UNIVERSITI TEKNOLOGI MARA

THE EFFECTS OF PROBLEM-SOLVING APPROACH ON THE DEVELOPMENT OF MATHEMATICAL THINKING

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Thesis submitted in fulfilment
of the requirements for the degree of
Doctor of Philosophy
(Education)

Faculty of Education

April 2024

ABSTRACT

The ability to engage in mathematical thinking and apply it to problem-solving constitutes a fundamental objective of mathematics teaching and learning. Current findings have depicted that students are grappling with significant challenges in developing these cognitive abilities skills. This necessitates an immediate investigation to enhance students' mathematical reasoning and problem-solving abilities. Thus, the aim of this study to examines the impact of a problem-solving approach (PSA) on the development of students' mathematical thinking within the context of undergraduate programs at a public university. It aims to assess the effects of the PSA on students' achievements, cognitive-metacognitive processes, and heuristics knowledge before and after intervention. A mixed-method approach (embedded design) was employed for data collection. Firstly, a quasi-experimental design was used, involving two intact groups of first-year undergraduates (n=49), with 24 students in the experimental group and 25 students in the control group. Both groups underwent pre-tests and post-tests, with an 8-week intervention period, to assess and compare the participants' progress in mathematical thinking scores and heuristics knowledge. Secondly, three students were selected from the experimental group for interviews, using a thinking-aloud protocol before, during, and after the intervention. The aim was to examine the development progress in problem-solving and cognitive-metacognitive thinking processes. The integration of quantitative and qualitative data provided deeper insights into the participant's experiences and the effectiveness of the intervention in enhancing their problem-solving skills. Descriptive analysis of the pretest among the 49 students indicated a low level of attainment in mathematical thinking scores (mean=6.61; SD=3.26) out of a maximum score of 40, depicting a poor performance with a percentage score of 16.5% among the participants. The main study findings revealed that the PSA had a significant impact on mathematical thinking achievement, as evidenced by test scores ($F(1,47)=81.05$, $p<0.05$). The results suggest that the intervention of the problem-solving approach enhanced participants' achievement in mathematical thinking. Similarly, the PSA had a positive effect on students' cognitive-metacognitive strategies development ($F(1,47) = 36.12$, $p <0.05$). Regression analysis further elucidated that heuristic knowledge significantly predicted mathematical thinking scores. Observations during think-aloud sessions demonstrated progress in problem-solving activities and cognitive processes among selected participants, indicating enhanced metacognitive skills, including read-analyse-explore-plan-implement-verify strategies. Implications suggest that incorporating heuristics-based approaches in mathematics instruction can improve problem-solving abilities and enhance mathematical thinking among undergraduates. This pedagogical approach fosters positive attitudes towards mathematics, supporting students' academic growth and cognitive development.

Keywords: problem solving approach, mathematical thinking, achievement, cognitive-metacognitive strategies, heuristics

ACKNOWLEDGEMENT

Firstly, I would wish to thank The Almighty God, Allah S.W.T for the blessing and the opportunities to pursue my PhD in this study, also keeping me in good health, giving me strength, His Guidance and for His love and always listening to my prayers. Without the blessing and guidance from God, this thesis will never have been completed.

I also extend my heartfelt thanks to my esteemed supervisors, Prof Dr Parmjit Singh and Dr Geethanjali Narayanan, for their invaluable guidance, unwavering support, and constructive feedback that have been instrumental in shaping the direction and quality of this thesis. I owe a debt of gratitude to both of them for his countless hours reflecting, reading, encouraging and most of all patience throughout the entire process. Their unwavering support and encouragement have been instrumental in navigating the challenges and uncertainties encountered along this path, and I am truly grateful for their presence in my academic and personal life.

Besides, my heartfelt appreciation goes out to my loving family, especially my wife, Anis Aimuni Binti Azmi, whose endless encouragement, understanding, and patience have been the driving force behind my perseverance during this academic pursuit.

I would also like to express my profound gratitude to the Malaysian Ministry of Higher Education (MOHE) and Universiti Teknologi MARA (UiTM) for providing me with the scholarship under the Skim Latihan Akademik Bumiputera (SLAB) and the staff scholarship respectively. Your generous support has enabled me to pursue my studies and embark on this enriching academic endeavor. These investment in my education is deeply appreciated and has played a crucial role in my academic journey.

Furthermore, I am indebted to my colleagues, Nor Syazwani Mohd Rasid, Muhamad Furkan Mat Salleh, and Mohamad Hisyam Ismail, for their stimulating ideas, insightful brainstorming sessions, and camaraderie, which have significantly contributed to the development and enhancement of my research work.

Once again, I extend my sincere thanks to all those who have played a part, big or small, in the completion of this thesis. Your contributions have been invaluable, and I am deeply grateful for your continuous support.

God Bless All of you. Amin….

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1.1 Introduction

The new curriculum that was developed by the Ministry of Education (MOE) has incorporated producing individuals who are mathematically "*fikrah"*, which translates as an individual who can think mathematically, creatively and innovatively, apply mathematical knowledge competently and skills effectively, as well as able to solve problems and make decisions responsibly (MOE, 2015). This new curriculum not only targets the capabilities of the students in 3Rs (Reading, wRiting & aRithmetic), but also in developing higher-order thinking skills. The National Education Blueprint 2013-2025 (PPPM, 2013) has aimed that every student will learn how to continue acquiring knowledge throughout their lives (instilling a love for inquiry and lifelong learning), to be able to connect different pieces of knowledge, and, most importantly in a knowledge-based economy, to create new knowledge (MOE, 2015).

Mathematical thinking is beyond computational skills. It is the underpinning, fundamental conceptual thinking ability and how it relates to the real world. It relates to logical, analytic thinking and quantitative reasoning (Devlin, 2012). According to Schoenfeld (1992), to develop mathematical thinking among students, the necessary cognition processes are identified, evaluated and well monitored. Problem-solving is proven to be an effective tool to develop these cognitive processes among students. It enables the learners to think authentically according to the situation, where there is certain insecurity, doubts and clarity with reading or discussion. This is unlike homework where there is a fixed answer with a particular way of solving the problems. For example in Japan, problem-solving approaches are used to cultivate thinking and independent learning (Isoda, 2010). At the current time, many countries have used Programme for International Student Assessment (PISA) and the Trends in International Mathematics and Science Study (TIMSS) as a benchmark of their Science and Mathematics proficiency for school standards, which includes Malaysia. In PISA and TIMSS study, mathematical literacy is demonstrated through students' ability to analyse, reason and communicate effectively as they pose, solve and interpret mathematical problems that involve quantitative, spatial, probabilistic or other