

TABLE OF CONTENTS

APPROVAL SHEET	ii
DECLARATION	iii
PREFACE AND ACKNOWLEDGMENTS	iv
ABSTRACT	vi
TABLE OF CONTENTS	viii
LIST OF TABLES	xi
LIST OF FIGURES	xiii
LIST OF APPENDICES	xvi
CHAPTER I : INTRODUCTION	1
1.1 Background of the Research	1
1.2 Problem Statement and Research Questions	6
1.3 Purposes of the Research	6
1.4 Contributions of Research	7
1.5 Explanation of Terms	7
1.6 Dissertation Structure	9
CHAPTER II : THEORETICAL FOUNDATION	10
2.1 Characteristics of Chemical Concepts and its' Learning	11
2.2 Analysis of Solid State Chemistry Concepts	15
2.3 Previous Research of Solid State Chemistry Learning Process	32
2.4 Theoretical Framework Underlying Research	34
2.4.1 Modeling Skills	34
2.4.2 Domain-Specific Critical Thinking and its' Role in Chemistry Learning	37
2.4.3. Nature of Science and Technology (NOST)	41
2.4.4. Model of Educational Reconstruction (MER)	43

2.5 Relevant Research	46
2.6 Conceptual Framework of Learning Design	52
CHAPTER III: RESEARCH METHOD	55
3.1 Research Paradigm	55
3.2 Research Design	56
3.3 Participants and Research Setting	58
3.4 Research Instruments	59
3.4.1 Questions that Measure Domains-Knowledge	59
3.4.2 Questions that Measure Domains-Specific Critical Thinking	61
3.4.3 Questions that Measure Modeling skills	63
3.4.4 Questionnaire that Measure Students' View of NOST Aspects	67
3.6 Data Analysis	67
CHAPTER IV: FINDINGS AND DISCUSSION	73
4.1 Preliminary Research	73
4.1.1 Analysis of scientists' conceptions	73
4.1.2 Analysis of Students' Conceptions	76
4.1.3 Constructing Learning Design Based on MER	79
4.2 Pilot Study	99
4.2.1 Learning Process in Metallic Crystal Concept	99
4.2.2 Learning Process in Covalent Network Concept	106
4.2.3 Learning Process in Ionic Concept	112
4.2.4 Descriptions of Laboratory Activities	118
4.2.4.1 Glass and Polymer Conductive	118
4.2.4.2 Simple Graphene Fabrication in Laboratory Scale	121
4.2.5. Reconstruction of Instructional Materials in SSC Learning Process Based on MER	122
4.3 Implementation of solid state chemistry learning based on MER	126
4.3.1 Students' Conceptual-Knowledge	127
4.3.2 Domain-specific CT skills	141
4.3.3 Modeling Skills	147

4.3.4 Multiple Correlation Analysis	160
4.3.5 Students' Views of NOST Aspects	163
CHAPTER V: CONCLUSION AND RECOMMENDATIONS	172
5.1 Conclusion	172
5.2 Recommendation	173
REFERENCES	175
APPENDICES	187

LIST OF TABLES

Table 2.1	Learning chemistry sequence	13
Table 2.2	Ratio of radii	28
Table 2.3	Properties of Diamond and Graphite	30
Table 2.4	Modeling Skills Categories	36
Table 2.5	Indicator of critical thinking skills	40
Table 3.1	Criteria of domain-knowledge questions	59
Table 3.2	Criteria of domain-specific CT questions	61
Table 3.3	Distribution of question item	63
Table 3.4	Criteria of modeling skills questions	63
Table 3.5	Sample of domain-specific CT (analysis) and modeling skills (Sub-modeling 2) question	65
Table 3.6	Data Collection Techniques and analysis	67
Table 3.7	Scoring guide for domain knowledge	68
Table 3.8	Scoring guide for domain specific CT	69
Table 3.9	Scoring guide for modeling skills	71
Table 3.10	n-gain interpretation based on Hake (1998)	72
Table 4.1	Students' alternative conception about solid state chemistry	78
Table 4.2	Learning Design Base MER	81
Table 4.3	Display of Media	85
Table 4.4	Sample of Worksheet	92
Table 4.5	Example of students' questions on metallic crystal	101
Table 4.6	Students' Hypotheses on metallic crystal	102
Table 4.7	List of investigations plan on metallic crystal	103

Table 4.8	Example of students' questions on covalent network	107
Table 4.9	Students' Hypotheses on covalent network	108
Table 4.10	List of investigations plan on covalent network	109
Table 4.11	Example of students' questions on ionic crystal	114
Table 4.12	Students' Hypotheses on ionic crystal	115
Table 4.13	Investigations plan on ionic crystal	116
Table 4.14	Experimental results of conducting conductive glass	120
Table 4.15	Finding at Pilot Study	122
Table 4.16	Category of Students' Domain-Knowledge before and after learning base MER	129
Table 4.17	Normality test in each domain-knowledge (<i>One-Sample Kolmogorov- Smirnov Test</i>)	134
Table 4.18	Paired sample t-test and Wilcoxon test between pre-test dan post-test students' domain knowledge	135
Table 4.19	Normality test in each domain-specific CT (<i>One-Sample Kolmogorov- Smirnov Test</i>)	142
Table 4.20	Paired sample t-test and Wilcoxon test between pre-test and post-test students' domain-specific CT	143
Table 4.21	Normality test in each modeling skills (<i>One-Sample Kolmogorov- Smirnov Test</i>)	148
Table 4.22	Paired sample t-test and Wilcoxon test between pre-test and post-test students' modeling skills	149
Table 4.23	Analysis of Sub-modeling skill 1 and domain specific CT skills	150
Table 4.24	Analysis of Sub-modeling skill 2 and domain specific CT skills	153
Table 4.25	Coefficient among Variables	161
Table 4.26	Students' engagement on learning process	165
Table 4.27	Students' view NOST	166

LIST OF FIGURES

Figure 2.1a	Electron motion before the electric current flowed	15
Figure 2.1b	Electron motion after the electric current flowed	15
Figure 2.2a	Illustration of Ion / Electron Movement because there is an empty hole	16
Figure 2.2b	Doping Illustration on Polymers	16
Figure 2.3a	Model of band theory	17
Figure 2.3b	The relative energies of occupied and empty bands in a conductor, semiconductor and insulator	17
Figure 2.4a	Semiconductors intrinsic Model before Electrical Flow	18
Figure 2.4b	Semiconductors intrinsic Model after Electrical Flow	18
Figure 2.5a	Semiconductor extrinsic type p model before electric flow	18
Figure 2.5b	Semiconductor extrinsic type p model after electric flow	18
Figure 2.6a	Semiconductor extrinsic type n model before electric flow	18
Figure 2.6b	Semiconductor extrinsic type n model after electric flow	18
Figure 2.7	The reason metal deform	19
Figure 2.8a	Sodium Crystal Crystal Lattice	19
Figure 2.8b	Copper Crystal Crystal Lattice	19
Figure 2.9a	Magnesium metal	21
Figure 2.9b	Copper metal	21
Figure 2.10a	Cubic Closed Packing	21
Figure 2.10b	Hexagonal Closed Packing	21
Figure 2.11a	Composition of Substitution Metal Alloys	23
Figure 2.11b	Composition of Interstition Metal Alloys	23
Figure 2.11c	Composition of Substitution and interstition Metal Alloys	23
Figure 2.12	Metallic crystal and alloy Concept Map	24
Figure 2.13	Model of fragility ionic crystal	25
Figure 2.14a	Schottky Defects	26
Figure 2.14b	Frankel Defects	26

Figure 2.14c	Presence impurities	26
Figure 2.15	NaCl dissolve process on water solvent	27
Figure 2.16a	Ideal ion pairs without the occurrence of polarization	27
Figure 2.16b	The ion pair is polarized equally	27
Figure 2.16c	Extreme polarization will result in the formation of covalent bonds	27
Figure 2.17	Ionic Crystal Concept Map	29
Figure 2.18a	Graphite Structure	31
Figure 2.18b	Diamond Structure	31
Figure 2.19	Relationship among domain-knowledge, domain-specific, and domain-general CT.	39
Figure 2.20	Learning Reconstruction Process	44
Figure 2.21	Learning based on MER to enhance domain-knowledge, modeling skills and domain-specific CT	45
Figure 2.22	Conceptual framework of learning design	54
Figure 3.1	Research Paradigm	55
Figure 3.2	Research Design	57
Figure 4.1	Concept Map, Represented Scientists' Conceptions on Solid State Chemistry Concepts	74
Figure 4.2	Concept Map, Represented Students' Conceptions on Solid State Chemistry Concepts	77
Figure 4.3	Sample of Reconstruction Process	80
Figure 4.4	Steps to Design Learning base MER	82
Figure 4.5	Students' concept map of metallic crystal	100
Figure 4.6	Appearance of Media in Metallic Crystal Topic	104
Figure 4.7	Appearance of student activities on metallic crystals topic	105
Figure 4.8	Appearance students' concept map after pilot study on the metallic crystals topics	105
Figure 4.9	Appearance of media on covalent network concept	100
Figure 4.10	Appearance of students activities on covalent network worksheets	111

Figure 4.11	Sample concept map students after pilot study on the topic of covalent network	112
Figure 4.12	Sample concept map students before pilot study on the topic of ionic crystal	114
Figure 4.13	Appearance of media on ionic crystal	116
Figure 4.14	Appearance of student' activities on the ionic crystal worksheet	117
Figure 4.15	Appearance of students' concept map after intervention on the ionic crystal topic	117
Figure 4.16	Dopant spraying technique on glass	119
Figure 4.17	Measurements of conductive glass resistance	120
Figure 4.18	Process of Reconstruction	125
Figure 4.19a	Conception of Students before Intervention	131
Figure 4.19b	Conception of Students after Intervention	131
Figure 4.20	Average percentages of pretest, post-test, and n-gain scores of students on each domain-knowledge	137
Figure 4.21	Average percentages of pretest, post-test, and n-gain scores of students on each domain-specific CT	144
Figure 4.22	Average percentages of pretest, post-test, and n-gain scores of students on each modeling skills	149
Figure 4.23	Scatter plot of Multiple regression	161

LIST OF APPENDICES

Appendix A	Students' Conceptions	187
Appendix B	Scientists' Conceptions	193
Appendix C	Concept Analysis	194
Appendix D	Reconstruction for each concept	203
Appendix E	Learning Design	234
	1. Metallic Crystal	234
	2. Ionic Crystal	238
	3. Covalent Network	242
Appendix F	Instruments	245
	1. Domain-Specific CT skills	245
	2. Modeling skills	266
	3. Questionnaire	282
Appendix G	Results of Validation by Experts	287
Appendix H	Results of Reliability	289
Appendix I	Worksheet	290
	1. Metallic Crystal	290
	2. Ionic Crystal	298
	3. Covalent Network	304
	4. Conductive Glass and DSSC	310

	5. Conductive Polymer	314
Appendix J	Storyboard of Media	316
	1. Ionic Crystal	316
	2. Metallic Crystal	323
	3. Covalent Network	344
Appendix K	SPSS Output	353