivation in Mathematics 40
2.9 Theoretical Framework of the Study 42
2.10 Conceptual Framework of the Study 43

3 METHODOLOGY 45
3.1 Introduction 45
3.2 Research Design 45
3.2.1 Qualitative Phase 46
3.2.2 Quantitative Phase 46
3.3 Location of the Study 47
3.4 Population and Sampling 48
3.4.1 Qualitative Phase 48
3.4.2 Quantitative Phase 49
3.5 Threats to Experimental Validity 49
3.5.1 Threats to Internal Validity 50
3.5.2 Threats to External Validity 53
3.6 Instrumentation 53
3.6.1 Instruments for Lecturers (Qualitative Phase) 53
3.6.1.1 Interview Protocol 53
3.6.1.2 Mathematics Tests 54
3.6.1.3 Observation Forms 55
3.6.1.4 Research Lessons 56
3.6.2 Instruments for Students (Quantitative Phase) 58
3.6.2.1 Mathematics Problem Solving Tests 58
3.6.2.2 Weighted Scores 60
3.6.2.3 Mathematics Anxiety Questionnaire 61
3.6.2.4 Questionnaire about Motivation in Mathematics 61
3.7 Validity of Instruments 62
3.7.1 Qualitative Method 62
3.7.1.1 Interview Protocol 62

3.7.1.2 Mathematics Tests for Lecturers 63
3.7.1.3 Classroom Observation Form 64
3.7.1.4 Research Lessons 64
3.7.2 Quantitative Method 64
3.7.2.1 Mathematics Problem Solving Tests 64
3.7.2.2 Rubric for Problem Solving Skills 65
3.7.2.3 Mathematics Anxiety and Motivation Questionnaire 67
3.8 Pilot Study 68
3.8.1 Qualitative Part (Instruments for Lecturers) 68
3.8.2 Quantitative Part (Instruments for Students) 68
3.9 Reliability of Instruments 69
3.9.1 Reliability of Instruments for Lecturers 69
3.9.2 Reliability of Instruments for Students 69
3.9.2.1 Motivation Questionnaire 69
3.9.2.2 Anxiety questionnaire 70
3.9.2.3 Mathematics Problem Solving Tests 70
3.10 Data Collection 74
3.10.1 The Methods of Data Collection for Qualitative phase 75
3.10.2 The Methods of Data Collection for Quantitative phase 75
3.11 Procedures of the Study 76
3.11.1 The procedures of qualitative phase of the study 76
3.11.2 The procedures of Experiments (Quantitative Phase of the Study) 77
3.12 Data Analysis 79
3.12.1 Qualitative Data 79
3.12.1.1 Observations Data 79
3.12.1.2 Data From Mathematics Tests 79
3.12.1.3 Data From Interviews 79
3.12.2 Quantitative Data 80
3.12.2.1 Preliminary Analysis 80
3.12.2.2 Descriptive Statistics 80
3.12.2.3 Inferential Statistics 80
3.13 Participant Consent 82

4 DEVELOPMENT OF LESSON STUDY PROGRAMME 83
4.1 Introduction 83
4.2 Mathematics Problem 83
4.3 Chapter on Function in the Mathematics 1 Textbook 87
4.4 Research Lessons 90
4.5 Research Lessons Steps 93
4.5.1 Analysis Phase 93
4.5.2 Design Phase 95
4.5.2.1 Writing the Performance Objectives 95
4.5.2.2 Clarifying the Instructional Strategy 95
4.5.3 Development Phase 100

4.5.3.1 Developing the Instructional Activities 100
4.5.3.2 Materials Development Tools and Resources 101
4.5.4 Implementation Phase 101
4.5.4.1 Training the Lecturer 101
4.5.4.2 Prepare the Students 101
4.5.4.3 Organizing the Learning Environment 101
4.5.5 Evaluation Phase 102
4.5.5.1 Expert Review 102
4.5.5.2 Development Try-Out 105
4.6 The Role of Physics Lecturer in the Study 105
4.7 The Role of the Researcher in the Study 106

5 FINDINGS AND RESULTS 107
5.1 Introduction 107
5.2 Findings of the Qualitative Study 107
5.2.1 Participants in Qualitative Study 107
5.2.2 Lecturers' Content Knowledge Before and After the Being Involved in the Lesson Study 108
5.2.3 Lecturers' Pedagogical Content Knowledge Before and After Being Involved in the Lesson Study 135
5.2.4 Overview of Qualitative Part 162
5.3 Quantitative Research 162
5.4 Summary of Findings 181
5.4.1 Summary of Findings for the Qualitative Part of the Study 181
5.4.2 Summary of Findings for the Quantitative Part of the Study 181

6 CONCLUSION 185
6.1 Introduction 185
6.2 Summary of Research 185
6.2.1 Qualitative phase 185
6.2.2 Quantitative Phase 185
6.3 Summary of Findings 186
6.3.1 Summary of Findings for the Qualitative Part of the Study 186
6.3.2 Summary of Results in Quantitative Phase 186
6.4 Discussion of Findings and Results 187
6.4.1 Discussion of Findings for Qualitative Phase 187
6.4.1.1 Lecturers' Content Knowledge 188
6.4.1.2 Lecturers' Pedagogical Content Knowledge 191
6.4.2 Discussion of Results in Quantitative Phase 192
6.4.2.1 Mathematical Problem Solving Skills 192
6.4.2.2 Mathematics Anxiety among Students 193
6.4.2.3 Students' Motivation in Mathematics 193

6.5 Lesson Study in Foundation Center 194
6.6 Implications 196
6.7 Recommendations for Further Study 197
6.8 Summary 197

REFERENCES 200
APPENDICES 216
BIODATA OF STUDENT 263
LIST OF PUBLICATIONS 264

LIST OF TABLES

Table		Page
2.1	The Process of Proving Distance Formula for 2nd Secondary Students	22
2.2	Summary of the Types of Teacher Knowledge	27
2.3	Examples of Problem Solving Models	34
2.4	Different Formulas for Distance of Point from a Line	37
2.5	Dimensions of Higher Order Thinking Skills	38
3.1	The Pretest-Posttest Control Group Design	47
3.2	Lecturer Participants for Qualitative Phase	49
3.3	Sections of the Interview 1 and Interview 2 with Mathematics Lecturers	54
3.4	Examples of Test Items of the Lecturers Tests	55
3.5	Example of Each Category of Classroom Observation Form	56
3.6	Topics of the Research Lessons	57
3.7	Scoring for Students' Answers in Mathematics Tests	58
3.8	Example of Test Items of the Pre-test and Post-test	59
3.9	Example of Test Items of the Test 1 and Test 2	60
3.10	Example of the Test Items of the Mathematics Anxiety Test	61
3.11	Example of Test Items of the Motivation Test	62
3.12	Content Validity of Interview Protocol	63
3.13	Content Validity of Lecturers Tests	63
3.14	Content Validity of Classroom Observation Form	64
3.15	Content Validity of Problem Solving Test	65
3.16	The Description of Scoring for this Problem	66
3.17	Sample of Solutions With Different Scores	67
3.18	Content Validity of Mathematics Anxiety and Motivation Tests	68

3.19	Internal Consistency of Mathematics Tests	70
3.20	Rating of Correlation Coefficient	70
3.21	Correlation Coefficient Index of Pre-test	71
3.22	Correlation Coefficient Index of Post-test	71
3.23	Determine High-score and Low-score Groups	72
3.24	Index of Discrimination	72
3.25	Item Indices of Pre-test	73
3.26	Item Indices of Post-test	73
3.27	Correlation Coefficient Scoring Index of Pre-test	74
3.28	Correlation Coefficient Scoring Index of Post-test	74
3.29	Objectives of the Qualitative Phase of Study Linked to the Data Sources	75
3.30	Objectives of the Quantitative Phase of Study Linked to the Data Sources	76
3.31	The Flow of Fieldwork for qualitative part of the study	77
3.32	The Flow of Fieldwork for Quantitative Part of the Study	78
3.33	Analysis Method for Quantitative Data	81
4.1	The Differences Between CCK and SCK by Examples	84
4.2	Some Examples Related to the SCK	85
4.3	Examples about KCS and KCT	86
4.4	The Number of Mathematics Problems in the Mathematics 1 Textbook	88
4.5	The Number of Mathematics Problems Used in Each Lecturer's Lesson	89
4.6	The Formal Sessions with Lecturers	92
4.7	The Number of Mathematics Problems in the Research Lessons	93
4.8	The Sequence of Activities Related to Even and Odd Functions	96
4.9	Evaluation in Pilot Test on Contents of Research Lesson	103

4.10	Evaluation in Pilot Test of Suitability of Pedagogical Approach of Research Lesson	104
5.1	Participants' Demographics in Qualitative Study	108
5.2	Classroom Observation Form for Content Knowledge	117
5.3	Content Knowledge of Lecturer C	117
5.4	The Percentage of Correct Answers among the Lecturers in Test 1	118
5.5	The Percentage of Correct Answers among the Lecturers in Test 2	120
5.6	Lecturers Marks for the Students' Answers	125
5.7	The Mean and SD of Marks Given byLecturers to Student's Answer	125
5.8	The Lecturers' Ideas about the Application of Functions	130
5.9	The Lecturers Ideas about the Application of Derivative in Real Life	131
5.10	Lecturers' Perceptions of their Content Knowledge in Interview 1	132
5.11	Lecturers' Perceptions of their Content Knowledge in Interview 2	134
5.12	The Performance of Lecturer C in Experimental and Control Groups	137
5.13	The Time Management of Lecturer C in Experimental and Control Groups	138
5.14	The Scores of Lecturer C for Student Assessment	138
5.15	The Quality of Lecturer's Teaching Materials in Experimental and Control Groups	139
5.16	The Method of Teaching in Experimental and Control Groups	139
5.17	Scores for Students' Activity in Experimental and Control Groups	140
5.18	The Percentage of Correct Answers among Lecturers in Test 1	141
5.19	The Percentage of Correct Answers among Lecturers in Test 2	142
5.20	The Examples Chose by Lecturers about the Concept of Function	144
5.21	Lecturers' Ideas about a Practical Example for Sequence	144
5.22	Some Examples about a Practical Function in Human Life	145
5.23	Mathematics Lecturers' Ideas about the Time Management	150
5.24	Mathematics Lecturers' Ideas about the Students' Assessment	151

5.25	Mathematics Lecturers' Ideas about Their Teaching Materials	152
5.26	Mathematics Lecturers' Ideas about Their Teaching Method	153
5.27	Mathematics Lecturers' Ideas about the Students' Activities	155
5.28	Mathematics Lecturers' Ideas about the Time Management	156
5.29	Mathematics Lecturers' Ideas about the Students' Assessment	157
5.30	Mathematics Lecturers' Ideas about Their Teaching Materials	158
5.31	Mathematics Lecturers' Ideas about the Teaching Method	159
5.32	Mathematics Lecturers' Ideas about the Students' Activities	161
5.33	The Improvement of Lecturers in Different Parts of Interview	162
5.34	Scores in Problem Solving Tests	162
5.35	The Normality of Scores in Test1 and Test2	163
5.36	Normality Test for Data	164
5.37	Means of all Mathematics Test Scores in the Experimental and Control Groups	164
5.38	Within-Subjects Factors	165
5.39	Mauchly's Test of Sphericity	165
5.40	Test of Within-Subjects Effects	166
5.41	Pairwise Comparisons	166
5.42	Test of Normality by Kurtosis and Skewness	167
5.43	The Descriptive of Scores for all Groups	167
5.44	Compare the Mean Scores in Test w1	168
5.45	Comparion of Mean Scores of Experimental and Control Groups in Tests	168
5.46	Within-Subjects Factors	169
5.47	Mauchly's Test of Sphericity	169
5.48	Test of Within-Subjects Effects	169
5.49	Comparisons of Methods at Different Points of Times	170

5.50	Normality Test for Data	171
5.51	Results of t-test for Mathematics Anxiety	171
5.52	Normality Test for Scores	171
5.53	Results of t-test for Motivation Pre-test between Experimental and Control Groups	172
5.54	Results of t-test for Motivation Post-test between Experimental and Control Groups	173
5.55	Test of Between Subjects Effects	174
5.56	Multivariate Tests	174
5.57	Results of Multivariate Tests of two-way MANOVA	175
5.58	Results of Test of Between Subjects Effects	176
5.59	Results of the Multivariate Tests	176
5.60	Within-Subjects Factors	177
5.61	Mauchly's Test of Sphericity	177
5.62	Test of Within-Subjects Effects	177
5.63	Pairwise Comparisons	178
5.64	Test of Between Subjects Effects	179
5.65	Multivariate Tests	179
5.66	The Results of Kruskal-Wallis Test for Motivation Scores in Pre-test	180
5.67	The Results of Kruskal-Wallis Test in Post-test by Gender	180
5.68	Summary of Findings in the Qualitative Part of the Study	181
5.69	Summary of Findings in the Quantitative Part of the Study	182

LIST OF FIGURES

Figure		Page
2.1	A Model of Pedagogical Content Knowledge	23
2.2	Technological Pedagogical Content Knowledge Framework	27
2.4	A Model of Mathematics Problem Solving by McDonald (2009)	35
2.5	A Conceptual Model of Mathematics Problem Solving	35
2.6	Revised Taxonomy Bloom (2001)	38
2.7	Theoretical Framework of the Study	43
2.8	Conceptual Framework of the Study	44
3.1	The Design of Qualitative Part of the Study	46
3.2	The Processes of Lesson Study In the Research	57
4.1	The Main Factors for Each Research Lesson	91
4.2	The Steps in Developing Research Lessons	91
5.1	Trigonometric Values for some Angles Using Trigonometric Circle	110
5.2	Performance of Lecturers Before and After the Study	121
5.3	The Scores of Lecturers in Test 1 and Test 2	143
5.4	Comparison of Means of Mathematics Tests Scores	166
5.5	Comparison of Students' Performance in Problem Solving	170
5.6	Compare the Mean Scores in Problem Solving Tests by Gender	178
6.1	The Impact of Lesson Study on Lecturers CK and PCK in the Study	195
6.2	How Lesson Study Impact Students Outcomes	195
6.3	Educational Triangle	198
6.4	Educational Triangle for the Study	198

LIST OF APPENDICES

Appendix		Page
A	Interviews Questions for Lecturers	216
B	Test 1 and Test 2 for Mathematics Lecturers	220
C	Test 1 and Test 2 for Mathematics Lecturers	223
D	Form for Observation Notes for Lecturers Meeting	225
E	Informal Observation Form	226
F	Classroom Observation Form	227
G	Sample of a Research Lesson	230
H	Experts in English Language	235
I	Pre-test for Students	236
J	Post-test for Students	238
K	Rubric for pre-test and post-test	240
L	Mathematics Problem Solving Tests (Test 1 and Test 2)	243
M	Rubrics for Test 1 and Test 2	244
N	Mathematics Anxiety Questionnaire	246
O	Permission Letter for the Questionnaire of Mathematics Anxiety	248
P	Questionnaire about the Motivation in Mathematics	249
Q	Permission Letter for the Questionnaire of the Motivation in Mathematics	252
R	Panel of Experts for Lecturers' Interviews	253
S	Panel of Experts for Lecturers Tests	254
T	Panel of Experts for Observation Forms	255
U	Panel of Experts for Research Lessons	256
V	Panel of Experts for Students' Tests in Mathematical Problem Solving	257
W	Criteria of Problem Solving Skills (Rubric)	258

X Panel of Experts for Anxiety and Motivation Questionnaires 259

Y Consent Forms for Principal of Foundation Centre, Lecturers and Students 260

LIST OF ABBREVIATIONS

ADDIE	Analysis, Design, Development, Implementation, and Evaluation
CCK	Common Content Knowledge
CK	Content Knowledge
CPD	Continuous Professional Development
EDA	Exploratory Data Analysis
HOTs	Higher Order Thinking skills
KCS	Knowledge of content and Students
KCT	Knowledge of Content and Teaching
MOE	Ministry of Education
NCTM	National Council of Teachers of Mathematics
PCK	Pedagogical Content Knowledge
PISA	Program for International Student Assessment
RMC	Research Management Centre
SCK	Specialized Content Knowledge
TALIS	Teaching and Learning International Survey
TIMSS	Trends in International Mathematics and Science Study
UK	United Kingdom
US	United States

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

It is clear that mathematics is a practical science in human life and mathematicians could provide the answer to many questions of other sciences. In other words, mathematics is a fundamental subject that contributes to other areas such as the science, technology, art, social science, and engineering. Therefore, mathematics is a main subject to be offered for primary and secondary schools in every country. In fact, mathematics education is too critical for individual countries and for the global economy as a whole (Harsono, 2016; Mundy, 2007).

The effort to ensure students have the basic knowledge in mathematics to prepare them for future undertakings has to start from the teachers. Hence, developed countries focus on improving mathematics educators' knowledge and skills in their initiatives to improve students' abilities in mathematics. Although, mathematics educators can improve their content knowledge and pedagogical content knowledge with the aids of technology such as smart phone, tablets and the wide use of internet, collaborative work with other colleagues and sharing of their experiences and knowledge can be more beneficial. Thus, educators through suitable teaching methods can improve their students reasoning, thinking skills and problem solving abilities (Ibibio & Sanderson, 2016). In many of countries, mathematics teachers tend to stick to their traditional ways of teaching and they resist changes in their delivery methods (Khalid, 2017; Mon, Dali, & Sam, 2016; Sherman & Wither, 2003). It has been observed that majority of students in these traditionally taught classes cannot learn mathematics conceptually and they do not find the instruction interesting (Harsono, 2016). Their lack of skills in mathematics problem solving also create many challenges for them in learning mathematics (Palraj, Dewitt, & Alias, 2017; Peranginangin & Surya, 2017; Tambychik & Meerah, 2010).

1.2 Professional Development for Mathematics Teachers

Improving the quality of teaching by increasing the content knowledge (CK) and pedagogical content knowledge (PCK) of mathematics teachers in order to improve student's achievement is significant to teacher's professional development. National Council of Teachers of Mathematics (NCTM) (2000) explained that educational standards should encourage students to solve complex mathematics problems in order to increase the general mathematical understanding. Mathematics teachers need to continuously learn new conceptual techniques from in-service courses and workshops in order to improve their knowledge. However, Soebari (2012) found that these professional development activities are not relevant for all mathematics teachers although they received new materials. The materials that the teachers received from the professional development courses may not be suitable with their

school context because of differences in student numbers, students' abilities, resources and facilities (Harsono, 2016). Problem solving is the most important part of mathematics teaching and learning. It seems mathematics teachers need to improve their knowledge about content, pedagogy, context, technology and psychology in order to prepare suitable situations in mathematics learning among their students through problem solving.

Mathematical CK is an important part of mathematics teachers' knowledge because it relates to deep understanding of mathematics topics and link between topics. With adequate knowledge, educators would be able to facilitate students to enhance their mathematics knowledge and prepare them for their future lives (Capraro, Capraro, Parker, Kulm, & Raulerson, 2005; Harsono, 2016). Ball et al. (2008) based on Shulman's definition (1986) divided CK in two parts as follows:

i. Common content knowledge (CCK), which refers to mathematical knowledge which is not specific to teaching, and
ii. Specialized content knowledge (SCK), which is the mathematical knowledge used in teaching.

Mathematics CK is the core of mathematics educators' knowledge and it is strongly related to mathematics teachers' PCK. Effective and interestingly conducted teaching not only requires high level of CK but also PCK which include teachers' practice, module, method, and abilities in creating appropriate activities for students.

Mathematics educators need to understand the mathematics subject, pedagogy and students as learners as part of their professional development (Mon et al., 2016). They can improve PCK through their experiences in the classroom, collaboratively working with colleagues and participating in workshops or in-service courses. Ball et al. (2008) divided PCK in two parts as follows:

i. Knowledge of content and students (KCS), which refers to how students learn the concept of mathematics, and
ii. Knowledge of content and teaching (KCS), which emphasizs on mathematics lessons including selection of examples, exercises and problems.

1.3 Lesson Study

The Japanese model of Lesson Study has transformed schools into learning organizations and Lesson Study has received attention of educational researchers and agents of education and learning improvement across the world from the last decade (Farhoush, Majedi, & Behrangi, 2017). Dudley (2011) and Harsono (2016) described Lesson Study as an approach which is a highly specified form of classroom action research focusing on the development of mathematics teachers practice knowledge

and CK. The main purpose of the Lesson Study approach is to encourage mathematics teachers to be more responsive to student's achievement and improve the quality of teaching and learning (Iksan & Md Rahim, 2017; Saito & Sato, 2012). The results of Japanese students in international assessments such as Trends in International Mathematics and Science Study (TIMSS), TIMSS Advanced and Programme for International Students Assessment (PISA) reflect that Lesson Study is an effective method for teaching in Japan. Muarata and Takahashi's (2002) study which involved 125 primary school teachers in the vicinity of Tokyo found that 91.3% of respondents felt that the Lesson Study was found to be effective and efficient.

Grossman and McDonald (2008) asserted that teachers' pedagogy needs to be enhanced through intensed prolonged training. There need to be more effort to improve teaching quality, hence researchers and educators have become interested in developing more prolonged forms of professional development, including Lesson Study (Harsono, 2016).

Hurst, Armstrong and Young (2011) explained that professional development could develop self-confidence, content knowledge, pedagogical knowledge, and engagement with students. Lesson Study is a teacher's professional development model and educators can used it for every subject at any level of education (Cheng & Yee, 2011). The results of many studies showed that Lesson Study is a dynamic teaching approach for school levels and it has potentials in improving mathematics teachers' knowledge and performance. The researcher is interested to study about Lesson Study in foundation level, because there is no study about the impact of Lesson Study on lecturers' knowledge and students' outcomes in the Malaysian context. Furthermore, the researcher is a mathematics educator at this level and he is familiar with the environment and situation of mathematics teaching and learning in this level.

1.4 Mathematics Problem Solving Ability among Students

Problem solving is the core of mathematics learning and many countries try to improve the PCK of mathematics teachers to improve the students' higher order thinking skills through problem solving. For example, mathematics education in Japan focuses on problem solving and higher order thinking among students, thus the results of Japanese students in mathematics are among the highest in international assessments. In problem solving method, two important components should be considered by educators. First, students need to learn how to minimize memorization and second, how they can improve higher order thinking skills.

Many students believe that mathematics is hard and not motivating therefore, many of them do not like to continue formal mathematics study at the university level (Ricks, 2009). Students with low level of motivation and interest in mathematics cannot learn the concept of mathematics easily (TIMSS, 2015). Therefore, this group of students is usually confused when doing mathematical problem solving. Arem

(2009) described that low ability in problem solving and mathematical thinking results in mathematics anxiety among students, which then influences students' performance. It has been established that there is a strong negative relationship between the level of mathematics anxiety and students problem solving ability in mathematics (Elenchothy, 2007; Sherman & Wither, 2003; Zakaria, Zain, Ahmad, & Erlina, 2012). Therefore, problem solving approach has an important role in improving mathematics problem solving ability among students and educators should consider it as an important aspect of learning mathematics.

1.5 Statement of the Problem

Malaysia is a developing nation and its aim is to be a developed country therefore, Malaysian Ministry of Education (MOE) has been planning strategically to improve the education standard to be at par with developed countries (Mon et al., 2016). They further added MOE tries to enhance the knowledge of educators and students in mathematics as a fundamental subject, which is done through problem solving and higher order thinking.

In Malaysia, as in few other countries, students are facing difficulties in mathematics problem solving and their abilities do not allow them to solve the problems completely (Matanluk, Johari, & Matanluk, 2013; Palraj et al., 2017; Peranginangin & Surya, 2017). The results of Malaysian students in international mathematics assessments such as TIMSS and PISA indicated that students in secondary schools seem to lack problem solving skills (Abdullah & Peters, 2015). One of the factors that contributes to students poor performance in problem solving is the teaching method because the majority of educators teach mathematics by emphasising on practice of routine exercises and conduct it in traditional way, hence many students do not have the mastery of the problem solving process (Khalid, 2017; Mon et al., 2016).

The results of the 8th grade students in TIMSS from 1999 to 2015 illustrate that Malaysian student's performance in mathematics is so much lower as compared to other Asian countries such as Japan, China, South Korea and Singapore. The ranks of Malaysian 8th grade students in mathematics were 16, 10, 20, 26 and 22 in TIMSS assessments in the year 1999, 2003, 2007, 2011 and 2015 respectively. Meanwhile, in 2007, 2011 and 2015, the Malaysian 8th grade average score in mathematics were below the international average score (TIMSS, 2015). It also seems there is considerable difference between the performance of Malaysian students in problem solving and higher order thinking skills by gender. For instance, in all TIMSS assessments the average scores of girls were higher than the average scores of boys.

In PISA, Malaysia ranks 52 out of 65 for mathematics and 39 out of 44 in problem solving (OECD, 2014). For higher order thinking skills, about half of the Malaysian participants in PISA were in level 1 (Remembering), only about 1% were able to solve the most complex problems at level 5 (Evaluating) and 6 (Creating) and most students were at level 2 (Understanding) or 3 (Applying) (OECD, 2014). In fact, the

results of Malaysian 8th grade students in TIMSS and 15-years students in PISA showed that mathematics problem solving skills are poor among secondary school students. Mathematics teaching in Malaysia can still be characterized as teacher-centred with emphasis on solving of exercises through traditional method (Khalid, 2017; Lim, 2010; Mon, 2009). Khalid (2017) explained that mathematics teachers use chalk-and-talk approach and spend a lot of time drilling the students with practice exercises and past examination questions. Public examination questions do not require higher order thinking skills but rather, rote memorization and procedural skills. Johannsdottir (2013) claimed that the quality of students mathematical problem solving and abilities will continue to other grade levels. It can be assumed that performance of students in schools will be carried on to their pre-university and university education.

The results of the international assessments confirm that problem solving skill is poor among Malaysian students, which is partly contributed by the traditional teaching methods practiced by teachers (Khalid, 2017). In secondary schools, mathematics teachers normally prefer to provide practices on routine mathematics exercises, instead of mathematics problems. At higher levels, especially in pre-university or university programmes, mathematics teaching creates an even bigger challenge for majority of the educators because of the complexity of the contents. Hence, educators often resort to the use of mathematics exercises for their students because teaching problem solving would require higher level of CK and PCK and more time (Mon, 2009). Mathematics problem solving posed difficulty among Malaysian students as well students of other countries (Harsono, 2016; Intaros, Inprasitha, & Srisawadi, 2013; McDonald, 2009; Mon, 2009). However, how can students learn mathematics without problem solving and how can students experience the beauty of mathematics without problem solving?

Inability to do problem solving may result in the students memorizing the methods to solve the problems. Memorization method is common among the majority of Malaysian students in secondary schools (Khalid, 2017; Mon, 2009). They memorize the theorems, formulas, shortcuts, mathematics relations, methods and techniques but they may not be able to apply them in problem solving. The frustration in doing problem solving may cause them to lose confidence and motivation. For example, the studies about TIMSS (2015) illustrated that the Malaysian students had the lowest motivation (after Thailand students) in learning mathematics. The results of some studies about the mathematics anxiety in Malaysia showed that approximately a third of students in secondary schools annoy from high level of mathematics anxiety and they engage in negative thinking about their self-ability (Arem, 2009; Mohamed & Tarmizi, 2010; Zakaria et al., 2012). Researchers who investigated the countries that are successful in mathematics, in search of the success formula often found that the quality of the mathematics teachers is one common key component that determines mathematics achievement among students (Mon et al., 2016; Stanford & Reeves, 2009).

The result of a study by Alfan and Othman (2005) showed that students performance at the university level is closely related to their performance prior to entering the university, especially in subjects such as mathematics. Hattie (2009) explained that students' mathematics performance is not related to their abilities and characteristics, but contributed significantly by other factors such as teaching methods. In foundation centers, lecturers lack opportunities to participate in in-service programmes. Usually lecturers with degrees related to pure mathematics and applied mathematics teach the mathematics courses at this level. There is a need for them to improve their CK and PCK continuously based on new methods, techniques and learning theories. Thus, suitable professional development programme is necessary for mathematics educators in foundation level to continuously develop their ability in helping students to improve their problem solving and higher order thinking skills. It is evident that Lesson Study is an effective approach to improve CK and PCK of teachers. Consequently, this results in better instruction and increased performance, higher motivation and less anxiety among the students. However, Lesson Study has been implemented and tested mainly in schools and no study has focused on pre-university or university students. For this reason, this study sought to look into the impact of Lesson Study at the pre-university level, which is the Foundation level, on the lecturers' CK and PCK and also the students' outcomes.

1.6 Objectives of the Study

The aims of this study are twofold. Firstly, to investigate the impact of Lesson Study on mathematics lecturer's CK and PCK. Secondly, to determine the impact of Lesson Study on student's outcomes, specifically problem solving abilities, mathematics anxiety and motivation in mathematics. The purpose of the Lesson Study is to improve mathematics lecturers' knowledge and teaching practices in order to improve student's mathematics learning and problem solving. The main objectives of this study are as follows:

1. To describe the lecturers' content knowledge (CCK and SCK) before and after their involvement in the Lesson Study.
2. To describe the lecturers' pedagogical content knowledge (KCT and KCS) before and after their involvement in the Lesson Study.
3. To determine the impact of the implementation of Lesson Study on students' problem solving abilities, mathematics anxiety and motivation in learning mathematics.
4. To determine whether there are statistical differences in the interaction of treatment groups and gender on students' problem solving abilities, mathematics anxiety and motivation in learning mathematics.

1.7 Research Questions

The objectives of this study will be achieved through the following research questions:

1. What are the lecturers' content knowledge before and after being involved in the Lesson Study? (Objective 1)
2. What are the lecturers' pedagogical content knowledge (in aspects of classroom time management, students' assessments, lecturers' materials, teaching method and students' activities) before and after being involved in the Lesson Study? (Objective 2)
3. What is the impact of the implementation of Lesson Study on students' ability in mathematical problem solving? (Objective 3)
4. What is the impact of the implementation of Lesson Study on students' mathematics anxiety? (Objective 3)
5. What is the impact of the implementation of Lesson Study on students' motivation in mathematics learning? (Objective 3)
6. What is the interaction between treatment groups and gender on problem solving skills? (Objective 4)
7. What is the interaction between treatment groups and gender on mathematics anxiety? (Objective 4)
8. What is the interaction between treatment groups and gender on motivation in mathematics learning? (Objective 4)

1.8 Research Hypotheses

Based on the research questions (RQ) 3, 4, 5, 6, 7 and 8, the following hypotheses were stipulated:

H_{01} There is no statistical significant difference in the problem solving Test1 scores between the experimental and control groups. (RQ 3)

H_{02} There is no statistical significant difference in the problem solving Test2 scores between the experimental and control groups. (RQ 3)

H_{03} There is no statistical significant difference in the problem solving post-test scores between the experimental and control groups. (RQ 3)

H_{04} There is no statistical significant difference in the problem solving follow-up test scores between the experimental and control groups. (RQ 3)

H_{05} There is no statistical significant difference in the problem solving test scores between the experimental and control groups during times points between pre-test, post-test and follow-up test. (RQ 3)

H_{06} There is no statistical significant difference in the weighted scores of mathematics problem solving Test w2 between the experimental and control groups. (RQ 3)

H_{07} There is no statistical significant difference in the weighted scores of mathematics problem solving Test w3 between the experimental and control groups. (RQ 3)

H_{08} There is no statistical significant difference in the weighted scores of mathematics problem solving Test w4 between the experimental and control groups. (RQ 3)

H_{09} There is no statistical significant difference in the weighted scores of mathematics problem solving Test w5 between the experimental and control groups. (RQ 3)

H_{10} There is no statistical significant difference in the weighted scores of mathematics problem solving tests between the experimental and control groups during times points between Test w1, Test w2, Test w3, Test w4 and Test w5. (RQ 3)

H_{11} There is no statistical significant difference in the mathematics anxiety post-test scores between the experimental and control groups. (RQ 4)

H_{12} There is no statistical significant difference in the mathematics motivation post-test scores between the experimental and control groups. (RQ 5)

H_{13} There is no statistical significant difference in the intrinsic motivation post-test scores between the experimental and control groups. (RQ 5)

H_{14} There is no statistical significant difference in the mastery orientation post-test scores between the experimental and control groups. (RQ 5)

H_{15} There is no statistical significant difference in the performance orientation post-test scores between the experimental and control groups. (RQ 5)

H_{16} There is no statistical significant difference in the expectancy post-test scores between the experimental and control groups. (RQ 5)

H_{17} There is no statistical significant interaction between treatment groups and gender on problem solving test scores in Test1 and Test2. (RQ 6)

H_{18} There is no statistical significant interaction between treatment groups and gender on problem solving test scores in post-test and follow-up test. (RQ 6)

H_{19} There is no statistical significant interaction between treatment groups and gender on weighted scores of problem solving tests in Test w2, Test w3, Test w4 and Test w5. (RQ 6)

H_{20} There is no statistical significant difference in the weighted scores of mathematics problem solving tests between the experimental and control groups during time points between Test w1, Test w2, Test w3, Test w4 and Test w5 by gender. (RQ 6)

H_{21} There is no statistical significant interaction between treatment groups and gender on mathematics anxiety scores in pre-test and post-test. (RQ 7)

H_{22} There is no statistical significant difference in the mathematics motivation post-test scores between experimental and control groups by gender. (RQ 8)

H_{23} There is no statistical significant difference in the intrinsic motivation post-test scores between experimental and control groups by gender. (RQ 8)

H_{24} There is no statistical significant difference in the mastery orientation post-test scores between experimental and control groups by gender. (RQ 8)

H_{25} There is no statistical significant difference in the performance orientation post-test scores between experimental and control groups by gender. (RQ 8)

H_{26} There is no statistical significant difference in the expectancy post-test scores between experimental and control groups by gender. (RQ 8)

1.9 Significance of the Study

Mathematics teachers need to continuously try out new approaches to improve students' learning in mathematics. Malaysia has been undergoing several education revamps and reviews especially in its educational policies to achieve a higher level of educational standard (Mon, 2009). Hence, the findings of this study will contribute greatly to the limited knowledge exploration on the use of the Lesson Study approach in improving both the teachers and students' knowledge. This study will also broaden the understanding on the implementation of Lesson Study in Malaysian mathematics education. In designing effective Lesson Study environment, educational designers need to have a clear understanding of the implementation levels and stages of the Lesson Study approach.

Findings of this study would allow administrative leaders and policymakers to develop a clear understanding of the requirement and implementation of the Lesson Study approach. In particular, to improve the mathematics standards, change needs to be addressed in three dimensions; the mathematics teachers/lecturers' professional development, student's achievement in problem solving and producing suitable textbooks and modules which have specific focus and guide on problem solving.

Mathematics is one of the core courses subjects taught in Malaysian curriculum, as well as in many other countries. The task of the mathematics teachers at all levels is considered critical and challenging. Thus, mathematics lecturers and teachers need

to continuously improve their content knowledge and pedagogical content knowledge.

1.10 Limitation of Study

This study involved seven mathematics lecturers, a physics lecturer and the researcher as participants of the Lesson Study group and two classes of a foundation programme in one public university in Malaysia. For the experiment to determine the impact of the Lesson Study, only 86 students were involved. This is considered adequate for an experimental study. However, studies such as this, done within a specific context would have limitations in terms of generalization to other lecturers in other foundation centres or to those teaching other subjects. The findings of this research are based on the data collected from questionnaires, problem solving tests, interviews with mathematics lecturers and observations of their discussions. Thus, the accuracy and truthfulness of the data are also based on the quality of participants' responses and participations.

1.11 Operational Definitions

Every key phrase used in this research is conceptually and operationally defined in order to help the researcher in developing the research instruments, data analysis, and discussion of the findings.

1.11.1 Mathematical Problem Solving

According to NCTM (2000), a mathematics task is considered as a mathematics problem if the students are engaged with the task for the first time and it creates a challenge for them. Therefore, in this study, mathematical problem solving refers to engaging students in mathematics tasks that they have not encountered before. In this study, students' ability to solve mathematics problems is measured using problem solving pre-test, Test 1, Test 2, post-test, follow-up test and weighted scores for all tests (Test w1, Test w2, Test w3, Test w4 and Test w5). To determine whether a task is a problem, each question was checked with the materials in the textbook and lecturers' lessons. Specifically, the mathematics problems that relate to student's everyday life and with other subjects such as physics, chemistry and biology are referred to as practical problems.

1.11.2 Mathematics Exercise

Based on NCTM's (2000) definition, a task is regarded merely as a mathematics exercise if the task is not new and not a challenge for the students. In this study, mathematics exercise solving refers to engaging students in tasks that students have learned or solved before.

1.11.3 Lesson Study and Research Lesson

Lesson Study refers to a teaching approach that brings a group of mathematics teachers/lecturers to work collaboratively on a topic to plan a lesson, teach and/or observe the lesson, reflect and discuss on the lesson that was taught in order to improve student's achievement in mathematics learning and problem solving (Matanluk et al., 2013). These lessons that are developed are referred to as Research Lessons (Fujii, 2016) or Study Lessons (Fernandez & Yoshida, 2004).

1.11.4 Professional Development

According to Avalos (2011), "professional development is about teachers learning, learning how to learn, and transforming their knowledge into practice for the benefit of their students' growth. Teacher professional learning is a complex process, which requires cognitive and emotional involvement of teachers individually and collectively, the capacity and willingness to examine where each one stands in terms of convictions and beliefs and the perusal and enactment of appropriate alternatives for improvement or change" (p. 10). Education experts such as Crawford (2009) and King (2012) used the term continuous professional development, thus in some parts of this study, the term continuous professional development is used instead of professional development depending on the source of reference. In this study, programmes and activities that provides opportunities for lecturers to extend their knowledge is considered as part of professional development.

1.11.4.1 Content Knowledge (CK)

According to Shulman (1986), teacher's CK refers to the teacher's knowledge of the subject matter taught. Similarly, Ball et al. (2008) defined mathematical CK as mathematics knowledge used in teaching. In this study, mathematics lecturer's CK comprises of their common content knowledge (CCK) and specialized content knowledge (SCK).

a) CCK is defined "as the mathematical knowledge and skill used in settings other than teaching" (p. 399). In this study, CCK is determined using interviews, tests and odservations.
b) SCK is the CK unique to teaching. Teachers make use of this knowledge in analyzing students' errors, providing creative solutions, and when they explain and justify reasons behind mathematical procedures and algorithms. In this study, SCK is determined using interviews, tests and observations.

1.11.4.2 Pedagogical Content Knowledge (PCK)

Shulman (1987) defines PCK as "the blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organized,

represented, and adapted to the diverse interests and abilities of learners, and presented for instruction" (p. 9). Ball et al. (2008) categorized PCK into two types; (i) knowledge of content and students (KCS) that refers to the interaction between the students and the content, and (ii) knowledge of content and teaching (KCT) that merges the knowledge of mathematics and teaching. Morrison and Luttenegger (2015) defined PCK as the intersection of lecturer's CK, pedagogical knowledge and context knowledge of the student's learning situation. In this study, PCK includes CK, pedagogical knowledge, context knowledge and psychological knowledge. So at the foundation level, a lot of factors in mathematics teaching are related to the lecturers' PCK. However, this study only emphasized on five important factors namely time management, students' assessment, lecturers' materials, teaching method and students' activity. Mathematics lecturers' PCK is determined using interviews, mathematics tests and observations of the lecturers' activities in the Research Lessons process.

1.11.4.2.1 Time Management

Sahito, Khawaja, Panhwar, Siddiqui and Saeed (2016) explained that time management is a process of managing the time according to the need and requirement of work and activities in order to utilize and save time for an effective organizational progress and success. In this study, time management refers to the lecturers consideration of suitable time needed for students' activities in problem solving. Therefore, time management is determined through interviews and observations of the lecturers' activities in the Lesson Study group discussion and teaching in the class.

1.11.4.2.2 Students' Assessment

Mathematics lecturers normally assess their students through some formal assessments such as quizzes, mid-term test, final examination and assignments. In this study, students' assessment refers to the activities and it characterizes the knowledge and skills of the lecturer in using formative assessments during whole-class lessons especially in doing mathematical problem solving. This method of students' assessment require high level of PCK in order for the lecturers to discuss, encourage, evaluate and guide students. Falk (2012) concluded that through collaborative work, the teachers used their PCK as an integral part of their formative assessment practice. Studies of the development of teachers' pedagogical content-specific knowledge for teaching suggest that this knowledge can be developed through activities within or similar to formative assessment practices (Drageset, 2010). In this study, assessment of students by the lecturers is described from the interviews and observations.

1.11.4.2.3 Lecturers' Materials

Lecturers can plan the daily lesson plans individually or in a team. In this study, lecturers' materials refers to lessons that are developed through collaborative work in determining suitable mathematics materials especially mathematics problems and practical problems, and gauging time needed to enhance and encourage students' problem solving during class time. The quality of the lesson plans are described based on interviews, observations, Research Lessons and the materials taught by lecturers in their classes.

1.11.4.2.4 Teaching Method

Dorgu (2015) explained that method of teaching is a strategy by which a teacher/lecturer delivers his/her subject matter to the students based on some predetermined instructional objectives in order to enhance learning among the learners. In this study, teaching method refers to a strategy by which lecturer delivers mathematics materials to the students by emphasizing on problem solving in order to improve students' learning. Meanwhile, teaching method used by the lecturers is summarized in this research based on the interviews, observations and Research Lessons conducted.

1.11.4.2.5 Students' Activity

Every individual and teamwork by students in the classroom that were designed by mathematics lecturers such as communication (oral and/or written) among students in order to improve their abilities in problem solving are considered as student activity. Student activity helps students to have deep understanding about problem solving and critical thinking. Student activities are described through the interviews, observations and Research Lessons.

1.11.5 Mathematics Anxiety

Mathematics anxiety is defined as "feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (Richardson & Suinn, 1972, p.551). In this study, student's mathematics anxiety was measured using a questionnaire developed by Bai (2011).

1.11.6 Motivation in Mathematics

Butler (2016) explained that if a person tends to engage in mathematics when the opportunity presents itself, then the person is considered to have motivation for mathematics. Operationally, a person has motivation for mathematics if he or she has high scores on an instrument, which has some evidence for validity, intended to

measure motivation for mathematics. In this study, student's motivation in mathematics is measured using a questionnaire developed by Butler (2016). In this instrument, the first four items focused on intrinsic motivation as per self-determination theory, the next four items are mastery orientation as per achievement goal theory, the next four items are performance orientation as per achievement goal theory, and the last four items are expectancy as per expectancy-value theory.

REFERENCES

Abdullah, A. H., Rahman, S. N. S. A., & Hamzah, M. H. (2017). Metacognitive skills of Malaysian Students in Non-Routine Mathematical Problem Solving. *Bolema*, *31*(57), 310–322.

Abdullah, A., & Peters, R. F. (2015). Malaysia's Post-PISA2012 Direction. *International Journal of Culture and History*, *1*(1), 15–20.

Abiko, T. (2011). A response from Japan to LRP's ten principles for effective pedagogy. *Research Papers in Education, 26(3)*, 357–365.

Ahearn, S. (2011). Renewal through lesson study. *Education Digest: Essential Readings Condensed for Quick Review*, *77*(1), 17–21.

Akiba, M., Murata, A., Howard, C. C., & Wilkinson, B. (2018). Lesson study design features for supporting collaborative teacher learning. *Teaching and Teacher Education*, *77*, 352–365.

Akkus, R., Hand, B., & Seymour, J. (2008). Understanding students' understanding of functions. *Mathematics Teaching Incorporating Micromath*, *207*, 10–13.

Al-Yateem, N. (2012). The effect of interview recording on quality of data obtained: a methodological reflection. *Nurse Researcher*, *19*(4), 31–35.

Alfan, E., & Othman, M. N. (2005). "Undergraduate students'' performance: the case of University of Malaya"." *Quality Assurance in Education*, *13*(4), 329–343. https://doi.org/DOI 10.1108/09684880510626593

Amalia, E., Surya, E., & Syahputra, E. (2017). The Effectiveness of Using Problem Based Learning (PBL) In Mathematics Problem Solving Ability for Junior High School Students. *International Journal of Education Research and Innovative Ideas in Education*, *3*(2), 3402–3406.

Ames, C., & Archer, J. (1987). mothers' beliefs about the role of ability and effort in school learning. *Journal of Educational Psychology*, *79*(4), 409–414.

Arem, C. A. (2009). Conquering Math Anxiety. *3rd Edn., Cengage Learning, Belmont, ISBN-10: 0495829404, Pp: 215*.

Aritonang, K. T. (2008). Minat dan motivasi dalam meningkatkan hasil belajar siswa [Interest and motivation to improve students' achievement]. *Jurnal Pendidikan Penabur [Sower Education Journal]*, *7*(10), 11–21.

Ary, D., Jacobs, L. C., Sorensen, C. K., & Walker, D. (2014). *Introduction to research in education* (9th ed.). Wadsworth: London.

Asami-Johansson, Y. (2015). Designing Mathematics Lessons Using Japanese Problem Solving Oriented Lesson Structure. *A Swedish Case Study. Department of Mathematics Linköping University, SE-581 83 Linköping,*

Sweden.

Ashcraft, M. H. (2002). Math Anxiety: personal, educational, and cognitive consequences. *Current Directions in Psychological Sciences*, *11*(5), 181–185.

Austin, L. (2017). Leading the Introduction and Development of Lesson and Learning Study in an English Secondary Academy. *International Journal for Lesson and Learning Studies*, *6*(1), 80–96. https://doi.org/10.1108/IJLLS-10-2016-0036

Avalos, B. (2011). Teacher professional development in teaching and teacher education over ten years. *Teaching and Teacher Education*, *37*(4), 409–423.

Bai, H. (2011). Cross-validating a bidimensional mathematics anxiety scale. *Assessment*, *18*(1), 115–122.

Ball, D. L., & Bass, H. (2000). Interweaving content and pedagogy in teaching and learning to teach: Knowing and using mathematics. *Multiple Perspectives on the Teaching and Learning of Mathematics*, *4*, 83–104.

Ball, D. L., Thames, M. H., & Phelps, G. C. (2008). Content knowledge for teaching: What makes it special? *Journal of Teacher Education*, *59*(5), 389–407.

Bandura, A. (1997). Self-efficacy: The exercise of self-control. *Gordonsville, VA: WH Freeman & Co*.

Bautista, A., & Ortega-Ruiz, R. (2015). Teacher professional development: International perspectives and approaches. *Psychology, Society and Education*, *7*(3), 240–251.

Bautista, A., Wong, J., & Gopinathan, S. (2015). Teacher professional development in Singapore: Depicting the landscape. *Psychology, Socety and Education*, *7*(3), 311–326.

Betz, N. E. (1978). Prevalence, distribution, and correlates of math anxiety in college students. *Journal of Counseling Psychology*, *25*(5), 441–448.

Bloom, B. (1956). Taxonomy of educational objectives: The classification of educational goals. *New York, NY: Longmans, Green*.

Boaler, J. (1999). Participation, knowledge and beliefs: A community perspective on mathematics learning. *Educational Studies in Mathematics*, *40*(3), 259–281.

Bradshaw, Z., & Hazell, A. (2017). "Developing problem-solving skills in mathematics: a lesson study." *International Journal for Lesson and Learning Studies*, *6*(1), 32–44.

Brahier, D. J. (2011). Motivation and disposition: Pathways to learning mathematics. *Reston, VA: National Council of Teachers of Mathematics*.

Burghes, D., & Robinson, D. (2009). Lesson Study: Enhancing Mathematics Teaching and Learning. *Guidance. Ireland: CfBT. Retrieved From*. https://doi.org/Http://webfronter,com/bexley/maths/menu2/Frontpage_files/Subject_Leaders/images/2LessonStudy_v9_Web_pdf

Burroughs, E. A., & Luebeck, J. L. (2010). Pre-service Teachers in Mathematics Lesson Study. *The Mathematics Enthusiast*, *7*(2), 391–400.

Butler, K. L. (2016). *Motivation for Mathematics: The Development and Initial Validation of an Abbreviated Instrument*. University of South Florida, United States.

Capraro, R. M., Capraro, M. M., Parker, D., Kulm, G., & Raulerson, T. (2005). The mathematics content knowledge role in developing preservice teachers' pedagogical content knowledge. *Journal of Research in Childhood Education*, *20*(2), 102–118.

Carey, E., Hill, F., Devine, A., & Szucs, D. (2016). *The Chicken or the Egg? The Direction of the Relationship Between Mathematics Anxiety and Mathematics Performance*. https://doi.org/doi: 10.3389/Ipsyg.2015.01987

Carrol, C. (2013). *Exploring the Impact of Lesson Study on the Theory-practice Gap in Pre-service Teacher Education*. University of Limerick, United States.

Chai, C. S., Koh, J. H. L., & tasi, C. (2013). A Review of Technological Pedagogical Content Knowledge. *Educational Technology and Society*, *16*(2), 31–51.

Cheng, L. p, & Yee, l P. (2011). A Singapore case of lesson study. *The Mathematics Educator*, *21*(2), 34–57.

Chia, H. M., Lim, C. S., & Chew, C. M. (2015). Exploring the quality of teaching practices of Lesson Study Research Lessons. *7th ICMI-East Asia Regional Conference on Mathematics Education*, 11-15 May 2015, Cebu City, Philippines.

Christensen, L. B., Johnson, B., & Turner, L. A. (2014). *Research methods, design, and analysis* (12th ed.). pearson.

Chua, P. H. (2009). Roles of teachers network and zone activities. In W. K. Yoong, L. P. Yee, B. Kaur, F. P. Yee & N. S. Fong (Eds.). *Mathematics Education: The Singapore Journey*, *2*, 85–103.

Cohan, A., & Honigsfeld, A. (2007). Incorporating "Lesson study" in Teacher Preparation. *The Educational Form*, *71*(1), 81–92.*college students*. (n.d.).

Crawford, K. (2009). *Continuing Professional Development in Higher Education: Voices from Below*. University of Lincoln, United Kingdom.

Creswell, J. W. (2014). *Research Design: Qualitative, Quantitative and Mixed Methods Approaches* (4th ed.). Thousand Oaks, CA: Sage.

Darling-Hammond, L., Wei, R. C., Andree, A., Richardson, N., & Orphanos, S. (2009). Professional learning in the learning profession. *Washington, DC: National Staff Development Council*.

Davis, B. (1997). Listening for differences: An evolving conception of mathematics teaching. *Journal for Research in Mathematics Education*, *28*(3), 355–376.

Dede, Y., & Soybas, D. (2011). Perservice Mathematics Teachers' Experiences about Function and Equation Concepts. *Eurasia Journal of Mathematics, Science and Technology Education*, *7*(2), 89–102.

Demir, K., Czerniak, C. M., & Hart, L. C. (2013). Implementing Japanese Lesson Study in a Higher Education Context. *Journal of College Science Teaching*, *42*(4), 22–27.

Departmental Report. (2008). *Department for Children, Schools and Families*. https://doi.org/https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/324671/dcsf_departmental_report_2008.pdf

Devine, A., Fawcett, K., Szucs, D., & Dowker, A. (2012). Gender differences in mathematics anxiety and the relation to mathematics performance while controlling for test anxiety. *Behavioral and Brain Functions*, *8*(33), 1–9.

Dick, W., Carey, L., & Carey, J. (2009). *The Systematic Design of Instruction* (7th ed.). Boston, MA: Pearson A&B.

Doig, B., & Groves, G. (2011). Japanese Lesson Study: Teacher Professional Development through Communities of Inquiry. *Mathematics Teacher Education and Development*, *13*(1), 77–93.

Doorman, M., Drijvers, P., Gravemeijer, K., Boon, P., & Reed, H. (2012). Tool use and the development of the function concept: From repeated calculations to functional thinking. *International Journal of Science and Mathematics Education*, *10*(6), 1243–1267. https://doi.org/10.1007/s10763-012-9329-0

Dorgu, T. E. (2015). Different Teaching Methods: A Panacea for Effective Curriculum Implementation in the Classroom. *International Journal of Secondary Education*, *3*(6), 77–87. https://doi.org/doi: 10.11648/j.ijsedu.s.2015030601.13

Dowker, A., Sarkar, A., & Looi, C. Y. (2016). Mathematics anxiety: What have we learned in 60 years? *Frontiers in Psychology*, *7*(508), 1–16.

Drageset, O. G. (2010). The Interplay Between the Beliefs and the Knowledge of Mathematics Teachers. *Mathematics Teacher Education and Development*, *12*(1), 30–49.

Dudley, P. (2014). *Lesson Study: a handbook for teachers and school leaders*. Retrieved from www.lessonstudy.co.uk

Dudley, Pete. (2011). *Lesson Study: a handbook online*. https://doi.org/http://lessonstudy.co.uk/wp- content/uploads/2012/03/Lesson Study Handbook-011011-1.pdf

Elenchothy, D. (2007). Mathematics Anxiety and Mathematics Achievement. *Mathematics Education Research Journal*, *15(2)*, 138–150.

Elliot, A. J., & Harackiewicz, J. M. (1996). Approach and Avoidance Achievement Goals and Intrinsic Motivation: A Mediational Analysis. *Journal of Personality and Social Psychology*, *70*(3), 461–475.

Elliott, J. (2019). What is Lesson Study? *European Journal of Education*, *54*(2), 175–188. https://doi.org/10.1111/ejed.12339

Eng, T. H., Li, V. L., & Julaihi, N. H. (2013). Lecturers' Perceptions, Students' Problems and Solutions for Handling High-Failure Rate Mathematics Courses. *Procedia - Social and Behavioral Sciences*, *90*, 853–861.

Falk, A. (2012). Teachers learning from professional development in elementary science: Reciprocal relations between formative assessment and pedagogical content knowledge. *Science Education*, *96*(2), 265–290. https://doi.org/doi: 10.1002/sce.20473

Farhoush, M., Majedi, P., & Behrangi, M. (2017). Application of Education Management and Lesson Study in Teaching Mathematics to Students of Second Grade of Public School in District 3 of Tehran. *International Education Studies*, *10*(2), 104–113.

Fernandez, C., Cannon, J., & Chokshi, S. (2003). A U.S.-Japan lesson study collaboration reveals critical lenses for examining practice. *Teaching and Teacher Education*, *19*, 171–185.

Fernandez, C., & Yoshida, M. (2004). *A case of a Japanese approach to improving instruction through school-based teacher development*. Mahwah, NJ: Lawrence Erlbaum.

Fleury, S. C. (1998). Social studies, trivial constructivism, and the politics of social knowledge. *In M. Larochelle, N. Bednarz, & J. Garrison (Eds.), Constructivism and Education (Pp.156-172).*, Cambridge, UK: Cambridge University Press.

Fraenkel, J. R., Wallen, N. E., & Hyun, H. H. (2012). *How to design and evaluate research in education* (8th ed.). New York: McGraw-Hill.

Friedman, A., & Phillips, M. (2010). Continuing professional development: Developing a vision. *Journal of Education and Work*, *17*(3), 361–376.

Fujii, T. (2014). Theorizing Lesson Study in mathematics education as an emerging research area (2): Identifying components and its structure of Lesson Study (in Japanese). *In Proceedings of Second Annual Spring Conference of Japan Society of Mathematical Education (Pp. 111–118)*.

Fujii, T. (2016). Designing and adapting tasks in lesson planning: a critical process of Lesson Study. *ZDM - Mathematics Education*, *48*(4), 411–423.

Gagne, M. R., Wager, W. W., Golas, K. C., & Keller, J. M. (2005). *Principles of instructional design* (5th ed.). Belmont, CA: Wadsworth.

Gallagher, P., & Darcy, L. (2018). Lesson Research Proposal for 2 nd Year Coordinate Geometry-Distance Formula. *Deansrath Community College*. https://doi.org/https://www.projectmaths.ie/documents/MathsCounts2018/CovertheDistanceFaster_Y2_HL_S2_MOR.pdf

Gay, L. R., Mills, G. E., & Airasian, P. W. (2012). *Educational research: competencies for analysis and applications* (10th ed.). Boston: Pearson.

Gergen, K. J. (1995). Social construction and the educational process. *In L. P. Steffe & J. Gale, Constructivism in Education (Pp. 17-39). N.J.: Lawrence Erlbaum Associates*.

Grossman, P., & McDonald, M. (2008). Back to the Future: Directions for Research in Teaching and Teacher Education. *American Educational Research Journal*, *45*(1), 184–205. https://doi.org/DOI: 10.3102/0002831207312906

Guskey, T. R. (2002). Professional Development and Teacher Change. *Teachers and Teaching: Theory and Practice*, *8*(3/4), 381–391. https://doi.org/DOI: 10.1080/135406002100000512

Hanfstingl, B., Rauch, F., & Zehetmeier, S. (2019). Lesson Study, learning study and action research: are there more differences than a discussion about terms and schools? *Educational Action Research*, *27*(4), 455–459. https://doi.org/10.1080/09650792.2019.1652450

Harsono, M. (2016). *The Impact of Lesson Study on Primary School Teacher's knowledge and Skills in Differentiating Primary School Mathematics Instruction: A Digital Mixed Methods Approach*. Unpublished doctoral dissertation, Curtin University, Australia.

Hattie, J. (2011). Visible learning - Synthesis of over 800 meta-analyses relating to achievement. *Journal of Chemical Information and Modeling*, *53*, 219–221.

Hemmings, B., Grootenbore, P., & Kay, R. (2011). Predicting mathematics achievement: The influence of prior achievement and attitudes. *International Journal of Science and Mathematics Education*, *9*(3), 691–705.

Heng, C. H., & Ziguang, Y. (2015). Framework of Assessment for the Evaluation of Thinking Skills of Tertiary Level Students. *Australian International Academic Centre*, *6*(5), 67–72.

Heong, Y. M., Yunus, J. B., & Hassan, R. B. (2011). The perception of the level of higher order thiniking skills among technical education students. *International Conference on Social Science and Humanity*, *5*, 281–285.

Hill, F., Mammarella, I. C., Devine, A., Caviola, S., Passolunghi, M. C., & Szűcs, D. (2016). Maths anxiety in primary and secondary school students: Gender differences, developmental changes and anxiety specificity. *Learning and Individual Differences*, *48*, 45–53. https://doi.org/http://dx.doi.org/10.1016/j.lindif.2016.02.006

Hill, H. C., Rowan, B., & Ball, D. L. (2005). Effects of teachers' mathematical knowledge for teaching on student achievement. *American Education Research Journal*, *42*(2), 371–406.

Holden, J. T. (2015). *AN INTRODUCTION TO THE ADDIE INSTRUCTIONAL SYSTEMS DESIGN MODEL*. https://doi.org/https://static.secure.website/wscfus/4899501/uploads/White_Paper--Introduction_to_the_ADDIE_ISD_Model.pdf

Hoover, W. (1996). The practice implications of constructivism. *SEDL Letter*, *9(3)*, 1–2.

Horn, I. S., Garner, B., Kane, B. D., & Brasel, J. (2017). A taxonomy of instructional learning opportunities in teachers' workgroup conversations. *Journal of Teacher Education*, *68*(1), 41–54.

Horn, I. S., & Little, J. W. (2010). Attending to problems of practice: Routines and resources for professional learning in teachers' workplace interactions. *American Educational Research Journal*, *47*(1), 181–217.

Huang, R., & Shimizu, Y. (2016). Improving teaching, developing teachers and teacher educators, and linking theory and practice through Lesson Study in mathematics: An international perspective. *ZDM Mathematics Education*, *48*(4), 393–409.

Hurst, C., Armstrong, T., & Young, M. (2011). Making a difference for Indigenous children. In J. Clark, B. Kissane, J. Mousley, T. Spencer, & S. Thornton (Eds.), Mathematics: Traditions and [new j practices (Proceedings of the 34th annual conference of the Mathematics Education Research Group of Aust. *Adelaide, SA: AAMT & MERGA*.

Ibibio, C. C., & Sanderson, O. M. (2016). PRACTICAL UTILITY OF MATHEMATICS CONCEPTS AMONG SENIOR SECONDARY SCHOOL STUDENTS IN RIVERS STATE. *European Journal of Mathematics and Computer Science*, *3*(1), 15–22.

Iksan, Z. H., & Md Rahim, M. (2017). Reflections on teaching and learning of mathematics through lesson study and video critique. *Advances in Social Sciences Research Journal*, *4*(1), 50–61. https://doi.org/https://doi.org/10.14738/assrj.41.2499

Intaros, J., Inprasitha, M., & Srisawadi, N. (2013). Students' problem solving strategies in problem solving-mathematics classroom. *5th World Conference on Educational Sciences (WCES)*, *115*, 4119–4123.

Irvine, J. (2015). Problem Solving as Motivation in Mathematics: Just in Time Teaching. *Journal of Mathematical Science*, *2*, 106–117.

Jacobs, J., Seago, N., & Koellner, K. (2017). Preparing facilitators to use and adapt mathematics professional development materials productively. *International Journal of STEM Education*, *4*(30), 2–14. https://doi.org/DOI 10.1186/s40594-017-0089-9

Jalal, F., Samani, M., Chang, M. C., Stevenson, R., Ragatz, A. B., & Negara, S. D. (2009). Teacher certification in Indonesia: A strategy for teacher quality improvement. *Jakarta, Indonesia: Ministry of National Education of Indonesia and The World Bank.*

Johannsdottir, B. (2013). *THE MATHEMATICAL CONTENT KNOWLEDGE OF PROSPECTIVE TEACHERS IN ICELAND*. COLUMBIA UNIVERSITY, NEW YORK, United States.

Johnson, R. B., & Christensen, L. B. (2014). *Educational research methods: Quantitative, qualitative, and mixed approaches* (5th ed.). Los Angeles, CA: Sage.

Jonah-Eteli, W. A. (2010). Teaching for meaning Concepts and generalization against teaching for examples, methods and formulae: views of Mathematics teachers in Bayelsa State. *Nigerian Journal of Science and Science Education*, *8*(2), 59–71.

Karelia, B. N., Pillai, A., & Vegada, B. N. (2013). The levels of difficulty and discrimination indices and relationship between them in four-response type multiple choice questions of pharmacology summative tests of Year II M.B.B.S students. *IeJSME*, *7*(2), 41–46.

Karimi, A., & Venkatesan, S. (2009). Mathematics Anxiety, Mathematics Performance and Academic Hardiness in High School Students. *International Journal of Educational Sciences*, *1*(1), 33–37.

Kashefi, H., Ismail, Z., Mirzaei, F., Tak, C. C., Obeng, S. N. W., & Ching, T. Y. (2017). Teaching and Learning Theories Applied in Mathematics Classroom among Primary School Teachers. *Conference Paper*. https://doi.org/Doi: 10.1109/WEEF.2017.8467070

Katz-Buonincontro, J., & Anderson, R. c. (2018). A Review of Articles Using Observation Methods to Study Creativity in Education (1980–2018). *Journal of Creative Behavior*, 1–17.

Kazemi, F., Zaman, A., & Ghafar, A. (2014). *Localizing Lesson Study for the Math Teachers ' Professional Development , Necessities and Prohibitions*. *4*(9S), 504–508.

Kellaghan, T. (2004). 'Preparing teachers for the 21st century: Report of the working group on preservice teacher education.' *Teacher Education in the Republic of*

Ireland: Retrospect and Prospect, Armagh: Centre for Cross-Border Studies, 19-25.

Khalid, M. (2017). Fostering Problem Solving and Performance Assessment among Malaysian Mathematics Teachers. *Sains Humanika*, *9*(1–2), 51–55.

Khatoon, T., & Mohmood, S. (2010). Mathematics anxiety among secondary school students in India and its relationship to achievement in mathematics. *European Journal of Social Sciences*, *16*(1), 75–86.

Kim, H. (2013). Statistical notes for clinical researchers : assessing normal distribution (2) using skewness and kurtosis. *Restorative Dentistry & Endodontics*, *7658*(2), 52–54.

King, F. (2012). *Developing and Sustaining Teachers' Professional Learning: A Case Study of Collaborative Professional Development*. University of Licoin, United Kingdom.

Klassen, A. C., Creswell, J., Clark, V. L. P., Smith, K. C., & Meissner, H. I. (2012). Best practices in mixed methods for quality of life research. *Quality of Life Research*, *21*(3), 377–380.

Kleickmann, T., Richter, D., Kunter, M., Elsner, J., Besser, M., Krauss, S., & Baumert, J. (2013). Teachers' Content Knowledge and Pedagogical Content Knowledge: The Role of Structural Differences in Teacher Education. *Journal of Teacher Education*, *64*(1), 90–106.

Klein, F. (2016). *Elementary mathematics from a higher standpoint: arithmetic, algebra, analysis*. Vol. 1. Berlin: Springer. Original work published 1908.

Koehler, M. J., & Mishra, P. (2009). What is technological pedagogical content knowledge? *Contemporary Issues in Technology and Teacher Education*, *9*(1), 60–70.

Koning, J., Blomeke, S., Paine, L., Schmidt, W. H., & Hsieh, F. (2011). General pedagogical knowledge of future middle school teachers: On the complex ecology of teacher education in the United States, Germany, and Taiwan. *Journal of Teacher Education*, *62*(2), 188–201.

Kunimune, S., & Souma, K. (2009). Suugakuteki katsudo no Jissen pulanshu Dai 2 gakunen hen [Practical lesson plan collection for mathematical activities. For grade eight]. *Tokyo, Meijitosho*.

Kusukar, R., Croiset, G., & Ten Cate, O. (2013). Implications of gender differences in motivation among medical students. *Medical Teacher*, *35*(2), 173–174.

Kvedere, L. (2012). Mathematics Self-concept of the 9th Grade Students in Latvia. *Procedia - Social and Behavioral Sciences*, *46*, 3380–3384. Retrieved from http://dx.doi.org/10.1016/j.sbspro.2012.06.070

Kyttälä, M., & Björn, P. M. (2014). The role of literacy skills in adolescents' mathematics word problem performance: Controlling for visuo-spatial ability and mathematics anxiety. *Learning and Individual Differences*, *29*, 59–66.

Lee, J. F. K. (2008). A Hong Kong case of Lesson Study-Benefits and concerns. *Teaching and Teacher Education*, *24*(5), 1115–1124.

Lesson Study: professional deve. (n.d.).

Lewis, C. (2002). *Lesson study: A handbook of teacher-led instructional change*. Philadelphia: Research for Better Schools.

lieberman, J. (2009). doi:10.1186/s40064-015-1358-z. *Professional Development in Education*, *35*(1), 83–99.

Lim, C. S. (2010). Assessment in Malaysian School Mathematics: Issues and Concerns. *Paper Presented At The Meeting of the APEC-Tsukuba International Conference, Japan*.

Lim, K. H. (2006). *Students' mental act of anticipating in solving problems involving algebraic inequalities and equations*. University of California, United States.

Ling, L. M., Man, P. C. P., Yuk, K. P., Lun, A. L. Y., Yan, P. W., Wah, P. L.-F. Y., & Ping, D. N. F. (2005). Development and impact. In L. M. Ling, P. W. Yan & P. C. P. Man (Eds.). *For Each and Everyone: Catering for Individual Differences through Learning Studies*, (pp. 41–74). Hong Kong: Hong Kong University Press.

Louise, D., Cowan, P., & Cantiey, I. (2017). The Mathematical Transition to Higher Education – A case study of Engineering Students in one Institute of Technology. *Ireland International Conference in Education (IICE 2017)*. https://doi.org/10.2053/IICE.2017.0050

Matanluk, K., Johari, K., & Matanluk, O. (2013). The Perception of Teachers and Students toward Lesson Study Implementation at Rural School of Sabah: A Pilot Study. *Procedia - Social and Behavioral Sciences*, *90*, 245–250.

McBain, R. (2011). *How High Can Students Think? A Study of Students' Cognitive Levels Using Bloom's Taxonomy in Social Studies*. https://doi.org/https://files.eric.ed.gov/fulltext/ED524386.pdf

McCormack, A., Gore, J., & Thomas, K. (2006). Early career teacher professional learning. *Asia-Pacific Journal of Teacher Education*, *34*(1), 95–113.

McDonald, S. E. (2009). *A Model of Teacher Professional Development Based on the principles of Lesson Study*. ph.D. Thesis, Queensland University of Technology, Brisbane, Australia.

Meyer, R. D. (2005). *Lesson Study: The Effects on Teachers and Students in Urban Middle Schools*. Baylor University, United States.

Meyer, S., & Ward, P. (2014). ‘ How to ’ Use Social Theory Within and Throughout Qualitative Research in Healthcare Contexts. *Sociology Compass*, *8*(5), 525–539.

Michelsen, C. (2006). Functions: a modelling tool in mathematics and science. *ZDM. Int. J. Math. Educ*, *38*(3), 269–280.

Ministry of Education. (2014). Malaysian Education Blueprint Annual Report. *Kuala Lumpur*.

Ministry of Education Malaysia. (2012). *Malaysia Education Blueprint 2013 - 2025. Education*. https://doi.org/doi:10.1016/j.tate.2010.08.007

Mishra, P., Pandey, C. M., Singh, U., Gupta, A., Sahu, C., & Keshri, A. (2019). Descriptive Statistics and Normality Tests for Statistical Data. *Ann Card Anaesth*, *22*, 67–72.

Mohamed, S. H., & Tarmizi, R. A. (2010). Anxiety in mathematics learning among secondary school learners: A comparative study between Tanzania and Malaysia. *Procedia - Social and Behavioral Sciences*, *8*, 498–504.

Mon, C. C. (2009). *Implementation of Lesson Study as an Innovative Professional Development Model among Mathematics Teachers*. universiti of Sains, Malaysia.

Mon, C. C., Dali, M. H., & Sam, L. C. (2016). Implementation of lesson study as an innovative professional development model among Malaysian school teachers. *Malaysian Journal of Learning and Instruction*, *13*(1), 83–111.

Morrison, A. D., & Luttenegger, K. C. (2015). Measuring Pedagogical Content Knowledge Using Multiple Points of Data. *Metropolitan State University of Denver, Colorado, United States*, *20*(6), 804–816.

Morrison, G., Ross, S., Kalman, H., & Kemp, J. (2011). *Designing effective instruction* (6th ed.). New York: John Wiley & Sons.

Muarata, A., & Takahashi, A. (2002). District level Lesson Study: How do Japanese teachers improve their teaching of elementary Mathematics? *Paper Presented at the Research Pre-Session of the Annual Meeting of the National Council of Teachers of Mathematics*. https://doi.org/Las Vegas. April 2002.

Muir, T., Beswick, K., & Williamson, J. (2008). “I’m Not Very Good at Solving Problems”: An Exploration of Students’ Problem Solving Behaviours. *Journal of Mathematical Behavior*, *27*(3), 228–241.

Mundy, K. (2007). Global govermance, educational change. *Comparative Education*, *43*(3), 339–357.

Murata, A. (2011). Introduction: Conceptual overview of lesson study. In L. C. Hart, A. S. Alston, & A. Murata (Eds.). *Lesson Study Research and Practice in Mathematics Education*, (pp. 1-12). Dordrecht, !e Netherlands: Springer.

National Council of Teachers of Mathematics (NCTM). (2000). *Executive summary - Principals and standards for school mathematics*. 1–6. Retrieved from http://www.nctm.org/uploadedFiles/Math_Standards/12752_exec_pssm.pdf

Nishimura, K., Kobayashi, R., & Ohta, S. (2018). Lesson Study at Upper Secondary Level in Japan. *Journal of the International Society for Design and Development in Education*, *3*(11), 1–15.

O'Sullivan, B., Breen, S., & O'Shea, A. (2013). We Never Did This: A Framework for Measuring Novelty of Tasks in Mathematics Textbooks. In T. Dooley, S. NicMhuiri, M. O Reilly, & R. Ward (Eds.). *Fifth Conference on Research in Mathematics Education MEI 5 (Pp. 294 – 295). St. Patrick's College, Drumcondra, Dublin 9*.

OECD. (2014). *PISA 2012 Results in Focus What 15-year-Olds Know And What They Can Do With What They Know*.

Oehrtman, M., Carlson, M., & Thompson, P. W. (2008). Foundational reasoning abilities that promote coherence in students' understandings of function. In M. P. Carlson & C. Rasmussen (Eds.),. *Making the Connection: Research and Practice in Undergraduate Mathematics*, 27–42.

Ono, Y., & Ferreira, J. G. (2009). A case study of continuing teacher professional development through lesson study in South Africa. *South Africa Journal of Education*, *30*(1), 59–74.

Pallant, J. (2013). *SPSS survival manual : A step by step guide to data analysis using IBM SPSS* (4th ed.). Crows Nest, NSW: Allen & Unwin.

Palraj, S., Dewitt, D., & Alias, N. (2017). Teachers Beliefs in Problem Solving in Rural Malaysian Secondary Schools. *Malaysian Online Journal of Educational Technology*, *5*(4), 45–57.

Parks, A. N. (2008). Messy learning: Preservice teachers' lesson-study conversations about mathematics and students. *Teaching and Teacher Education*, *24*(5), 1200–1216.

Peranginangin, S. A., & Surya, E. (2017). An Analysis of Students' Mathematics Problem Solving Ability in VII Grade at SMP Negeri 4 Pancurbatu. *International Journal of Sciences: Basic and Applied Research (IJSBAR)*, *33*(2), 57–67.

Perlman, C. L. (1994). *The CPS performance assessment idea book*. Chicago IL, Chicago Public Schools.

Pintrich, P. R. (2003). A Motivational Science Perspective on the Role of Student Motivation in Learning and Teaching Contexts. *Journal of Educational Psychology*, *95*(4), 667–686. https://doi.org/http://dx.doi.org/10.1037/0022-0663.95.4.667

Polya, G. (1945). How to solve it; a new aspect of mathematical method. Princeton. *NJ: Princeton University Press*.

Ponce, G. (2007). Critical juncture ahead: Proceed with caution to introduce the concept of function. *Mathematics Teacher, 101*(2), 136–144.

Purnakanishtha, S., Suwannatthachote, P., & Nilsook, P. (2014). Development and Validation of a Problem Solving Skill Test in Robot Programming Using Scaffolding Tools. *Journal of Social Sciences, 2*, 47–53.

Ramezanzadeh, B. (2008). *The analysis of Test Items*. https://doi.org/b-ramezanzadeh.blogfa.com/post/27

Richardson, F. C., & Suinn, R. M. (1972). The mathematics anxiety rating scale: Psychometric data. *Journal of Counseling Psychology*, *19*(6), 551–554.

Richland, L. E., & Simms, N. (2015). Analogy, higher order thinking, and education. *Comparative Human Development, University of Chicago*, *6*, 177–192. https://doi.org/doi: 10.1002/wsc.1336

Ricks, T. E. (2009). Mathematics Is Motivating. *The Mathematics Educator*, *19*(2), 2–9.

Rock, T. C., & Wilson, C. (2005). Improving Teaching through Lesson Study. *Teacher Education Quarterly*, *32*(1), 77–92.

Rose, J., & Reynolds, D. (2014). Teacher's Continuing Professional Development: A New Approach. *International Congress for Effectiveness and Improvement*, 219–240.

Rowntree, D. (1981). *Statistics Without Tears*. Penguin Books ltd.

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist*, *55*(1), 68–78. https://doi.org/http://dx.doi.org/10.1037/0003-066X.55.1.68

Sahito, Z., Khawaja, M., Panhwar, U. M., Siddiqui, A., & Saeed, H. (2016). Teachers' Time Management and the Performance of Students: A Comparison of Government and Private Schools of Hyderabad, Sindh, Pakistan. *World Journal of Education*, *6*(6), 42–50. https://doi.org/doi:10.5430/wje.v6n6p42

Saito, E., & Sato, M. (2012). Lesson study as an instrument for school reform: A case of Japanese practices. *Management in Education*, *26*(4), 181–186. https://doi.org/https://doi.org/10.1177/0892020612445101

Saran, R. (2018). Investigating the Impact of Lesson Study and Pedagogical Content Knowledge on Mathematics Teaching Practices of Minority Pre-Service Teachers. *Medgar Evers College, CUNY, United States*.

Sengodan, V., & Iksan, Z. H. (2012). Students' learning styles and intrinsic motivation in learning mathematics. *Asian Social Science*, *8*(16), 17–23.

Sherman, B., & Wither, D. (2003). Mathematics Anxiety and Mathematics Achievement. *Mathematics Education Research Journal*, *15(2)*, 138–150.

Shuilleabhain, A. N. (2015). *Developing Mathematics Teachers' Pedagogical Content Knowledge through Lesson Study: A Multiple Case Study at a Time of Curriculum Change*. University College Dublin, Ireland.

Shulman, L. S. (1986). Knowledge Growth in Teaching. *Educational Researcher*, *15*(2), 4–14.

Shulman, L. S. (1987). Knowing and teaching: Foundations of the new reform. *Harvard Educational Review*, *57(1)*, 1–22.

Smit, R., & Humpert, w. (2012). Differentiated instruction in small schools. *Teaching and Teacher Education*, *28*(8), 1152–1162. https://doi.org/doi:10.1016/j.tate.2012.07.003

Smith, M. S. (2001). Practice-based professional development for teachers of mathematics. Reston. *Reston, VA: The National Council of Teachers of Mathematics, Inc*.

Soebari, T. S. (2012). *Investigating the effectiveness of a professional development initiative for lower secondary teachers in Indonesia*. Curtin University, Perth.

Stanford, B., & Reeves, S. (2009). Making it happen: Using Differentiated Instruction, Retrofit framework, and Universal Design for Learning. *TEACHING Exceptional Children Plus*, *5*(6), 1–9. https://doi.org/http://escholarship.bc.edu/education/tecplus/vol5/iss6/art4

Students' difficulties in mathematics problem-solving: What do they say? (n.d.).

Supriatna, A. (2011). Indonesia's issues and challenges on teacher professional development. *CICE Series*, *4*(2), 29–42.

Suryadi, D. (2013). Didactical Design Research (DDR) to improve the teaching of mathematics. *Journal of Mathematical Education*, *10*(1), 91–107.

Tabachnick, B. G., & Fidell, L. S. (2007). *Using multivariate statistics* (5th ed.). Boston, MA, : Allyn & Bacon/Pearson Education.

Tambychik, T., & Meerah, T. S. M. (2010). Students' difficulties in mathematics problem solving: What do they say? *Procedia Social and Behavioral Sciences*, *8*, 142–151.

Tan, Y. M. (2014). Enriching a collaborative teacher inquiry discourse: exploring teachers' experiences of a theory-framed discourse in a Singapore case of Lesson Study. *Educational Action Research*, *22*(3), 411–427. https://doi.org/Doi:10.1080/09650792.2014.880360

Taylor, A. R., Anderson, S., Meyer, K., Wagner, M. K., & West, C. (2005). Lesson Study: A professional development model for mathematics reform. *The Rural Educator*, *26*(2), 17–22.

Thomas, G., & Thorne, A. (2009). How To Increase Higher Level Thinking. *Metarie, LA: Center for Development and Learning*. https://doi.org/http://www.cdl.org/resource-library/articles /HOT.php?type=subject&id=18

Thompson. (2015). *An Analysis of the Perceived Impact of Lesson Study on Improving Secondary School STEM Teacher Effectiveness*. University of Central Florida, United States.

Thompson, A. D., & Mishra, P. (2007). Breaking News: TPCK Becomes TPACK! *Journal of Computing in Teacher Education*, *24*(2), 38–39.

TIMSS. (2015). *Trends in international mathematics and science study, International Associations for the Evaluation of Educational achievement*.

Ugbe, A. U., Bessong, F. E., & Agah, J. J. (2010). The mathematics/science teachers' factor in achievement of the goal of Universal Basic Education (UBE). *Global Journal of Educational Research*, *9*(1 & 2), 35–37, 39–43.

Vitasari, P., Herawan, T., Wahab, M. N. A., Othman, A., & Sinnadarai, S. K. (2010). Exploring Mathematics Anxiety among Engineering Students. *Social and Behavioral Sciences*, *8*, 482–489.

Vitasari, P., Wahab, M. N. A., Othman, A., Herawan, T., & Sinnadurai, S. K. (2010). The relationship between study anxiety and academic performance among engineering students. *Procedia - Social and Behavioral Sciences*, *8*(5), 490–497.

Voss, T., Kunter, M., & Baumert, J. (2011). Assessing teacher candidates' general pedagogical/ psychological knowledge. *Test Construction and Validation. Journal of Educational Psychology*, *103*(4), 952–969.

Wang, C. K. J., Liu, W. C., Nie, Y., Chye, Y. L. S., Lim, B. S. C., Liem, G. A., … Chiu, C. Y. (2017). *Latent profile analysis of students' motivation and outcomes in mathematics: an organismic integration theory perspective*. 1–18.

Wu, H. (2011). The mis-education of mathematics teachers. *Notices of the AMS*, *58*(3), 372–384.

Yang, Y. (2009). How a Chinese teacher improved classroom teaching in Teaching Research Group: A case study on Pythagoras theorem teaching in Shanghai. *Mathematics Teacher Education and Development*, *41*(3), 279–296.

Yanping, F., Lee, C. K. E., & Haron, S. T. B. S. (2009). Lesson study in mathematics: Three cases from Singapore. In W. K. Yoong, L. P. Yee, B. Kaur, F. P. Yee & N. S. Fong (Eds.). *Mathematics Education: The Singapore Journey Series on Mathematics Education*, (Vol. 2, pp. 104–129). Singapore: World Scientific.

Yarcma, C. H. (2010). Mathematics teachers' views of accountability testing revealed through Lesson Study. *Mathematics Teacher Education and Development*, *12*(1), 3–18.

Yoshida, M. (2005). Using Lesson Study to develop effective blackboard practice. *In P. Wang-Iverson & M. Yoshida (Eds.), Building Our Understanding of Lesson Study. Philadelphia: Research for Better Schools*, 93–100.

Yuksel-Sahin, F. (2008). MATHEMATICS ANXIETY AMONG 4th AND 5th GRADE TURKISH ELEMENTARY SCHOOL STUDENTS. *Nternational Electronic Journal of Mathematics Education*, *3*(3), 179–192.

Zakaria, E., & Syamaun, M. (2017). The Effect of Realistic Mathematics Education Approach on Students' Achievement and Attitudes towards Mathematics. *Mathematics Education Trends and Research*, *1*, 32–40.

Zakaria, E., Zain, N. M., Ahmad, N. A., & Erlina, A. (2012). Mathematics anxiety and achievement among secondary school students. *American Journal of Applied Sciences*, *9*(11), 1828–1832.

Zanaton, I., & Marziah, R. (2017). Reflections on teaching and learning of mathematics through Lesson Study and Video Critique. *Advances in Social Sciences Rsearch Journal*, *4*(1), 50–61.

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Hosseinali Gholami was born in Mashhad, north east of Iran. His master degree is in pure mathematics from Ferdowsi University of Mashhad in 2006. He is a mathematics educator at pre-university level (foundation level). Also he has several years experiences in teaching mathematics courses for teacher students at Farhangian University in Mashhad.

In 2016, he was registered in Mathematics Education PhD program at the Institute of Mathematical Research (INSPEM), Universiti Putra Malaysia (UPM). As for his experience in publications and production, he has authored, moderated and edited various books and modules in the field of calculus, algebra, geometry, trigonometry, probability and statistics. Furthermore, he teaches in-service courses for mathematics teachers.

He is interested in new methods of teaching such as Lesson Study because this teamwork approach helps mathematics educators to share their knowledge, skills and experiences in order to have better performance in their classes. He is now in the process of completing his PhD dissertation titled "Impact of Lesson Study on Mathematics Lecturers' Content Knowledge and Pedagogical Content Knowledge and Students' Problem Solving Ability, Motivation and Anxiety" at the Universiti Putra Malaysia.

LIST OF PUBLICATIONS

Gholami, H., Yunus, A. S. M., Ayub, A. F. M & Kamarudin, N. (2019). The Impact of Lesson Study on Achievement in Mathematical Problem Solving and Higher Order Thinking Skills (HOTS) among Foundation Level Students. *International Journal of Innovation, Creativity and Change*. 10(2), 289-313.

Gholami, H., Yunus, A. S. M., Ayub, A. F. M & Kamarudin, N. (2020). Impact of Lesson Study on Motivation and Achievement in Mathematics of Malaysian Foundation Programme Students. *Journal of Mathematics Education.* 5(1), 39-53.

Gholami, H., Yunus, A. S. M., Ayub, A. F. M & Kamarudin, N. Impact of Lesson Study on Mathematics Anxiety and Mathematics Achievement of Malaysian Foundation Programme Students. *International Journal of Evaluation and Research in Education (IJERE).* Accepted on 17th Feb 2021.

Gholami, H., Yunus, A. S. M., Ayub, A. F. M. Improving Mathematics Lecturers' Pedagogical Content Knowledge through Lesson Study. *The International Journal of Science, Mathematics and Technology Learning.* Accepted on 9th January 2021.

Gholami, H & Abdul Sathar, M. H. (2021). THE APPLICATION OF CIRCLE EQUATION IN BUILDING COMPOSITE FRONTAGE. *Advances in Mathematics: Scientific Journal*. 10(1), 29-35.

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