THE EFFECT OF CONCEPT VISUALISATION ON CRITICAL THINKING SKILLS IN SCIENCE LEARNING AMONG MALAYSIAN PRIMARY SCHOOL CHILDREN

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ABSTRACT

It was necessary to promote critical thinking skills among students because a lack of critical thinking skills among students had been a persistent drawback in primary science education. According to studies, the idea visual image was used to improve critical thinking skills with some techniques being more practical than others. The study's goal was to determine whether conception mapping (a conception visual image technique) was an effective technique for developing essential thinking ability in science learning among Malaysian primary school children. For this purpose, students using concept mapping were compared to students using mind mapping (the existing visualisation technique). A quasi-experimental methodology was used with a total of seventy students; thirty-five students in the mind map class and the remaining was in the concept map class. The concept map class used concept mapping strategy while the mind map class used mind mapping strategy. The two classes were given a pre-test and a post-test on their science achievement and critical thinking skills. The gain score means for science achievement and critical thinking skill in both groups were compared using independent t-test and descriptive statistics. In learning science, a satisfaction questionnaire and a behavioural checklist were also used to assess students' attitudes and interactions with concept mapping and mind mapping. The data analysis results showed that the gain score means for the concept map class were greater than the gain score means of the mind map class on science achievement as well as critical thinking with $p < .05$ indicating statistical significance. In addition, students in the concept map class were more positive about the visualisation technique used than students in the mind map class ($p < .05$). As a result, the findings supported the conclusion that the concept mapping strategy was more effective in improving students' critical thinking skills and science learning. Thus, concept mapping was preferred over mind-mapping as a classroom learning tool for science teaching and learning in primary schools to support science learning and the development of critical thinking skills.

Keywords: Concept mapping, mind mapping, visualisation technique, science learning, critical thinking, satisfaction, interaction, descriptive statistics

APPROVAL

This is to certify that this thesis conforms to acceptable of scholarly presentation and is fully adequate, in quality and scope, for the fulfilment of the requirements for the degree of Doctor of Philosophy

The student has been supervised by: **Professor Dr. Maizam Alias**

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This thesis was submitted to Asia e University and is accepted as fulfilment of the requirements for the degree of Doctor of Philosophy.

Professor Dr Titik Khawa Abdul Rahman
Asia e University
Chairman, Examination Committee
(28 March 2023)

DECLARATION

I hereby declare that the thesis submitted in fulfillment of the PhD degree is my own work and that all contributions from any other persons or sources are properly and duly cited. I further declare that the material has not been submitted either in whole or in part, for a degree at this or any other university. In making this declaration, I understand and acknowledge any breaches in this declaration constitute academic misconduct, which may result in my expulsion from the programme and/or exclusion from the award of the degree.

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Signature of Candidate: **Date:** 28 March 2023

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LIST OF ABBREVIATION

ANOVA	Analysis of Variance
BPK	Curriculum Development Section
CM	Concept Map
CTS	Critical Thinking Skills
DSKP	Curriculum Standard and Assessment Document
DV	Dependent Variable
FPK	National Education Philosophy
IV	Independent Variable
KBSR	Integrated Curriculum for Primary School
KSSR	Primary School Standard Curriculum
MOE	Malaysian Ministry of Education
MM	Mind Map
PBL	Problem-based Learning
UPSR	Primary School Achievement Test

CHAPTER 1

INTRODUCTION

The economic development and expansion of a country (or nation) were significantly influenced by education (Permani, 2009). Governments of developing countries were undertaking huge expenditure on the improvement of the education sector as it was believed that the knowledge imparted to the children in classrooms was a determinant for high standard of living, improved stability, and future growth of the respective developing countries (Odit, Dookhan and Fauzel, 2010). Therefore, the target group that was essential to a country's growth was students in all types of educational institutions, whether at the primary, secondary, or higher levels (Bhardwaj, 2016). These students were tasked with carrying out the nation's (or the country's) aim of encouraging high standards of education among the students (Hanushek and Wößmann, 2007).

The knowledge, abilities, and competencies possessed by younger generations (or the students) were critical to a country's success in the face of international economic rivalry (Bhardwaj, 2016). Higher level thinking skills which call for students (or learners) to analyse, evaluate, and create (the skills that demanded students to think critically) were particularly important for these young generations as these skills would enable the young generations to think strategically (or having a proactive planning) and put their theories into practise for the benefit or advantage of the nation (Odit, Dookhan and Fauzel, 2010).

Critical thinking skills were crucial to higher level thinking skills and it differentiated the skills of critical thinking from the lower level thinking skills. Lower level thinking skills only included (or consisted) basic skills liked remembering, understanding, and applying (Bloom's Taxonomy: Cognitive Domains). Meanwhile,

the three highest levels in Bloom's Taxonomy (analysis, synthesis, and evaluation) were frequently said to represent critical thinking (Lai, 2011). The components of critical thinking which included analysing, reasoning, evaluating, problem solving, and decision making (Saiz and Rivas, 2008) would enable students to analyse arguments, making inferences using reasoning, to evaluate information and forming opinion, and performing problem-solving and decision-making more effectively or constructively (Lai, 2011; Snyder and Snyder, 2008).

Acquiring or gaining the skills of critical thinking (Malaysian Ministry of Education [MOE], 2013) was crucial (or significant) as the world was becoming more complex and sophisticated (Uribe-Enciso, Enciso and Daza, 2017). The rapid changes and development in recent times were exposing individuals to various challenges which required important skills and expertise such as critical thinking for making effective decisions. For example, the popularity of mass media and the explosion of information from networking sites were confusing the students with a range of information. As a result, confronting the challenges posed by the complexity of daily life necessitates not only extensive knowledge but also the ability to apply that knowledge in a variety of situations. For this purpose (or reason), students should be taught critical thinking skills and how to analyse information before applying the skills in their daily lives (Tayyeb, 2013). Giam and Duke (2003) suggested that critical thinking was essential (or absolutely necessary) to form citizens who knew and were able to use their minds in the face of adversity, stress, and changes. Therefore, it was crucial for the Malaysian Ministry of Education (MOE) to produce students who could think critically besides capability of meeting the aspirations and wishes of their family, society, and country (Zhaffar, Hamzah and Razak, 2017). This was stated in the Malaysian National Education Philosophy where one of the

aspirations for students was to improve the skills of thinking (Viera, Viera and Martin, 2011).

Critical thinking abilities (or the skills of critical thinking) and to put knowledge into practise appropriately required a person to have a deep understanding of concepts (Nappi, 2017; Mitrevski and Zajkov, 2011) that were foundational to the issue being addressed. Thus, meaningful understandings of concepts was necessary (Agra, Formiga, Oliveira, Costa, Fernandes and Nóbrega, 2019) for a person to judge and to evaluate propositions as concepts form the basis of propositions (Kinchin, Möllits and Reiska, 2019). For this reason, several teaching and learning tools had been proposed to help the understandings of concepts in the form of visual depictions and diagrams such as mind mapping (Davies, 2011) and concept mapping (Beavers, 2014; Liu, Zhao, Ma and Bo, 2014; Whiting and Sines, 2012).

1.0 Background of the Study

To better meet the needs of learners (or students) to develop greater thinking skills especially the skills of critical thinking, Malaysia's primary education system had been transformed from the old primary school syllabus (Integrated Curriculum for Primary School, 1983) to the new primary school syllabus (Primary School Standard Curriculum, 2011). The transformation was based on the 1983 integrated approach and improvements had been made in the 2011 new primary school syllabus (Shan, Yunus, Mohamad and Malaysia, 2016).

Compared to the old primary school syllabus which only focused on three main skills (reading, writing, and counting), the new primary school syllabus focused on four skills namely reading, writing, counting, and reasoning (Malaysian Ministry of Education [MOE], 2013). The new transformation emphasised reasoning skills which was one of the components of critical thinking, in order to go after the

advancement of consideration, technology, economics, and globalisation (Curriculum Development Division, 2012). The new curriculum empowered students as well as the teachers, and enriched the students and the teachers with the capabilities to increase their thinking, thus gave them more room and freedom to exercise their creativity (Malaysian Education Blueprint, 2013-2025; Malaysian Ministry of Education [MOE], 2013). This was supported by Noraini and Khairul (2014) that Malaysian education aimed to develop students' critical, creative, and collaborative thinking abilities and potential.

As a result, reasoning skills (which went hand-in hand with critical thinking and was also one of the key components of the critical thinking besides creative thinking, decision making, and problem solving) were expected to enable students to provide a causal and rational logic state in ordered to solve any problems (or come to conclusions), to understand the learning process, to differentiate between the good and the bad, and to understand the cause and effect of events, things, or conditions (Aziz, Shamsuri and Damayanti, 2013). A student who was good at reasoning possessed the following characteristics: (1) bold and wise in asking questions, (2) critical in thinking, creative, and innovative, (3) curiosity, (4) displayed flexible thinking, (5) willing to work together (group tasks/activities), (6) risk takers, (7) had foresight, and (8) were able to make comparison (Curriculum Development Division, 2012).

Meanwhile, higher level thinking skills (the skills that went beyond basic observation of facts and memorisation which also the skills of critical thinking) was one of the important elements emphasised in the Malaysian primary education (Malaysian Education Blueprint, 2013-2025; Sulaiman, Muniyan, Madhvan, Hassan, Syrene and Rahim, 2017) and students were expected to apply their knowledge, skills,

and values for reasoning and reflection at the higher levels of Bloom's Taxonomy of Cognitive Domains (Malaysian Ministry of Education [MOE], 2013; Chun and Abdullah, 2019). Higher level thinking skills occurred when a person took new information, and the previously stored information in the memory and interrelated, rearranged, and extended this information in order to find possible answers in perplexing situations. This was in line with what proposed by David Ausubel that students associated new information with relevant concepts already present in their cognitive structure. Therefore, to encourage the application of higher level thinking skills in students and also to demonstrate students' critical thinking skills, a newer approach (or method/strategy) was required for better teaching and learning as suggested by Smith (2014).

Therefore, as emphasised by the Malaysian Ministry of Education (MOE) to develop students' critical thinking skills, problem-based learning was one of the approaches that had been implemented in the teaching and learning process to achieve this goal (Malaysian Ministry of Education [MOE], 2013). Through problem-based learning, students were expected to achieve specific learning to make them competent and capable besides having the opportunity to demonstrate problem-solving and reasoning, thus improving critical thinking skills as suggested by Ram, Ram and Sprague (2009), Makin (2016) and Kurniawati (2019).

Problem-based learning had been introduced in primary school science and this approach was applied by teachers in the classroom to promote students' critical thinking and also to strengthens students' skills of reasoning (Curriculum Development Division, 2012 and Lai 2011). Students worked in small groups; three to five students per group (Malaysian Ministry of Education [MOE], 2013; Curriculum Development Division, 2012) on real world problems (or real situations), and students

were given the opportunity to identify the ideas and skills required to solve the problems they faced (or confronted) (Sulaiman, Muniyan, Madhvan, Hassan, Syrene and Rahim, 2017).

In Malaysia primary school's curriculum, subject of science helped students to develop the skills of critical thinking and creative thinking about life in general (Aziz, Shamsuri and Damayanti, 2013). Through learning science, students were expected to improve, and to develop their scientific and critical thinking abilities (or critical thinking skills) as mentioned by Mataniari, Willison, Effendi Hasibuan, Sulistiyo and Dewi (2020). However, the development of scientific and thinking skills were dependent on the approaches and tools used (or applied) in science teaching and learning (Kurniawati, 2019). The method of lecturing (or lecture method), however, would not achieve such learning goals when learning science and this was supported by Kurniawati (2019) that lecture method would not improved the students' thinking skills and the learning process only reached the level of memorising (which was one of the lower level thinking components).

In addition to the problem-based learning approach, teachers and students must used or applied mind maps in their teaching and learning to improve critical thinking skills (Malaysian Ministry of Education [MOE], 2013; Curriculum Development Division, 2012). As suggested by Adodo (2013), students who used mind mapping were expected to be able to think critically, to solve problems, became more creative, and be accountable for their own learning. Thus, mind mapping as proposed by Tony Buzan in the 1960s was introduced in the Malaysia Innovative Thinking program (National Education Blueprint, 2013-2025) which was expected to enhance and to develop critical thinking skills among students. This teaching and learning tool was defined by Eppler (2006) as a multi-colored and image-centered

radial diagram that represented semantic or other hierarchical connections between portions of learned material. In science class, teachers and students used mind maps within problem-based learning in finding solutions to a problem or a situation (Hmelo-Silver, 2004). Thus, the combination of problem-based learning and mind maps in teaching and learning science was expected to be effective (or successful) in developing students to think critically as they used their imagination and explored associations between science concepts (Davies, 2011).

1.1 Problem Statement

Despite the application (or implementation) of mind mapping within problem-based learning in Malaysia primary school science, the students were still weak in critical thinking as demonstrated by their science standard examination results in the 2016 Malaysian Primary School Achievement Test (Panduan Malaysia, 2016) that indicated lack of higher level thinking skills in general and critical thinking in particular. Of the total 440,514 candidates who sat for the Malaysian Primary School Science Achievement Test, only 6.9% obtained A. In fact, this subject showed the lowest numbers of As compared to other core subjects such as the Malay Language, English Language, and Mathematics (Panduan Malaysia, Table 2 and Table 3, 2016).

From the Malaysian Primary School Achievement Test 2016 results analysis, the results showed that the candidates (or the students) were having difficulties with the new format in the test (Panduan Malaysia, 2016) as the new constructs tested consisted of critical thinking elements (National Education Blueprint, 2013-2025). In fact, as much as 40% of the questions assessed in the examination were higher level thinking items (as required by the Malaysian Ministry of Education [MOE], 2013) which also consisted reasoning items (which demanded students to think critically and also emphasised in the new primary school syllabus) compared with the old

Malaysian Primary School Achievement Test format which had no critical thinking items or reasoning items (Rajaendram, 2015). Students lacked of critical thinking skills may be due to a lack of meaningful understanding of concepts that were required for the development of higher level thinking skills (Robinson, Dailey, Hughes and Cotabish, 2014; Saido, Siraj, Nordin and Al-Amedy, 2017). This also could possibly be because students' learning methodologies (or strategies) did not allow them to construct appropriate understanding of fundamental science concepts. As a result, students demonstrated a negative attitude, a loss of interest, and a lack of concentration in class, resulting in low performance in public tests.

Components of critical thinking required appropriate selections and applications of concepts which depended on a person's understanding of the associated concepts (Dixon and Brown, 2012). Mind maps, as Eppler (2006) pointed out, did not support the development of meaningful understandings of concepts because mind maps did not show systematic relationships among sub-concepts relating to one concept which implied that students were not required to think critically when providing or constructing mind maps. Mind mappers only needed (or required) to generate related concepts to a main concept but did not need to propose and evaluated the specific relationships between these concepts (Martin, 2011). Thus, producing a mind map did not trigger the need for students to evaluate and to judge which were important aspects of critical thinking skills.

On the other hand, creating or constructing a concept map demanded that student who drew the maps proposed and evaluated connections between concepts (here students were required to think critically) in addition to generating multiple associated concepts (Soika, Reiska and Mikser, 2014). In short, concept mappings (activity of drawing concept maps) forced student who drew it to generate and to

evaluate their ideas which were crucial or very important to the advancement (or development) of critical thinking skills. In comparison to mind mappings, concept mapping was expected to be a potentially effective learning tool for improving children's learning and achievement in science, and critical thinking based on the nature of concept maps and the process of generating concept maps.

Previous studies using concept mapping in primary science had shown that concept mapping able to improve children's learning and also developed children's critical thinking skills. Çömek, Akınoğlu, Elmacı and Gündoğdu (2016) reported in their studies that concept mapping strategy helped students to improve their critical thinking abilities in primary science education. Meanwhile, a study conducted by Qarareh (2010) reported that students using concept mapping showed greater effect on academic achievement in primary science. The results were also supported by Ling and Boo (2007) that the use of concept mapping could enhance the learning and understanding of science concept among students. According to Ling and Boo (2007), students who applied concept mapping in their studies performed better as opposed to those who were not. This indicated that concept mapping was a better and more effective learning tool for improving students' learning and ability to think critically. Previous study had also revealed that concept mapping could help primary school students to develop their critical thinking abilities and science learning skills, and there was a strong possibility that similar findings would be found in the current study. However, similar findings could not be assumed to be found in all populations as the context of studies differ with respect to attributes of study population, culture, and learning context which may resulted in greater or lesser effect size and academic significance.