

Enhancing Problem-Solving Learning Through Abacus Mental Arithmetic: A Cognitive Science Perspective on Primary School Students

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Abstract

The importance of cultivating effective mathematical problem-solving skills in students is paramount in modern education. This study delves into the potential of abacus mental arithmetic as a method to enhance these skills among primary school students, viewed through the lens of cognitive science. The quasi-experimental design involved purposive sampling of thirty-two students, with a focus on evaluating the impact of abacus mental arithmetic on mixed mathematical operations. The methodology employed a pre-test and post-test based on mixed arithmetic operations to comprehensively assess students' mathematical problem-solving abilities. Additionally, a semi-structured interview format was utilized to gain insights into students' experiences with the abacus mental arithmetic method. Statistical analysis, conducted using the Statistical Package for Social Science version 20.0, unveiled a significant improvement in students' performance in solving mixed mathematical operations following the implementation of abacus mental arithmetic. Beyond quantitative metrics, qualitative findings from interviews revealed heightened understanding and motivation among the targeted age group of 11- to 13-year-old students. This research, positioned at the intersection of cognitive science and mathematics education, introduces an innovative approach to foster students' mathematical problem-solving skills. The study not only highlights the positive impact of abacus mental arithmetic but also underscores the importance of considering cognitive science perspectives in shaping effective teaching methodologies. As a continuation of this work, future research endeavors could explore additional cognitive benefits, extend the study to different age groups, and investigate the sustainability of the observed improvements over an extended period. This comprehensive exploration of abacus mental arithmetic's potential sets the stage for further advancements in enhancing students' mathematical problem-solving capabilities.

Keywords: Cognitive Science, Abacus Mental Arithmetic, Problem-Solving, Mixed Mathematical Operation, Mixed Arithmetic Operation

Introduction

Math is all around us, in everything we do. It is the building block for everything in our daily lives especially the science that deals with the logic of shape, quantity and arrangement (Gözde, 2020). Nonetheless, it is categorised as a non-routine problem if students must employ an advanced level of a mathematical idea to answer the supplied issue. One of the routine issues that are in symbolic style or mathematics word problems is found in the primary school curriculum (Tufan Adiguzel, 2003).

The Abacus Mental Arithmetic method in mathematics education process involves the operation of beads on the abacus that creates sound and psycho-motor skills with the touching and moving of the fingers on the abacus. Basic mathematics mixed operations such as addition, subtraction, multiplication and division require only a few simple movements of the beads using an abacus (Lee Jia Shyan, n.d.). As a result, students are actively involved in the process of mental and physical. It helps to generate mental images that can help to solve math problems.

Abacus Mental Arithmetic has been a part of the primary school mathematics curriculum since 2005, but not for all grades. Both parents and math educators will be concerned about the issue of this program's deployment. As a result, research on the use of abacus mental arithmetic to the teaching and learning of mathematics in Malaysia has not received much attention, and knowing more about it can help to guide future efforts. It might be difficult for students to comprehend the link between numbers without utilising actual things like abacus beads to connect numerical values (Sharma, 1993). Learning to count is just as crucial as utilising the developing brain to its full potential and boosting general intelligence. Mathematics problem solving is a notion that students may understand, but using the Abacus Mental Arithmetic approach technique may make it simpler for them.

The researcher attempts to investigate the use of Abacus Mental Arithmetic to enhance the learning of problem solving in mathematics mixed operation. The following questions will be answered in the study:

- I. What are students' performances of pre and post-test before and after implementation of Abacus mental Arithmetic?
- II. Is there any significant difference of students' achievement in mathematics problem solving of mixed operation after applying the Abacus Mental Arithmetic?
- III. What are students' experiences while applying the Abacus Mental Arithmetic?

Materials and methods

This study utilized a quantitative research design, specifically a quasi-experimental research approach. Quantitative analysis was employed to measure and analyze independent and dependent variables representing characteristics such as behaviors, attitudes, and skills. Apuke's (2017) framework guided the mathematical procedures and data analysis. The research was conducted at an Institution Centre situated in the district of Johor Bahru, where the researcher was affiliated. The location provided a suitable environment for the implementation of the Abacus Mental Arithmetic intervention. The study involved 32 students aged between 11 and 13 years. A convenience sampling method was employed, where the participants were selected based on their willingness to engage in the study. All students within the age range were eligible to participate, irrespective of their class. The research incorporated the Abacus Mental Arithmetic approach as the therapeutic

intervention. Prior to the implementation of the intervention, the selected participants completed a pre-test, which was designed and reviewed by a team of teachers, specialized in higher-order thinking skills (HOTS) questions. The pre-test was administered to the participants, allowing 30 minutes for completion. Following the pre-test, the Abacus Mental Arithmetic method was introduced, and the students underwent a four-week training program.

Quantitative data were collected through pre-tests and post-tests, conducted before and after the intervention, respectively. The post-test was administered immediately following the completion of the four-week training program. The performance of the participants was evaluated based on their test results. Data analysis was conducted using standard statistical procedures, including measures of central tendency and variability, to assess the effectiveness of the Abacus Mental Arithmetic approach. Relevant modifications to previously published methods were clearly indicated throughout the study.

Results

The mean pre-test score, as indicated in Table 1, was 7.81, suggesting that the majority of participants performed at a medium level. The range of scores varied from a minimum of 5 to a maximum of 12, with no participants falling into the low-performance category.

Table 1

Descriptive Statistics of Pre-test

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
PRETEST	32	5	12	7.81	1.991
Valid N (listwise)	32				

In Table 2, the descriptive statistics for the post-test showed an increase in the mean score to 9.50, with participants achieving scores ranging from 4 to 12. This increase indicates an improvement in participants' performance following the implementation of the Abacus Mental Arithmetic method.

Table 2

Descriptive Statistics of Post-test

Descriptive Statistics	N	Minimum	Maximum	Mean	Std. Deviation
POSTTEST	32	4	12	9.50	2.016
Valid N (listwise)	32				

Paired t-tests were conducted using SPSS 20.0 software, as presented in Tables 3 and 4. The results indicated a significant difference in the participants' achievement in solving mathematical problems after the application of the Abacus Mental Arithmetic method ($p =$

0.00). This rejection of the null hypothesis confirmed the method's efficacy in enhancing participants' problem-solving abilities.

Table 3
Paired Samples Statistics for Pre-test and Post-test

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	PRETEST	7.81	32	1.991	.352
	POSTTEST	9.50	32	2.016	.356

Table 4
Paired Samples Test for Pre-test and Post-test

Paired-Samples Statistics									
		Paired Differences							
		Mean	Std. Deviation	Std. Error Deviation	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
					Lower	Upper			
PAIR 1	PRE-TEST POST-TEST	1.688	1.378	.244	1.191	2.184	6.927	31	.000

The thematic analysis of the participants' interview transcripts, represented in Tables 5 and 6, revealed two prominent themes: "level of understanding" and "motivation." These themes highlighted the participants' varying levels of comprehension and their keen interest in utilizing the Abacus Mental Arithmetic method.

Table 5
Participants' Transcripts and Codes

EXCERPT	TRANSCRIPT	CODES
Low Performance Level (Participant 1)	Teacher: What do you think about the Abacus Mental Arithmetic? S9: Very hard Teacher: What do you feel when you use the Abacus Mental Arithmetic? S9: Hmm... It is hard to understand Teacher: Why do you feel that way? S9: Because it has too many levels to understand	Difficult Did not know Did not understand Interested

	<p>Teacher: Do you think the Abacus Mental Arithmetic is able to help you? S9: May be yes, but I don't know how to apply Teacher: Will you use this Abacus Mental Arithmetic in the future? Why? S9: If I understand, I will use it, because it looks interesting.</p>	<p>Interested</p>
<p>Medium Performance Level (Participant 2)</p>	<p>Teacher: What do you think about the Abacus Mental Arithmetic? S19: It is fun and interesting Teacher: What do you feel when you use the Abacus Mental Arithmetic? S19: It is fun and easy to get the answers Teacher: Why do you feel that way? S19: Because it is easy to understand Teacher: Do you think the Abacus Mental Arithmetic is able to help you? S19: Little bit because some question is too hard to apply the method. You can teach me again? Teacher: Will you use this Abacus Mental Arithmetic in the future? Why? S19: Of course. It is easy to use</p>	<p>Interested Helpful Understand Asking for re-teach Applied</p>
<p>High Performance Level (Participant 3)</p>	<p>Teacher: What do you think about the Abacus Mental Arithmetic? S4: It is very easy to apply Teacher: What do you feel when you use the Abacus Mental Arithmetic? S4: Very helpful. I became more understood and it is easier to answer questions. Teacher: Why do you feel that way? S4: Because the method is very unique and it depends on imagination Teacher: Do you think the Abacus Mental Arithmetic is able to help you? S4: Yes, because it is easier to apply. So, I can remember how to use this method in future. Teacher: Will you use this Abacus Mental Arithmetic in the future? Why? S4: Yes. I already understood and it is easy to apply.</p>	<p>Easy Helpful Understood Applied understood</p>

Table 6

Themes Based on the Transcription

THEME	CODES
LEVEL OF UNDERSTANDING	Difficult
	Did not know
	Did not understand
	Easy
	Understood
MOTIVATION	Interested
	Asking for re-teach
	Applied
	Helpful

Overall, the results from the pre- and post-tests, paired t-tests, and thematic analysis demonstrate the positive impact of the Abacus Mental Arithmetic method on participants' problem-solving abilities and their engagement with the learning process.

Discussions

The findings of this study provide valuable insights into the effectiveness of the Abacus Mental Arithmetic method in enhancing students' problem-solving abilities in mathematics. The analysis of the data revealed a significant difference in participants' achievement before and after the implementation of the Abacus Mental Arithmetic technique, leading to the rejection of the null hypothesis. This finding underscores the impact of the Abacus Mental Arithmetic method on participants' mathematical problem-solving skills.

In addressing the first research question, it became evident that participants initially approached problem-solving questions by identifying the main points but struggled to establish connections between the given information and the question requirements. Consequently, they encountered difficulties in formulating effective problem-solving strategies, leading to time-consuming and ineffective attempts at problem-solving.

The comparison between the pre-test and post-test results, pertaining to the second research question, indicated a notable improvement in students' performance in mathematics problem-solving following the application of the Abacus Mental Arithmetic method. Statistical analysis using paired t-tests and SPSS 20.0 software confirmed the significance of this improvement, highlighting the method's efficacy in enhancing participants' problem-solving abilities.

In delving into participants' experiences with the Abacus Mental Arithmetic technique, as part of addressing the third research question, a nuanced examination revealed diverse levels of understanding among the students. To elucidate these variations, interviews were conducted with three students who exhibited differing performance levels on the post-test. Employing thematic analysis, their experiences were systematically categorized and scrutinized, revealing two prominent themes, which are centering on the participants' degree of understanding and motivation.

The findings illuminated a notable contrast among the participants. Despite receiving guidance comparable to their peers, two participants consistently grappled with an inability to answer questions. This struggle endured from the pre-test to the post-test, underscoring a persistent difficulty in fully comprehending the requirements. In contrast to their counterparts who demonstrated improvement and perceived the Abacus Mental Arithmetic

method as a facilitator of problem-solving, these specific participants showed no progress. The root cause of their stagnation was traced back to a fundamental challenge — an inability to grasp the conceptual underpinnings of Abacus Mental Arithmetic.

While some students demonstrated improved problem-solving capabilities, others continued to struggle due to a lack of comprehension regarding the underlying concepts of the Abacus Mental Arithmetic method. These findings emphasize the importance of a thorough understanding of the methodology for effective application, highlighting the need for tailored support and strategies to address diverse levels of comprehension among students.

To further improve the implementation of the Abacus Mental Arithmetic method, several recommendations are proposed. Group work or peer-teaching sessions could be introduced to cater to varying levels of understanding among students, enabling peer-assisted learning and fostering a deeper grasp of the Abacus Mental Arithmetic concept. Additionally, scheduling the research during regular school sessions, rather than during holidays, could enhance students' focus and engagement, thereby maximizing the effectiveness of the intervention.

In conclusion, the findings underscore the significance of the Abacus Mental Arithmetic method in facilitating students' mathematical problem-solving skills. By addressing the challenges in comprehension and providing tailored support, educators can effectively integrate the Abacus Mental Arithmetic technique into the curriculum, thereby enhancing students' overall learning experiences and academic achievements in mathematics.

Conclusions

The present study has demonstrated the positive impact of the Abacus Mental Arithmetic method in enhancing students' problem-solving abilities in mathematics, as evidenced by significant improvements in participants' performance before and after the intervention. This highlights the efficacy of the Abacus Mental Arithmetic approach as a valuable tool in fostering students' mathematical skills and confidence.

For future research, it is recommended to explore the application of the Abacus Mental Arithmetic method in various mathematical calculations and across different mathematical topics. Additionally, conducting studies with a larger sample size could provide a more comprehensive understanding of the method's effects. Examining the applicability of the method in different types of sampling, including rural areas, and among students with varying levels of age and intelligence, could offer valuable insights into its universal effectiveness.

Furthermore, understanding teachers' perceptions and experiences in using the Abacus Mental Arithmetic method can provide valuable insights into its implementation in educational settings. Addressing the challenges faced by educators and students in problem-solving skill development is essential for integrating effective teaching approaches, such as the Abacus Mental Arithmetic method, into the curriculum.

The findings of this study underscore the need for a comprehensive approach to teaching problem-solving skills, emphasizing the importance of engaging students through varied learning strategies. The Abacus Mental Arithmetic method, with its potential to enhance understanding and motivation, can serve as a valuable tool for nurturing students' problem-solving abilities and fostering a positive attitude towards complex problem-solving tasks.

Ultimately, the Abacus Mental Arithmetic method stands as a promising approach to enhancing long-term arithmetic achievement, making mathematics more accessible and engaging for students. By incorporating this method into educational practices, educators can effectively equip students with the necessary skills and confidence to tackle complex problem-solving tasks, thereby fostering a positive learning environment for mathematics education.

Conflict of interests

The authors declare no conflict of interest.

Author Contributions

All authors contributed to the research design, data collection, data analysis, and write up. All authors contributed to the article and approved the submitted version.

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