Effects of research-based learning integrated with cognitive training for enhancing critical thinking skill

R Apaivatin, S Srikoon* and A Khemkhan
Curriculum and Instruction, School of Education, University of Phayao, Phayao 56000, Thailand
*Corresponding author’s e-mail address: sanit.sn@up.ac.th

Abstract. The research aimed to 1) to develop the lesson plans using the research-based learning integrated with cognitive training for grade 9 students and 2) to compare the students’ critical thinking skill between being taught by researched-based learning integrated with cognitive training and by traditional teaching method. The research samples using in this experimental research were grade 9 students of Phayamengrai School, Chiang Rai, Thailand in the academic year 2019 consisting of two samples: the experimental group taught by using research-based learning integrated with cognitive training was 30 students and the control group was 30 students taught by using the traditional lesson, selected by using cluster random sampling. The research instruments were the eight lesson plans focusing on earth and space science spending teaching 12 hours with the high reliability coefficient of 0.86 and the critical thinking skill test with the validity of 0.808. The data were analyzed by using mean, standard deviation and the MANOVA. The finding was the students’ critical thinking skills between two groups were significantly different. Obviously, the students in the experiment condition improved slightly more than those in traditional condition.

1. Introduction
Research-based learning is one of the learning models which are associated with analyzing, synthesizing and evaluating activities. These are able to improve the students’ integration and application of knowledge. The research-based learning is conducted under constructivism covering four aspects of meaningful learning consisting of constructing students’ understanding, developing prior knowledge, involving social interaction process and achieving through real world experience. Accordingly, using the research is a crucial way to enhance students’ effective learning quality because this composes of the systematical research components which are background, procedures, implementation, research results, discussion and publication of the finding results [15]. What’s more, the research based-learning is used to support the teaching with constructivists’ strategies focusing on an authentic learning, problem solving, cooperative learning, hands on and inquiry discovery approach [10]. Also, it results in 21st competencies in five main skills, adaptability, complex communication skills, problem-solving skills, self-management and systems thinking [7]. Moreover, it is able to cause other skills required to deal with the 21st century challenge such as work ethic, collaboration, communication, social responsibility, critical thinking and problem solving.

On the other hand, the research-based learning has been considered for decades due to its usefulness, unfortunately the research-based learning in classroom has not been adopted as a teaching
method [10]. Obviously, the Office of the Education Council found that most of the Thai learners lacked in thinking skills: Analytical thinking, Synthesis thinking, Critical thinking, Creative thinking, Reflective thinking and Vision [14]. This conformed to the state and problems in classroom showing that the Thai learners were short of critical thinking and scrutinizing skills leading to conclude and make decisions logically. Besides, the result of the national seminar to upgrade the quality of science education: Basic Education 2012, organized by the Office of the Basic Education Commission, the Kenan Foundation Asia and the institute for the Promotion of Teaching Science and Technology for the nationwide teachers helping brainstorm upon the result of students’ achievement on science and mathematics in the Program for International Student Assessment (PISA), found that the cause of Thai students’ low-level score was lacking in critical thinking skill. Apart from that, the ranking of educational competition held by IMD in 2001 showed that Thailand was ranked in 51st from 57 countries worldwide. In short, these results illustrated the quality of science education of Thai students that was out of date in learning and teaching process contributing students’ inappropriate thinking process [12]. Therefore, the Thai education has to adjust the learning’s main emphasis especially boosting the critical thinking skill which is essential for applying to use in daily life and real life along with integrating with all fields. Hence, it is important to create human resources with critical thinking, problem solving, communication skills and technology literacy requires adequate education and learning through the 21st century education by training students to improve their critical thinking skills especially the teacher had better try to apply a proper teaching method which allows them to respond to this phenomenon.

Working memory means the ability to hold in mind and operate small amounts of information for concise periods of time which is a significant requirement for many everyday tasks and is considered a critical influence on educational progress during childhood [5]. Consequently, cognitive training has been recognized of potential therapeutic benefit for remediation of cognitive shortage associated with neurodevelopmental disorders, acquired brain damage and aging [1], [6], [16]. In the classroom, it is better way to use the research-based learning integrated with cognitive training adapting the integration of the theoretical cognition base with in the use of appropriate data collection and analysis procedures to examine and study an occurrence. Likewise, the students should be involved in a learning process where the attention, working memory, mood and practice emerge and interconnect one another. They also need theoretically oriented method courses and need to work on skills and capabilities including generic skills such as critical and analytical thinking, information retrieval and evaluation; and problem solving. Furthermore, it can promote active learning which students learn most when they are actively involved in developing both their cognitive and skills leading the students apply concepts learned in the classroom to real life situation [2]. Undoubtedly, the research-based learning integrated with cognitive training is able to not only expand and progress the students’ abilities but also help Thai students lacking in critical thinking skill weave powerful intellectual and practical connections between frontiers and their own learning.

2. Objective of the study
This research attempts
2.1 to develop the lesson plans using the research-based learning integrated with cognitive training for grade 9 students.
2.2 to compare the students’ critical thinking skill between being taught by researched-based learning integrated with cognitive training and by traditional teaching method.

3. Details Experimental
3.1 Research design
This research was the experimental research using Pretest Posttest Control Group Design. The content using to develop the eight lesson plans for grade 9 students who attended fundamental science course (SC23101) in Semester 1 in the academic year 2019 spending 12 hours focused on the earth and space science based on the Basic Education Core Curriculum BE.2551 (AD.2008) [13].

3.2 Population and sample group

3.2.1. The population of this research was grade 9 students in the academic year 2019 of Phayamengrai School, Chiang Rai, Thailand. There were three classes consisting of 90 students totally.

3.2.2. The sample of this research was grade 9 students in the academic year 2019 of Phayamengrai School, Chiang Rai, Thailand, gaining two classes by cluster random sampling. Grade 9/1 students were 32 students who involved in the experimental group and grade 9/3 students were 30 students who were in the control group.

3.3 Variable

This research used two variables which were independent variable and dependent variable.

3.3.1. The independent variable was the researched-based learning integrated with cognitive training teaching method.

3.3.2. The dependent variable was the students' critical thinking skill consisting of four critical thinking skills: formulating research problem, scrutinizing data, formulating research hypothesis and generalizability [8].

3.4 Material

This research used two materials which were the lesson plans using the researched-based learning integrated with cognitive training teaching method and the critical thinking skill test.

3.4.1. The eight lesson plans which were 1) the raining season formation, 2) the waxing and waning, 3) the model of waxing and waning, 4) the solar system formation, 5) the solar system, 6) the orbit of planets, 7) the space technology and 8) the space exploration using the researched-based learning integrated with cognitive training teaching method focusing on the earth and space science based on the Basic Education Core Curriculum BE.2551 (AD.2008) [13] for grade 9 students who attended fundamental science course (SC23101) in Semester 1, Academic Year 2019 spending 12 hours. The researcher studied other scholars' teaching methods in terms of the researched-based learning and cognitive training and adjusted into six steps of researched-based learning integrated with cognitive training teaching method which were Step 1 Identifying the research problem, Step 2 Hypnotizing, Step 3 Hypothesis testing, Step 4 Data collecting, Step 5 Analyzing data and Step 6 Concluding. These eight lesson plans were examined the content validity by the five experts in scientific and curriculum and instruction fields, the results of all eight lesson plans showed with the high reliability coefficient of 0.86, the content validity ranging using the Index of Item-Objective Congruence (IOC) from 0.50 to 1.00, and the discrimination indices ranging from 0.56 to 0.72.

3.4.2. The critical thinking skill test upon formulating research problem, scrutinizing data, formulating research hypothesis and generalizability contained 40 questions which were multiple choice adapted from Pattanapon [8]. The validity of this test was 0.808. The difficulty indices of this test were ranging from 0.222 to 0.798. And, the discrimination indices of this test were ranging from 0.200 to 0.513.

3.5. Data Collection

The researcher collected the data as following.
3.5.1. The researcher asked for the permission from the school director, after that told the students who involved in this study to understand the research objectives clearly.

3.5.2. Before teaching, the researcher used the critical thinking skill test both experimental and control groups.

3.5.3. The researcher taught both experimental group using the researched-based learning integrated with cognitive training teaching method following developed lesson plans and control groups using the traditional teaching method following the lesson plans of the Institute for the Promotion of Teaching Science and Technology.

3.5.4. After finishing teaching for a while, the researcher had both groups do the critical thinking skill test.

3.6. Data Analysis

The researcher analyzed the data by comparing the results of critical thinking skills between the posttest of the experimental group and the control group. The data were analyzed by using mean, standard deviation and the MANOVA in this research.

4. Results

Results of this research were presented as following:

The result of the students' critical thinking skills between the experimental group and the control group showed in table 1.

| Sample Group | N  | Time    | \(\bar{x}\) | S.D. |
|--------------|----|---------|-------------|------|
| Experimental | 32 | Pre-test | 19.34       | 3.33 |
|              | 32 | Post-test| 24.15       | 2.65 |
| Control      | 30 | Pre-test | 16.86       | 3.23 |
|              | 30 | Post-test| 22.40       | 2.84 |

This table revealed that the average post-test score of the experiment group was 24.15 and the standard deviation was 2.65. Also, the average post-test score of the control group was 22.40 and the standard deviation was 2.84. The average pre-test score of the experiment group was 19.34 and the standard deviation was 3.33. Also, the average post-test score of the control group was 16.86 and the standard deviation was 3.23. The comparing results on students' critical thinking skills of the study between the experimental group and the control group showed in table 2.

| Effect         | Statistics     | Value | F    | df  | Sig. |
|----------------|----------------|-------|------|-----|------|
| Group          | Pillar's Trace | 0.40  | 9.63 | 4   | 0.00 |
|                | Wilks' Lambda  | 0.60  | 9.63 | 4   | 0.00 |
|                | Hotelling's Trace | 0.68  | 9.63 | 4   | 0.00 |
|                | Roy's Largest Root | 0.68  | 9.63 | 4   | 0.00 |

This table represented that the average score on students' critical thinking skills of the experiment group after completion (\(\bar{x}=24.15\)) was higher than the control group (\(\bar{x}=22.40\)) at 0.01 significant level.
Hence, the average post-test score of the experimental group which used the researched-based learning integrated with cognitive training teaching method was higher than the control group which used the traditional teaching method.

5. Discussion

Form the research result, the researcher found that both the researched-based learning integrated with cognitive training teaching method and the traditional teaching method suggesting by the Institute for the Promotion of Teaching Science and Technology were able to enhance the students' critical thinking skills. Probably, the 5E instructional model, one of the inquiry-based teaching and learning methods, which was suggested by the Institute for the Promotion of Teaching Science and Technology as the traditional teaching model was based upon cognitive psychology, constructivist-learning theory and best practices in science teaching. This teaching model comprises five steps that are Engage, Explore, Explain, Elaborate and Evaluation. Also, it was declared that when using this approach, students are able to redefine, reorganize, elaborate, and change their initial concepts through self-reflection and interaction with their peers and their environment. The students interpret objects and phenomena and internalize those interpretations in terms of their current conceptual understanding [3]. Apart from that the inquiry-based learning which is a dynamic learning approach is student center learning to build critical thinking skills, reasoning and subsequent creativity. It was explained that inquiry-based learning techniques enable to motivate students' critical thinking skills by letting students involve in exploring, asking, making, discovering and testing discoveries to seek new insights [9], [11].

Similarly, the research-based learning can devise a general question, overview of a research literature, defining the question, planning research activities, clarifying methods, undertaking investigation, analyzing data, interpretation and consideration of results and report and presentation of results. So, its implementation can strengthen students' critical thinking skills emerging from the abilities of interpretation, analysis, evaluation, inference and explanation [15]. Therefore, both teaching methods can be used to train students' critical thinking skills thanks to learning not only physically but also mentally through the research process which is experimenting activities, observing, asking, analyzing data and making conclusions.

In conclusion, the teacher had better to use different teaching methods along with the context to increase the students' experiences effectively. Besides, an effective teaching method which can help students engage with the subject matter and enjoy learning activity influences students' academic performance [4]. Providing all teachers realize about choosing the appropriate teaching method to enhance the students who lack any expected experiences, the students can achieve the educational standard and apply to use in their daily lives.

6. Acknowledge

This study was supported by the Unit of Excellence in Research Methodology of Innovations and Learning Sciences based on Educational Neurosciences Research Fund, University of Phayao, Thailand.
References

[1] Anguera J A Boccafuso J Rintoul J L Al-Hashimi O Faraji F Jonowich J Kong E Larraburo Y Rolle C Johnston E and Gazzaley A 2013 Video game training enhances cognitive control in older adults Nature 501 97-101

[2] Arora V P S Parul S and Neha G 2017 Higher Education Faculty Career Orientation and Advancement Research Based Learning (ECGE)

[3] Bybee R & Landes N M 1990 Science for Life and Living: An Elementary School Science Program from Biological Sciences Improvement Study (BSCS) The American Biology Teacher 40(2) 30-34

[4] Joel S M David M M & Stephen N M 2018 Relationship between Teaching Method and Students’ Performance in Mathematics in Public Secondary Schools in Dadaab Sub Country, Garissa Country, Kenya Journal of Research & Method in Education (IOSR-JRME) 8(5) 59-63

[5] Gathercole S E Pickering S J Knight C and Stemann Z 2003 Working memory skills and educational attainment: evidence from national curriculum assessments at 7 and 14 years of age Applied Cognitive Psychology 18 1-16

[6] Klingberg T Fernell E Olesen P J Johnson M Gustafsson P, Dahlstrom K, Gillberge C G Forssberge H and Westerberge H 2005 Computerized training of working memory in children with ADHD: a randomized, controlled trial J Am Acad Child Adolese Phychiatry 44 177-186

[7] Koenig J A and Rapporteur 2011 Assessing 21st century skills: summary of a workshop (National Academies Press, Washington DC)

[8] Orapin P 2008 A Construction of Critical Thinking Test for the Third Level Students in Secondary School, Nakhonsawan Educational Service Area Office (Bangkok, Faculty of Education, Srinakharinwirot University)

[9] Paulu N & Martin M 1992 Helping Your Child Learn Science (New York: U.S., Department of Education Office of Educational Research and Improvement)

[10] Poonpan S and Siriphan S 2001 Indicators of research-based learning instructional process: a case study of best practice in a primary school. Bangkok, Faculty of Education, Chulalongkorn University

[11] Spencer T L & Walker T M 2011 Creating a Love for Science for Elementary Students through Inquiry-based Learning Journal of Virginia Science Education 4(2) 18-24

[12] The Institute for the Promotion of Teaching Science and Technology 2012 Annual Report 2012 (Bangkok)

[13] The Office of the Basic Education Commission 2008 Basic Education Core Curriculum B.E. 2551 (A.D 2008) Bangkok: Ministry of Education

[14] The Office of the Education Council 2009 The prososal of reforming Thai Education in the second decade (2009 -2018) Bangkok, Phrik Wan Graphic Co.,Ltd

[15] Susiani T Salimi M and Hidayah R 2018 Research Based Learning (RBL): How to Improve Critical Thinking Skill? SHS Web of Conference 42 1-6

[16] Westerberg H Jacobaeus H Hirvikoski T Cleverper P Ostensson M L Bartfai A and Klingberg T 2007 Computerized working memory training after stroke: a pilot study Brain Inj 22 21-29