STATEMENT OF ORIGINALITY

This is to certify that to the best of my knowledge, the content dissertation entitled "Mathematical Abstraction of Pre-Service Mathematics Teachers in Learning Non-Conventional Mathematics Concept" is my own work. This dissertation has not been submitted for any degree or other purposes. I certify that the intellectual content of this dissertation is the product of my own work and that all the assistance received in preparing this thesis and sources have been acknowledged. I am not plagiarizing or citing in ways that are inconsistent with the ethics of science prevailing in scientific societies. On this statement, I am ready to bear the risks/sanctions if in the future found a violation of scientific ethics or there are claims from others to the authenticity of this work of mine.

Bandung, January 2018

Farida Nurhasanah

PERNYATAAN

Dengan ini saya menyatakan bahwa disertasi dengan judul "Mathematical

Abstraction of Pre-Service Mathematics Teachers in Learning Non-

Conventional Mathematics Concept" ini beserta seluruh isinya adalah benar-

benar karya saya sendiri. Saya tidak melakukan penjiplakan atau pengutipan

dengan cara-cara yang tidak sesuai dengan etika ilmu yang berlaku dalam

masyarakat keilmuan. Atas pernyataan ini, saya siap menanggung resiko/sanksi

apabila dikemudian hari ditemukan adanya pelanggaran etika keilmuan atau ada

klaim dari pihak lain terhadap keaslian karya saya ini.

Bandung, January 2018

Yang membuat pernyataan

Farida Nurhasanah

ACKNOWLEDGMENT OF AUTHORSHIP

This dissertation has led to several conferences, journal paper, and chapter book which are already published or in the process of publication. Some of the papers are prepared in collaboration with Prof. Yaya S. Kusumah, M.Sc., Ph.D., Prof. Jozua Sabandar, M.A., Ph.D. and Prof. Didi Suryadi, M.Ed. Two papers are prepared in collaboration with Prof. Yaya S. Kusumah, M.Sc., Ph.D., only. In addition, a paper published together with Prof. Turmudi, M.Ed., Ph.D. and Eyus Sudihartinih, M.Pd., and a paper published in collaboration with Ahmad Saddam Siregar, S.Si. I hereby would like to acknowledge the authorship and contribution of these academics to the relevant sections of this dissertation in which the contents of the jointly produced papers are used. A list of the papers stemming from this study is presented below.

- Nurhasanah, F., Sabandar, J., & Kusumah, Y. S. (2013). Abstraction Processes in Learning Geometry Using GSP. *Proceeding of 6th East Asia Regional Conference on Mathematics Education* (*Earcome 6*) 17-22 March 2013. Phuket: Prince Songkla University.
- Sabandar, J., & Nurhasanah, F. (2014). Hidden Curriculum in Promoting Self-Regulated Learning for Teachers. *Proceeding of International Seminar on Teaching and Learning in 21st Century: Challenge for Lecturer and teacher*, (pp.140-147). Bandung: Universitas Widyatama, Universitas Terbuka, Open University of Malaysia.
- Nurhasanah, F. & Siregar, A. S. (2015). Koordinat Paralel: Konsep Non-Konvensional untuk Mengembangkan Abstraksi Matematis Mahasiswa Calon Guru Matematika. *Proceeding of Seminar Matematika dan Pendidikan Matematika UNY* 2015, (pp. 1199-1205), Universitas Negeri Yogyakarta: Yogyakarta.
- Kusumah, Y. S., & Nurhasanah, F. (2016). The Endless Long-Term Programme of Mathematics Teachers Professional Development in Indonesia, in B. Kaur, O. N. Kwon, and Y. H. Leong (eds), *Professional Development of Mathematics Teachers An Asian Perspective*, (pp. 33-45). Singapore: Springer.
- Nurhasanah, F., Turmudi, & Sudihartinih, E. (2017). Parallel Coordinates: The Concept That Pre- Service Mathematics Teachers Need To Know. Proceeding of The 4th International Symposium On Mathematics Education Innovation Seameo Regional Centre For Qitep In Mathematics, (pp, 152 159), PPPTK-Matematka: Yogyakarta.

- Nurhasanah, F., Sabandar, J., & Kusumah, Y.S. (2017). Concept of Triangle: Examples of Mathematical Abstraction in Two Different Contexts. *International Journal on Emerging Mathematics Education* (IJEME), 1(1), (pp.53-70).
- Nurhasanah, F., Kusumah, Y. S., Sabandar, J., & Suryadi, D. (2017). Mathematical Abstraction: Constructing Concept of Parallel Coordinates. *Journal of Physics Conference Series*, 895(1):012076.
- Nurhasanah, F., Kusumah, Y.S., Sabandar, J. & Suryadi, D. (2017). Context Design for Abstraction of Pre-Service Mathematics Teachers in Learning Non-Conventional Mathematics Concept: An Apriori Analysis. Submitted and reviewed to Alberta Journal of Educational Research.
- Nurhasanah, F., Kusumah, Y. S., Sabandar, J., & Suryadi, D. (2017). The Role of Parallel Coordinates Concept in Analytic Geometry Classroom. *It has been presented in International Seminar on Mathematics, Science, and Computer Science Education, on October* 14, 2017.
- Nurhasanah, F., & Kusumah, Y. S. (2018). The Investigation of Pre-Service Mathematics Teachers' Abstraction Processes in Group And Classroom Contexts Using Rbc + C Model. Accepted to be presented in Earcome The 8th ICMI East Asia Regional Conference on Mathematics Education, in Taiwan on May 7 11, 2018.

ACKNOWLEDGMENTS

I would like to thank Allah SWT for giving me the best parents in the world who have an everlasting love for their daughter. Without their affection I could not reach this stage, completing my dissertation. I have never imagined that I could finish my thesis by having three periods of pregnancies and taking care of two babies and two children, but Allah SWT gives the strength through my parents' assistance. I will walk in a humble manner upon receiving my degree, knowing that it was Allah SWT who enabled me to reach this milestone in my life.

I owe my deepest gratitude to my supervisor, Professor Yaya S. Kusumah, MSc., Ph.D., the best supervisor a doctorate mathematics student can have. You have taught me by your own expert model how to create not only good but the best writing article through the comments and revision in the draft. Through a long discussion in your comfortable room, you show me how to be a patient, humble, and humorous scientist but still have a good critical thinking. You have a special skill of reviewing articles and selecting the words to express ideas in wonderful sentences. Most importantly, you bring me to experience the academic atmosphere in international forum that inspired me a lot. I am glad that I have had the opportunity to be one of those privileged to work with you.

I extend my sincere appreciation to Prof. Didi Suryadi, M.Ed., who has helped me in answering difficult questions that I ask to myself. My sincere appreciation also goes to Prof. Turmudi, M.Sc., M.Ed., Ph.D., Dr. Sufyani Prabawanto, M.Ed., Dr. Elah Nurlaelah, M.Si., and Eyus Sudihartinih, M.Pd., for all their valuable help, support, and unwavering assistance throughout the completion of this study.

I would like also to thank my extended family, my little sister, the big family of Mbah Hadiwijaya, Mbah H. Mawardi, and the big family of Mbah H. Madmasum, the big family of Marimun and Rasinah for their encouragement and prayer. Most of all, I would like to thank my loving husband, you have given me so much and loved me so well. I would not have accomplished this without you beside me.

Finally, I cannot thank Prof. Jozua Sabandar enough for encouraging me to

pursue something that I never imagine before in academic level. He always helps

me when I asked for it. I am impressed by the everlasting, enthusiastic attitude

that he has for guiding and motivating students. I would not have reached this

point in my career without the influence of Prof. Jozua Sabandar, M.A., Ph.D. He

not only served as my advisor during my Master and Doctorate studies at

Universitas Pendidikan Indonesia, but he has become a lifelong best friend.

The last but not least, I want to extend my high gratitude to my colleagues

in Mathematics Education Department, Sebelas Maret University, for their sincere

giving me the opportunity to take my doctorate degree. Also to my fellow friends,

Nurfadillah Siregar for every single support that you gave, for Ibu Maria, Puji

Lestari, Pak Joko, Pak Cecep, Ibu Laila, Pak Mujib, and all friends that cannot be

mentioned one by one in this page, thanks for the friendship. Thanks also to all

the committee of SEMDIKMAT 2016, thank you for trusting me! Thanks to Mr.

Juanda for the opportunity that you gave to me during my refreshing time in

finishing my dissertation.

Bandung, January 2018

Farida Nurhasanah

Farida Nurhasanah, 2018

DEDICATION

I dedicate my dissertation to my beloved parents, Hartini and Kasan for their unlimited loves.

This dissertation is a proof of a woman's love for her husband, Agus Fitriandi, and the children Mote, Moza, Mota, and baby Moze.

I dedicated this dissertation to every special person in my life who has been creating mosaics of my wings so that I can fly high out of the sky.

I dedicate this dissertation to myself who deserved to be happy for the choices of life that have been taken.

This love has guided me to find a long journey of a wonderful time of study in a wonderful place with wonderful people.

TABLE OF CONTENTS

		Pages
TITLE		i
ENDORS	SEMENT PAGE	ii
ABSTRA	CT	iii
STATEM	IENT OF ORIGINALITY	v
ACKNOV	WLEDGEMENT OF AUTHORSHIP	vii
ACKNOV	WLEDGEMENT	ix
DEDICA'	TION	xi
TABLE O	OF CONTENTS	xii
LIST OF	TABLES	xiv
LIST OF	FIGURES	xvii
LIST OF	APPENDIX	xix
BAB I	INTRODUCTION	1
	A. Rationale and Background	1
	B. Research Questions	10
	C. Aims of the Study	11
	D. Terminology	11
	E. Benefits of The Study	12
	F. Limitation of The Study	13
BAB II	LITERATURE REVIEW	15
	A. Mathematical Abstraction	15
	B. Types of Abstractions	18
	C. Levels of Abstraction	25
	D. Reducing Abstraction	27
	E. Mathematics Education Curriculum in Indonesia	31
	F. Non-Conventional Coordinates System	33
	G. Parallel Coordinate for Pre-Service Mathematics Teachers	37
BAB III	RESEARCH DESIGN AND METHODOLOGY	43
	A. Research Approach	43
	B. Research Procedures	44
	C. Participants and Setting	46

Farida Nurhasanah, 2018

	D. Data Collection Procedures	47
	E. Context Design for Mathematical Abstraction	49
	F. A Priori Analysis	54
BAB IV	RESULTS	62
	A. Analysis of Students' Prior Knowledge	62
	B. Constructing Concept of Parallel Coordinates in 2-	
	Dimension	65
	1. Episode I: Constructing E_{A1} and E_{A2}	66
	1.1 The Result of Microanalysis from Group 2	70
	1.2 The Result of Microanalysis from Group 5	75
	2. Episode II: Constructing E_B	80
	2.1 The Result of Microanalysis from Group 2	84
	2.2 The Result of Microanalysis from Group 9	85
	3. Episode III: Constructing <i>E</i> _C	91
	3.1 Constructing E_{CI}	91
	3.2 The Result of Microanalysis from Group 9	99
	3.3 Constructing E_{C2}	107
	4. Episode III: Constructing E_C	112
	4.1 Constructing E_{DI}	112
	4.2 Constructing <i>ED</i> ₂	117
	C. Mathematical Abstraction Levels of Pre-Service	
	Mathematics Teachers in Learning Parallel Coordinates	
	Concepts	123
	D. The Role of Parallel Coordinates Concept for Pre-	
	Service Mathematics Teachers in Mathematical	
	Abstraction	131
	1. Relation between Participants' prior Knowledge on	
	Cartesian coordinate and their Performance in	
	Parallel Coordinates	133
	2. Relation between the Performance on Abstraction	
	Test on Parallel Coordinates and the Performance of	
	Participants in Analytic Geometry	135

E. Final Remark	138
BAB 5 CONCLUSIONS	143
A. Mathematical Abstraction of Pre-Service Mathematics	
Teacher in Learning Non-Conventional Mathematics	
Concept	143
B. Mathematical Abstraction Levels of Pre-Service	
Mathematics Teacher in Learning Non-Conventional	
Mathematics Concept	144
C. Association between Mathematical Abstraction of Pre-	
Service Mathematics Teachers and Their Performance in	
Learning Analytic Geometry	145
D. Implications	146
E. Limitations and Further Study	147
REFERENCES	150
APPENDIX A	158
APPENDIX B	220

LIST OF TABLES

Table		Page
2.1	Indicators of Mathematical Abstractions Level	27
2.2	Differences of Mathematics Curriculum between Kurtilas and	
	KTSP	32
3.1	Description of Groups in this Study as A Part of the Context Design	46
3.2	Design of Learning Activities Based on AiC Framework	52
3.3	Key Concepts in Each Stage	55
4.1	Pre-service Mathematics Teachers' Prior Knowledge on Cartesian	
	Coordinate Topic	63
4.2	Knowledge Elements in Each Episode	65
4.3	The Hypothesis of Participants in Constructing E_{A2}	66
4.4	Cognitive Actions of RBC+C Abstraction Model in Topic of 2D	
	Parallel Coordinates	70
4.5	Table of RBC Analysis-1 of Group 2	72
4.6	Table of RBC Analysis-2 of Group 2	73
4.7	Table of RBC Analysis-1 of Group 5	76
4.8	Table of RBC Analysis-2 of Group 5	78
4.9	The Hypothesis of Every Group in Constructing E_B	80
4.10	Table of RBC Analysis-1 of Group 2	84
4.11	Table of RBC Analysis-1 of Group 9	86
4.12	Table of RBC Analysis-2 of Group 9	87
4.13	Table of RBC Analysis-3 of Group 9	88
4.14	Resume Types of Answers from All Group in Constructing E_C	92
4.15	Table of RBC Analysis-1 of Group 9	99
4.16	Table of RBC Analysis-2 of Group 9	100
4.17	Table of RBC Analysis-3 of Group 9	102
4.18	Table of RBC Analysis-4 of Group 9	104
4.19	Resume Types of Answers from All Group in Constructing E_{C2}	107
4.20	Resume Types of Answers from All Group in Constructing E_{D1}	112
4.21	Resume Types of Answers from All Group in Constructing E_{D2}	117
4.22	The Abstraction Level of Participants Based Data Analysis Result.	123

4.23	Participants' Statistic from Three Different Tests	132
4.24	Summary Statistics for Scores on Parallel Coordinates and Scores	
	on Analytic Geometry	137

LIST OF FIGURES

Figure	2	Page
2.1	Abstraction Level As The Quality of The Relationships between	
	The Object of Thought and The Thinking Person	29
2.2	Abstraction Level as Reflection of The Process-Object Duality	
		30
2.3	Abstraction Level Examines Abstraction by The Degree of	
	Complexity of The Mathematical Concept of Thought	31
2.4	Oblique Coordinate Systems	34
2.5	Cartesian Coordinate Systems	35
2.6	Constructing Parallel Coordinates with Four Dimensions	
	Represented by $N = 4$ Vertical Lines, Point $C(c_1, c_2, c_3, c_4)$	36
2.7	Graph of $y = x$ in 2-Dimension Parallel Coordinates	37
2.8	Representation of Point A in Cartesian Coordinate and Parallel	
	Coordinates	39
2.9	Representation of points $A(2,5)$, $B(4, -1)$, and $C(-2, -1)$ in Parallel	
	Coordinates	39
2.10a	A Sketch of Line $\ell \equiv y = 2x + 1$ in Cartesian Coordinate	40
2.10b	A Sketch of $\overline{\ell}$ (-3,-1) in Parallel Coordinates	40
2.11	A Point $\overline{\ell}$ is An Intersection of \overline{A} and \overline{B}	41
2.12	Lines Representing $y = x + b$ in Parallel Coordinates	42
2.13	Lines Representing $y = x + 3$	42
2.14	2D-Regions in Parallel Coordinates	43
3.1	Research Procedure	45
3.2	The Knowledge Elements in this Study	58
4.1	Example of Respondent's Answer Using Vector Approach	64
4.2	Illustration of The Thinking Process of S[8]	74
4.3	The Work of S[46] in Construction of E_{A2}	77
4.4	Participants' Answer on Whiteboard and Lecturer's Explanations	98
4.5	The Result of Group 9 in Constructing E _C	106

4.6	The Example of Participant' Answer Who Failed in Representing	
	Points on 2D Parallel Coordinates	125
4.7	The Example of Participant' Answer Who Failed in Representing	
	Objects both in Cartesian coordinate and 2D Parallel Coordinates	126
4.8	The Example of Participant' Answer Who Failed in Recognizing the	
	Mathematical Concept, Principle or Knowledge in the Context	
	Given	127
4.9	The Example of Participant' Answer who is in Transition to	
	Interiorization Level	129
4.10	The Example of Participant' Answer who Pass Level 3	129
4.11	The Example of Participant' Answer to Problem Number 2 in Level	
	4	130
4.12	The Example of Participant' Answer to Problem Number 4 in	
	Level 4	131
4.13	The Scatter Plot of Association between Test on Analytic	
	Geometry and Test on Parallel Coordinates and Abstraction Test	
	on Parallel Coordinates	133
4.14	Scatter Plot of Participants' Prior Knowledge Test on Cartesian	
	Coordinate	135

LIST OF APPENDIX

Appendix		Page
A-1	Form of Validation	158
A-2	Module of Parallel Coordinates	161
A-3	Design for Clinical Interview	183
A-4	Lesson Plan	185
A-5	Lesson Activity	194
A-6	Rubric for Problems in Parallel Coordinates Topic	203
A-7	Rubric for Prior Knowledge Test	211
A-8	Question Sheet on Parallel Coordinates Test	213
A-9	Scores of Participants in Three Different Tests	214
A-10	Correlation Test between Prior Knowledge Scores and Parallel	
	Coordinates Scores	216
A-11	Correlation Test between Parallel Coordinates Scores and	
	Analytic Geometry Scores	218
B-1	Video Transcript 1	220
B-2	Video Transcript 3	232
B-3	Video Transcript 4	238
B-4	Video Transcript 17	244
B-5	Video Transcript 2	249
B-6	Video Transcript 10	256
B-7	Video Transcript 11, 12, 13	258
B-8	Video Transcript 14	260
B-9	Video Transcript 15	262
B-10	Video Transcript 17	264
B-11	Video Transcript 18	268