

Improving the Reasoning Skills of Students to Overcome Learning Difficulties in Additional Mathematics: A Review

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Abstract

Reasoning skills are one of the primary components of the Higher Order Thinking Skills (HOTS) that students must become proficient at; as stipulated in the Malaysian Education Blueprint (MEB) 2013–2025. However, there is empirical evidence that suggests that the weakness in mathematical reasoning skills among the students at the primary level has an impact on the success or difficulty of learning mathematics at a higher level. The need for students to master mathematical reasoning is among the main causes of the decline of students' performance in learning Mathematics of analytical character (such as Additional Mathematics). The weakness mastery of mathematical reasoning skills among students at primary level is a period of significant impact on the success or difficulties in learning mathematics at a higher level. A review of the various delineating knowledge processing in the context of reasoning skills and learning difficulties in Mathematics and Additional Mathematics shows that reasoning skills begin the knowledge; it then moves into systematic thinking when one needs to bridge the prerequisites and new found knowledge while solving the complex or none-routine mathematics problem. It was recommended, based on the finding of this study, that mathematical reasoning is seen to be important to help students understand and master any mathematical concepts.

Keywords Reasoning skills, Higher Order Thinking Skills, Additional Mathematics, Mathematics

INTRODUCTION

The Ministry of Education launched an overall review on the education system in an effort to develop the Malaysian Education Blueprint (2013–2025) in October 2011 to prepare the young generation for the needs of the 21st century. In the new curriculum of Kurikulum Standard Sekolah Menengah (KSSM) and Kurikulum Standard Sekolah Rendah (KSSR) started in 2012 and will be fully implemented in 2017, the main focus is to foster a higher order thinking skills (HOTS) in order to produce students who could demonstrate their own abilities through reasoning skills (Switala, 2013).

One of the key elements of HOTS are reasoning skills, which are the capability to improve conceptual understanding and subsequently problem-solving skill among students (Jacob et al., 2012; Prusak et al., 2013; Lee et al., 2001). The findings of previous studies have shown that Malaysian students, whether at school or university levels, are

less proficient in reasoning skills (Amalina Ibrahim et al., 2012; Maidinsah, 2004). This situation shows that all parties should join their efforts and expertise to raise the levels of students' reasoning skills and produce competitive students towards the 21st century.

To achieve this aspiration, one of the challenges that teachers must address is the emphasis on thinking skills to improve students' mathematical performance, particularly in mastering reasoning skill (Asmah et al., 2014). Reasoning skills are very important in encouraging students to think more systematically, analytically, critically, and logically, as well as having the problem-solving skills, and ability to apply mathematical knowledge in real life (Hassan et al., 2012). Mathematical reasoning is a very important aspect in the field of mathematics and an important base for the effective learning of mathematics, which is based on the logical conclusion and accurate decision.

BACKGROUND PROBLEM

In general, Mathematics forms the most important basis of the knowledge of Science and Technology in getting the students ready to make critical thinking a culture (Arsaythamby, 2006). Additional Mathematics is an extended knowledge of Mathematics, often considered difficult and challenging by most students who are only able to understand it procedurally, whereas the main focus of Teaching and Learning (T&L) in secondary schools is on conceptual understanding to boost the potential of students to a higher level. According to a study conducted by (Amalina Ibrahim et al., 2012; Maidinshah, 2004; Hassan et al., 2012), students in Malaysia, both at the school and tertiary levels, were less capable of reasoning skills, especially in solving complex problems. Similarly, a study conducted by Noraini Aziz(2015) to identify the mastery of critical thinking skills among Form Four students who were taking Additional Mathematics, which components included making inferences, scrutinizing assumptions and interpretations, and evaluating students' arguments, found that, the T&L should give emphasis on the thinking skills application process, so that, students could improve their mastery of critical thinking skills, especially in solving Additional Mathematics problems.

THE ASSESSMENT

Based on the SPM 2013 Assessment Format, the paper one for mathematics only consists of 40% knowledge questions and 60% application questions, followed by paper two which tests 60% knowledge and 40% application, whereas the paper one of additional mathematics consists of 20% knowledge questions and 80% application questions. For the paper two, it consists of 60% application questions and 40% of problem-solving questions. The report from the Malaysian Examinations Syndicate 2013, indicates that excellent students do not face any problem in achieving high marks for core mathematics subject in the Malaysian Certificate of Education (SPM) but they face problems to score high marks for additional mathematics subject.

At the international level, the TIMSS assessment revealed that 40 to 45% of 8th grade students from the Asian countries, namely Singapore, Taipei, Korea and China, for their 4th and 8th grade students around the world are able to achieve excellent level approaching to or above the international benchmark compared to Malaysia which only achieved an

average ranking of 474 against 500, which is below average in terms of mathematics and science performance (Mullis et al., 2012).

This finding clearly indicates that Malaysian students apply less Higher Order Thinking Skills (HOTS) or non-routine problem solving which could increase the students' thinking skill because the weight in TIMSS assessment for cognitive domain is as follows; the application questions (39%) and reasoning (39%), while another 40% is for the questions on understanding. This analysis shows that Malaysian students are proficient in answering arithmetic questions but weak in answering questions written in passages, in providing opinions, and reasoning (Mullis et al., 2012).

REASONING SKILLS IN MATHEMATICS

Reasoning skills are one of the major components in Higher Order Thinking Skills (HOTS) to be mastered by students as stipulated in the Malaysian Education Development Plan (2013-2025). The need for students to master mathematical reasoning is seen to be even more important when they learn Additional Mathematics, particularly, for analytical mathematical topics such as Differentiation. In the Secondary School Standard Curriculum (SSM), which will be fully implemented in 2017, creative thinking, critical thinking and logical thinking skills, and higher order thinking skills are the main focus in the curriculum. The main focus of the curriculum is to foster higher order thinking skills (HOTS) among students, so that, they are able to demonstrate their own abilities through reasoning skills (Switala, 2013).

In general, mathematics is an important foundation for the branches of science and technology that prepare students with the principles of critical thinking (Arsaythamby, 2006). Additional mathematics is an addition for mathematics and is often considered difficult and challenging to most students, who could only master it on procedural basis, although the main focus of the teaching and learning (T&L) in secondary schools is the student's conceptual understanding in order to boost their potential to a higher level (Akgün et al., 2010).

The reasoning is an important basis for the effective and meaningful understanding of mathematics (Saad et al., 2012). Thus, by the 21st century, students are not only taught to obtain excellent results in the examination, but they also must translate and appreciate what they have learnt, either in solving workplace problems or living their daily lives in a proper and ordered manner. Thus, cognitive processes enable students to come up with the causes and consequences, as well as carrying out rational, logical, and meaningful steps in solving problems through reasoning skills.

Additional Mathematics is one of the analytical mathematical concepts which requires students to think before making a decision, by reasoning to solve problems, and needs them to have a good level of conceptual understanding to do the above task. As such, reasoning skills should be incorporated into the T&L process, to enable the students to have their thinking ability triggered, idea generated, mind controlled and good solutions achieved (Marzano, 1992). However, according to Okano (2010), after the teachers had diversified their teaching and learning methods, students were able to master Calculus, including Differentiation and Integration topics, well, despite their unfavourable achievement

in Mathematics at school. This process requires critical thinking skills beyond normal thinking skills. Earlier studies to identify the students' level of reasoning via Reasoning Test on Differentiation Questions (UPSP) conducted by Arshad et al., (2017) proved that, the requirement for the students to master mathematical reasoning was at a sufficient level, but the context grew wider when they learned analytical mathematical concepts, such as Additional Mathematics (Differentiation, Integration and others). Learning dimension introduced by Marzano (1992) could also be used to diversify and increase the T&L activities that would enhance students' reasoning skills, a major element in HOTS (Yee et al., 2015).

One of the main focuses of the mathematics syllabus is to produce students who are capable of reasoning. Therefore, several initiatives have been taken by the Ministry of Education, especially to increase students' reasoning skills by introducing the additional mathematics project paper in 2002 to improve the students' reasoning skills. In the process of executing these tasks, mathematical reasoning and communication are given a higher weightage than the ability to get the correct answers, which indeed requires the students' ability to think logically and systematically.

However, the study done by Ministry of Education in 2011 has shown that students are still weak in making mathematical reasoning due to over-dependence on teachers in solving the project paper problems. Through the implementation of this project paper, students have to solve the problems of the assigned task through activities such as questioning, discussing and arguing ideas, collecting and analysing data, conducting research, and producing a written report.

The Studies Related to the Reasoning Skill in Learning Mathematics

The curriculum KSSM which will be fully implemented in 2017, the creative and critical thinking skill, logic and higher order thinking skills are the main focus of the curriculum. The students made assumptions that mathematics is difficult even though it is taught using the low-level thinking approach (LLTA) only such as drills and T&L which are solely teacher-centred. This is the challenge that has to be faced by the teachers in order to ingrain critical thinking skills among students towards the 21st century by diversifying their teaching techniques that are capable of stimulating the students' interests to be critical in thinking, creative and innovative as well as to produce students that are capable of demonstrating their abilities through reasoning skills (Yee et al., 2015).

One of the initiatives in mastering the reasoning skill among the students in the subject of additional mathematics is through additional mathematics project paper which was first introduced in 2002. However, it failed to achieve its objective since the students were too dependent on the teachers in solving the problems in the project paper. There are four main focuses in the subject of additional mathematics as recommended by Ministry of Education namely, communication in mathematics, reasoning, make connections or connecting the dots, and the use of technology. Thus, it is clear that the mathematical reasoning skill is one of the key elements in the higher order thinking skills that are being greatly emphasized in learning Additional Mathematics in Malaysia, in order for the students to be capable of problem-solving, innovative and able to propose arguments based on evidence in decision making (Mohaffyza et al., 2013)

The reasoning skill is an important basis for a more effective and meaningful understanding of mathematics (Nor'ain Mohd Tajudin et al., 2012). By the 21st century, the students are not only taught to obtain excellent results in examinations but also to interpret and appreciate the knowledge and skills that have been taught to them, either in solving workplace problems or ensuring life is good and in order. Thus, the cognitive process that allows the students to reason out the causes and consequences, as well as ability to take rational, logical and meaningful steps in solving a problem is through the reasoning skill.

Besides, whenever a student view mathematics as a regulation, it will indirectly result in the student's inability to be creative in solving the mathematical problem while students who do not have any prerequisite are often able to perform their tasks well even though it is difficult to apply reasoning skill in problem-solving (Silver, 1990). Switala (2013) in his study on the argumentation skill focused on the trainee teachers found that it is very important to master the reasoning skill because it enables them to complete the given task in an effective manner based on concrete evidence. As in the study conducted by Akkus (2007), the combination of the mathematical reasoning heuristic approach (MRH) and problem-solving strategy focusing on the reasoning is able to improve student performance in mathematics.

However, a study conducted by Bergqvist (2012) concluded that the imitation reasoning underlying the mathematical concepts may weaken the students' understanding, which undermines the most important aspect within the context of reasoning where the teacher is able to encourage the students' mathematical creative thinking through the tasks or activities assigned during T&L (Boesen et al., 2010). As in the study by Erchick & Diana (2002) through 'The Square Thing', the teaching materials-based approach is capable of providing a positive impact to students in improving the problem solving and reasoning, as well as understanding of mathematics through the content and language of mathematics. Besides, the Dimension of Learning introduced by Marzano (1992) through the third dimension namely, developing and expanding the specialised knowledge on the reasoning skill can also assist in increasing the level of reasoning based on HOTS (Yee et al., 2015).

Thus, the mathematics teachers, in particular, need to change their mathematics teaching practice because the weakness in mathematical reasoning is one of the main reasons that causes students to experience difficulty in learning mathematics specifically the analytical mathematics (such as Additional Mathematics) and to ensure that learning not to focus solely on mastering mathematical content only.

The Difficulties in Learning Additional Mathematics

Additional Mathematics is an analytical mathematical that tests student's thinking style in order to make decisions such as reasoning in problem-solving. Students should also have a good proficiency level of conceptual understanding to execute the matters stated above. Hence, reasoning skills should be incorporated into the T&L processes so that students would be capable of acting on thinking, generating ideas, controlling their thoughts, and producing good solutions (Marzano, 1992).

The main factor that leads to the decline in additional mathematics performance is the mastery of conceptual understanding of students who are still at a minimum level, which indirectly hinders the promotion of higher order thinking skills (HOTS) (Zakaria et al.,

2010; Surif et al., 2012). The school culture that emphasises on simple problem solving and getting the correct answer without having to think, results in students with inadequate reasoning skills which are important in solving mathematical problems.

Other factors of deteriorated additional mathematics performance are: the inconsistent teaching approach and learning styles where the students do not know how to learn effectively (Aizikovitsh et al., 2010; Rohani, 1993), teachers who still stress on conventional teaching and place less emphasis on knowledge construction (Sokolowski, 2011), and high anxiety towards the subject of mathematics among students (Zakaria et al., 2012; Marzita, 2002; Wu et al., 2011).

CONCLUSION

The information, evidence, and critical arguments stated in the literature review suggest that there is empirical evidence that Malaysian students are proficient in understanding the procedural aspect and low-level mathematical thinking skill (LLMTS) but less proficient in understanding concepts and skills of the higher level mathematical thinking, particularly the reasoning skill. The reasoning skill is one of the primary components in LLMTS that needs to be mastered by the students as stipulated in Malaysian Education Blue Print 2013-2025.

The weakness in the mathematical reasoning skill among the students at the primary level will impact significantly on the success or difficulty of learning mathematics at a higher level. Although the percentage of excellent students in public examinations such as UPSR, SPM and STPM shows a significant increase every year, the Malaysian students' performance at international level in the TIMSS and PISA assessment shows an alarming decline.

TIMSS 2011 report found that Malaysian students are proficient in applying the standard mathematical procedure (such as arithmetic) but weak in mathematical reasoning. Therefore, the teachers are required to employ various teaching methods (Yee et al., 2015) in which their teaching must focus on the construction of knowledge and thinking skill at a higher level particularly the reasoning skill. The importance of proficient mathematical reasoning skill among the students in learning analytical mathematics such as Additional Mathematics is vital to enable students to build strong mathematical concepts and thus able to compete at the international level.

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