THE EFFECTIVENESS OF THE BRAINSTORMING TECHNIQUE TOWARD ENHANCING CREATIVE AND CRITICAL THINKING SKILLS AMONG SECONDARY IRAQI PHYSICS STUDENTS

FARAH M.R. HAMZA ALRUBAI

THESIS SUBMITTED IN FULFILMENT OF THE REQUIREMENT FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

FACULTY OF EDUCATION
UNIVERSITY OF MALAYA
KUALA LUMPUR

2014
UNIVERSITI MALAYA

ORIGINAL LITERARY WORK DECLARATION

Name of Candidate: FARAH M.R. HAMZA ALRUBAI (IC/Passport No: A5413465)
Registration/Matric No: PHA110008

Name of Degree: DOCTOR OF PHILOSOPHY


THE EFFECTIVENESS OF THE BRAINSTORMING TECHNIQUE TOWARDS ENHANCING CREATIVE AND CRITICAL THINKING SKILLS AMONG SECONDARY IRAQI PHYSICS STUDENTS
Field of Study: SCIENCE EDUCATION

I do solemnly and sincerely declare that:

(1) I am the sole author/writer of this Work;
(2) This Work is original;
(3) Any use of any work in which copyright exists was done by way of fair dealing and for permitted purposes and any excerpt or extract from, or reference to or reproduction of any copyright work has been disclosed expressly and sufficiently and the title of the Work and its authorship have been acknowledged in this Work;
(4) I do not have any actual knowledge nor do I ought reasonably to know that the making of this work constitutes an infringement of any copyright work;
(5) I hereby assign all and every rights in the copyright to this Work to the University of Malaya (“UM”), who henceforth shall be owner of the copyright in this Work and that any reproduction or use in any form or by any means whatsoever is prohibited without the written consent of UM having been first had and obtained;
(6) I am fully aware that if in the course of making this Work I have infringed any copyright whether intentionally or otherwise, I may be subject to legal action or any other action as may be determined by UM.

Candidate’s Signature

Date:

Subscribed and solemnly declared before,
Witness’s Signature

Date:

Name:

Designation:
ABSTRACT

Past research has established that Iraqi education lacks integration of creative and critical thinking skills in the classroom. Thus, the main purpose of this study was to investigate the effectiveness of the brainstorming technique towards enhancing creative and critical thinking skills among secondary Iraqi physics students.

First, the existing procedures for the brainstorming technique which comprised three original steps, problem identification, idea generation and idea evaluation were identified through a literature review. Three new steps, namely selection of the best idea, implementation and problem solving were added in this study. A mixed-method methodology was employed in the study. For the quantitative aspect, a quasi-experimental design was utilised. A total of 80 students from two intact classes in the Iraqi Saba School participated in the study. One class was taken as the control group (N = 41) who were taught physics via the traditional method while the other class was the experimental group (N = 39) who were taught physics via the brainstorming technique for four months. The Physics achievement test was prepared specifically for this study for the purpose of establishing homogeneity between the control and experimental groups. The independent variable was the method of instruction, either the brainstorming technique or traditional method. The dependent variables were performance in creative and critical thinking tests. The Torrance Test of Creative Thinking (TTCT) and the Watson Glaser Critical Thinking (WGCT) were modified and adapted to measure the respective dependent variables. The problem solving tasks in these tests were based on four physics topics namely, reflection of light, refraction of light, thin lenses, and color and electromagnetic spectrum. In the TTCT, there were three dimensions of creative thinking, fluency, flexibility and originality. For the WGCT, the five dimensions were inference, recognizing assumptions, deduction,
interpretation and evaluating arguments. Additionally, students’ perceptions about the brainstorming technique were captured through qualitative interviews and open-ended questionnaires.

Results of the t-test showed that the experimental and control groups were equal in the TTCT, WGCT and in physics achievement tests before the intervention. After the four months intervention, results of the multivariate analysis of variance (MANOVA) and analysis of covariance (ANCOVA) showed that there were significant differences in creative thinking overall and in the sub skills of fluency, flexibility, and originality between the groups. Results for the critical thinking test showed that there were statistically significant differences in critical thinking overall and in the sub skills recognizing assumptions, interpretation, and evaluating arguments between the groups. However, analysis showed there was no significant difference for the two sub skills of critical thinking which were inference and deduction skills.

The study revealed that the brainstorming technique could create scaffolds for the enhancement of creative and critical thinking, as the students proceeded through the various steps of the technique. Furthermore, students characterized brainstorming as an effective teaching technique for learning physics. Nonetheless, the Iraqi students also suggested several ideas to improve the brainstorming technique for the teaching and learning of physics.
ABSTRAK

Kajian lepas telah menunjukkan pendidikan di Iraq kurang dari aspek integrasi kemahiran berfikir kreatif dan kritikal dalam bilik darjah. Oleh itu, tujuan utama kajian ini adalah untuk menyiasat keberkesanan teknik brainstorming dalam peningkatan kemahiran berfikir secara kreatif dan kritikal dalam kalangan murid Fizik sekolah menengah Iraq.


ACKNOWLEDGEMENT

In the name of ALLAH, the most gracious and merciful:

I thank ALLAH who gave me the patience and strength during this period of study.

After that, I would like to express my thanks to my supervisor, Professor Dr. Esther Daniel for providing me the necessary assistance and guidance to complete this research.

I would like to convey my heartfelt gratitude and thanks to my husband (Saif) for his wonderful help and support. I wish to also thank my dear parents for their unending encouragement and assistance during my period of study.
# Table of Contents

## CHAPTER 1 INTRODUCTION

1.0 Introduction  
1.1 Background of Study  
1.2 The Education System in Iraq  
1.3 The Statement of Problem  
1.4 Objectives of Study  
1.5 Research Questions  
1.6 Research Hypotheses  
1.7 Rationale of the Study  
1.8 Significance of Study  
1.9 Definition of Terminologies  
1.10 Limitations of the Study  
1.11 Chapter Summary

## CHAPTER 2 LITERATURE REVIEW

2.0 Introduction  
2.1 Brainstorming Technique  
2.1.1 Different Techniques of Brainstorming  
2.1.2 Brainstorming for Productivity (Idea Generation)  
2.1.3 Brainstorming for Creative Thinking  
2.1.4 Brainstorming for Critical Thinking  
2.1.5 Students’ Perception of Brainstorming Technique  
2.1.6 Methodology Utilised in Previous Studies  
2.2 Creativity and Creative Thinking  
2.2.1 Creative Thinking Skills  
2.2.2 Characterizations of a Creative Thinker  
2.2.3 Procedures of Creative Thinking  
2.2.4 Creativity Studies in Science Education  
2.2.5 The Challenge of Enhancing Creative Thinking in Science Education  
2.2.6 Tests for Measuring Creative Thinking Skills  
2.2.7 Teaching Approaches Reported to Promote Creative Thinking
2.3 Critical Thinking
   2.3.1 Core Critical Thinking Skills 65
   2.3.2 Characterizations of a Critical Thinker 69
   2.3.3 Procedures of Critical Thinking 71
   2.3.4 Empirical Studies for Critical Thinking in Science Education 73
   2.3.5 The Challenge of Enhancing Critical Thinking in Science Education 74
   2.3.6 Tests for Measuring Critical Thinking Skills 76
   2.3.7 Instructional Strategies Used to Promote Critical Thinking 77
2.4 Research Combining both Creative and Critical Thinking 80
2.5 Creative and Critical Thinking Related to the Cognitive Domain of Bloom’s Taxonomy 82
2.6 Thinking Skills 84
2.7 The Learning Process and Problem-Solving 85
2.8 The Current Study Location among Previous Studies 88
2.9 Chapter Summary 89

CHAPTER 3 CONCEPTUALIZATION OF THE STUDY 90
3.0 Introduction 90
3.1 Conceptual Framework 91
3.2 Theoretical Framework 95
   3.2.1 Developing Theories of Brainstorming Technique 95
      3.2.1.1 Search of Idea in Associative Memory Theory (SIAM) 96
      3.2.1.2 Piaget’s Cognitive Development Theory (1929) 102
      3.2.1.3 Vygotsky’s Socio-Cultural Theory (1978) 104
   3.2.2 Interpretation of Search for Ideas in Associative Memory, Piaget’s Theory and Vygotsky’s Theory for the Present Study 106
3.3 Preparing Procedural Steps of the Brainstorming Technique for Use in this Study 108
   3.3.1 Thinking Models 108
   3.3.2 Problem-Solving Models 111
3.4 Scope of the Study 120
3.5 Chapter Summary 121

CHAPTER 4 METHODOLOGY 122
4.0 Introduction 122
4.1 Research Design 123
  4.1.1 The Researcher and the Participating Teachers 125
4.2 Research Variables 125
  4.2.1 Independent Variables 126
  4.2.2 Dependent Variables 126
4.3 Research Sample 127
4.4 Research Instruments 128
  4.4.1 Quantitative Data Collection Methods 129
    4.4.1.1 Creative Thinking Test 129
    4.4.1.2 Pilot Study of the Creative Thinking Test 132
    4.4.1.3 Critical Thinking Test 134
    4.4.1.4 Pilot Study of the Critical Thinking Test 137
    4.4.1.5 Physics Achievement Test 139
    4.4.1.6 Pilot Study of the Physics Achievement Test 140
    4.4.1.7 Students’ Perceptions of the Brainstorming Technique 142
  4.4.2 Qualitative Data Collection Methods 143
    4.4.2.1 Observation of Students 144
    4.4.2.2 Audio and Visual Data 145
    4.4.2.3 Students’ Feedback Journal 147
    4.4.2.4 Teacher Comments 148
    4.4.2.5 Student Interviews 149
4.5 Training of Physics Teacher to Use Brainstorming Technique and the Observer 150
4.6 Research Intervention 153
  4.6.1 The Steps of the Brainstorming Session 153
  4.6.2 The Planning and Execution of the Intervention 157
4.7 Analysis of Data 164
  4.7.1 Test Data 164
  4.7.2 Survey Data 165
  4.7.3 Observation, Interview, Student Feedback Journal and Teacher Comments Data 165
4.8 Management of Data 167
4.9 Reliability and Validity Issues of the Findings 180
4.10 Chapter Summary 185
CHAPTER 5 FINDINGS AND DISCUSSION

5.0 Introduction

5.1 Creative Thinking Skills, Critical Thinking Skills and Physics Achievement before the Brainstorming Technique Intervention
   5.1.1 Pre- Test of Creative Thinking
   5.1.2 Pre –Test of Critical Thinking
   5.1.3 Pre- Test of Physics Achievement

5.2 Creative and Critical Thinking after Utilizing the Brainstorming Technique
   5.2.1 Post test of Creative Thinking
   5.2.2 Post Test of Critical Thinking

5.3 The Enhancement of Creative and Critical Thinking Skills
   5.3.1 Key Elements in the Enhancement of Creative and Critical Thinking Skills
      5.3.1.1 Scaffolding through the Brainstorming Technique
      5.3.1.2 Motivation through the Utilization of the Brainstorming Technique
      5.3.1.3 Mental Processes in the Enhancement of Creative and Critical Thinking

5.4 Students Perceptions of Learning via THE Brainstorming Technique
   5.4.1 Learning outcomes Part A
      5.4.1.1 Application of knowledge and skills
      5.4.1.2 Communications skill
      5.4.1.3 Independent Learning
   5.4.2 Features of Brainstorming Technique Part B
   5.4.3 Open-Ended Questions Part C
      5.4.3.1 Characteristics of the Physics Lessons
      5.4.3.2 Learning Outcomes
      5.4.3.3 Problems Faced Students
      5.4.3.4 Suggestions for Improvements

5.5 Chapter Summary

CHAPTER 6 SUMMARY, IMPLICATIONS AND CONCLUSION

6.0 Introduction

6.1 Summary of research findings
6.2 Implications of the Study 299
6.3 Suggestions for Future Studies 303
6.4 Conclusion 304

REFERENCES 306
**List of Figures**

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Brainstorming technique for solving problems and decision making</td>
<td>5</td>
</tr>
<tr>
<td>1.2</td>
<td>Features of brainstorming technique</td>
<td>8</td>
</tr>
<tr>
<td>2.1</td>
<td>Influencing factors of group brainstorming effectiveness</td>
<td>36</td>
</tr>
<tr>
<td>2.2</td>
<td>The two-stage theory of production blocking</td>
<td>39</td>
</tr>
<tr>
<td>2.3</td>
<td>Three processes to reduce production loss in group brainstorming</td>
<td>41</td>
</tr>
<tr>
<td>2.4</td>
<td>Creative Thinking Skills</td>
<td>51</td>
</tr>
<tr>
<td>2.5</td>
<td>Characterization of creative thinkers</td>
<td>52</td>
</tr>
<tr>
<td>2.6</td>
<td>Creative thinking process</td>
<td>55</td>
</tr>
<tr>
<td>2.7</td>
<td>Relationship between disposition and critical thinking skills</td>
<td>68</td>
</tr>
<tr>
<td>2.8</td>
<td>Bloom Taxonomy of the cognitive domain</td>
<td>84</td>
</tr>
<tr>
<td>2.9</td>
<td>Relationship between learning, knowledge acquisition and problem solving</td>
<td>87</td>
</tr>
<tr>
<td>3.1</td>
<td>Conceptual framework of the study</td>
<td>94</td>
</tr>
<tr>
<td>3.2</td>
<td>Stage1 process of knowledge activation in Long-Term Memory</td>
<td>99</td>
</tr>
<tr>
<td>3.3</td>
<td>the researcher’s interpretation the stage2 (Ideas generation) of the</td>
<td>101</td>
</tr>
<tr>
<td></td>
<td>brainstorming technique</td>
<td></td>
</tr>
<tr>
<td>3.4</td>
<td>Theoretical framework of the study by interpreting Piaget theory</td>
<td>104</td>
</tr>
<tr>
<td>3.5</td>
<td>Theoretical framework of the study by interpreting Vygotsky’s theory</td>
<td>106</td>
</tr>
<tr>
<td>3.6</td>
<td>Synthesis of SIAM, Piaget and Vygotsky for learning during</td>
<td>107</td>
</tr>
<tr>
<td></td>
<td>brainstorming technique</td>
<td></td>
</tr>
<tr>
<td>3.7</td>
<td>Merger of three types of cognitive skills to solve the problem</td>
<td>112</td>
</tr>
<tr>
<td>3.8</td>
<td>Learning outcomes from brainstorming technique in this study</td>
<td>114</td>
</tr>
<tr>
<td>3.9</td>
<td>Procedural steps for brainstorming technique in this study</td>
<td>119</td>
</tr>
<tr>
<td>4.1</td>
<td>The six steps in the Brainstorming processing stages</td>
<td>156</td>
</tr>
<tr>
<td>4.2</td>
<td>Flowchart of procedure of the study</td>
<td>163</td>
</tr>
<tr>
<td>4.3</td>
<td>Design of the study</td>
<td>184</td>
</tr>
<tr>
<td>5.1</td>
<td>Histogram for the control and experimental groups for the creative thinking test</td>
<td>190</td>
</tr>
<tr>
<td>5.2</td>
<td>Histogram for control and experimental groups for critical thinking test</td>
<td>195</td>
</tr>
<tr>
<td>5.3</td>
<td>Histogram for the control and experimental groups for the physics achievement test</td>
<td>201</td>
</tr>
</tbody>
</table>
Figure 5.4 Comparison between the means of experimental and control group in creative thinking test

Figure 5.5 Compression between the means of experimental and control group in critical thinking test

Figure 5.6 Elements that have an effect on enhancing creative and critical thinking

Figure 5.7 Compare the student's answers in pre-post test of creative thinking

Figure 5.8 Components of the inference skill

Figure 5.9 Summary of key elements that enhancement of creative and critical thinking skills.
List of Tables

Table 2.1 Differences between individual and group brainstorming 40
Table 3.1 Past studies pertaining to the brainstorming technique 92
Table 3.2 Link between the problem-solving process, science process skills, creative thinking, and critical thinking investigated in this study 113
Table 4.1 Quasi-Experimental design used in this study 124
Table 4.2 Sample distribution for experimental and control group 128
Table 4.3 Example of a modification made for original creative thinking tests 130
Table 4.4 Scoring criteria of creative thinking skills 131
Table 4.5 Example of a modification made for creative thinking test after pilot study 132
Table 4.6 Correlation coefficients between each creative thinking skill and the total score of the test 133
Table 4.7 Cronbach's alpha coefficient for creative thinking skills 134
Table 4.8 Distribution of contents the critical thinking test 135
Table 4.9 Example of modification made for original critical thinking tests 136
Table 4.10 Correlation coefficients between each critical thinking skill and the total score 138
Table 4.11 Cronbach's alpha coefficient for critical thinking skills 139
Table 4.12 Example of a modification made for physics achievement test after pilot study 141
Table 4.13 Example of modification made for survey of student perceptions 143
Table 4.14 Instructions for physics teacher during brainstorming sessions 152
Table 4.15 Brainstorming technique procedure used for the experimental group 159
Table 4.16 Learning activity for experimental group by using brainstorming technique 161
Table 4.17 Learning activity for control group by using traditional method 162
Table 4.18 Themes derived for understanding the development of creative and critical thinking 169
Table 4.19 Themes derived for understanding the perceptions of students of teaching via brainstorming technique 175
Table 5.1 Kolmogorov-Smirnov and Shapiro-Wilk Tests for normality distribution 188
Table 5.2 Levene’s Test of Homogeneity of Variances 190
Table 5.3 t-test for creative thinking test 191
Table 5.4 Kolmogorov-Smirnov and Shapiro-Wilk Tests for normality distribution 194
Table 5.5 Levene Test of Homogeneity of Variances 196
Table 5.6 t-test for critical thinking test 197
Table 5.7 Kolmogorov-Smirnov and Shapiro-Wilk Tests for normality distribution 200
Table 5.8 Levene Test of Homogeneity of Variances 202
Table 5.9 t-test results for the physics achievement test 202
Table 5.10 Comparison of pre-test and post – test results for creative thinking 204
Table 5.11 Analysis of variance of gain scores for creative thinking test 208
Table 5.12 Within -subject contrast test for the creative thinking 210
Table 5.13 ANCOVA results for the creative thinking test 213
Table 5.14 MANOVA result for the creative thinking test 215
Table 5.15 A summary of the results of creative thinking test 217
Table 5.16 Comparison of pre-test and post – test results for critical thinking 219
Table 5.17 Analysis of variance of gain scores for critical thinking test 223
Table 5.18 Within -subject contrast test for the critical thinking 226
Table 5.19 ANCOVA result for critical thinking test 229
Table 5.20 MANOVA result of critical thinking test 232
Table 5.21 A summary of the results of the critical thinking test 235
Table 5.22 Compare the student's answers in pre-post test of critical thinking 268
Table 5.23 Physics students’ perceptions of brainstorming technique- part A 273
Table 5.24 A summary of the results of the students’ perceptions of application of knowledge and skills 275
Table 5.25 A summary of the results of the students’ perceptions of communication skills 276
Table 5.26 A summary of the results of the students’ perceptions of independent learning 278
Table 5.27 Part B: Students’ reflections on brainstorming specific features 280
# List of Appendices

<table>
<thead>
<tr>
<th>APPENDIX</th>
<th>Appendix Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Creative Thinking Test</td>
<td>328</td>
</tr>
<tr>
<td>B</td>
<td>Critical Thinking Test</td>
<td>334</td>
</tr>
<tr>
<td>C</td>
<td>Physics Achievement Test</td>
<td>346</td>
</tr>
<tr>
<td>D</td>
<td>Survey of Students’ Perception of Learning Using Brainstorming Technique</td>
<td>353</td>
</tr>
<tr>
<td>E</td>
<td>Observation Protocol</td>
<td>359</td>
</tr>
<tr>
<td>F</td>
<td>Students Feedback Journal</td>
<td>365</td>
</tr>
<tr>
<td>G</td>
<td>Interview Protocol</td>
<td>366</td>
</tr>
<tr>
<td>H</td>
<td>Example of Data</td>
<td>368</td>
</tr>
<tr>
<td>I</td>
<td>Groups of brainstorming technique</td>
<td>384</td>
</tr>
<tr>
<td>J</td>
<td>Tests (Arabic Version)</td>
<td>386</td>
</tr>
<tr>
<td>K</td>
<td>Physics students’ perceptions of brainstorming technique</td>
<td>408</td>
</tr>
</tbody>
</table>