JTAM (Jurnal Teori dan Aplikasi Matematika)
http://journal.ummat.ac.id/index.php/jtam
p-ISSN 2597-7512 | e-ISSN 2614-1175
Vol. 8, No. 1, January 2024, pp. 206-215

Mental Comparison of Students Learning Abacus-Arithmetic and Not Learning Abacus-Arithmetic on Mathematics Material

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Article History:
Received : 04-09-2023
Revised : 27-11-2023
Accepted : 27-11-2023
Online : 19-01-2024

Keywords:
Mathematics Students' Mentality;
Learning Abacus-Arithmetic
Ability.

ABSTRACT

Students' mental mastery in elementary school mathematics lessons in Indonesia is weak, slow, inaccurate, and declining. Mastery problems among elementary school students who have studied mental abacus arithmetic were found to be low. This is an urgent matter to research because there is a gap between theory, expectations, and reality. The purpose of this research was to compare the ability to solve mathematical problems between students who studied abacus mental arithmetic and students who did not study abacus mental arithmetic. This research involved 70 students. Data collection techniques using instruments, the instruments used were the first-semester mathematics exam and mental arithmetic exam. Data analysis techniques using SPSS Version 25.0 statistics, namely the t-test, were used to compare the ability to solve mathematical problems between students who studied mental abacus-arithmetic and students who did not study mental abacus-arithmetic. Pearson correlation was used to determine the relationship between students' mental arithmetic learning achievement and their ability to solve mathematical problems. The results of the research showed that there was a significant difference ($p<0.05$) in learning achievement on symbolic mathematics questions and mental arithmetic achievement between students who studied mental abacus calculation and students who did not study mental abacus calculation. The minimum score of the group that studied mental abacus calculation was higher compared to the group that did not study mental abacus calculation. However, there was no significant difference ($p<0.05$) in mathematics learning achievement between students who studied mental abacus-arithmetic and students who did not study mental abacus-arithmetic.

https://doi.org/10.31764/jtam.v8i1.17614

A. INTRODUCTION

The ability to solve mathematical problems refers to the ability of students to solve mathematical problems which include routine problems and non-routine problems (Kholid et al., 2020; Kadir & Yogyakarta, 2023; Pamungkas et al., 2023). According to Copur-Gencturk & Doleck (2021), if solving a problem only applies the algorithm that has been learned, then it is called a routine problem. When a student needs to think deeply to apply basic mathematical concepts to solve a given problem, it is called a non-routine problem. Problems related to the low school curriculum are usually routine problems in the form of symbolic problems and problems (Wahyu et al., 2023; Powell et al., 2020). According to Nurtanto et al. (2020) in the history of the development of mathematics education in Indonesia, the subject curriculum has

undergone many changes since independence until now. The Indonesian Ministry of Learning is sensitive to the quality of teaching and learning. Many efforts have been made to improve the quality of mathematics teaching and learning, one of which is by providing training to teachers (Rodríguez-Jiménez et al., 2023; Wei et al., 2023). Therefore, schools have introduced various creative and innovative approaches to improve students' skills in solving mathematical problems at school. To realize this desire, the use of the abacus has been introduced as a method to improve mathematics teaching and learning in elementary schools. The use of abacus-mental arithmetic is believed to increase computational skills and ability to solve mathematical problems among students (Widiyanto et al., 2016). In the abacus-mental arithmetic method, mathematics learning uses visuals through abacus beads, sounds, and psychomotor skills through finger movements on the abacus (Zhou et al., 2020). The student performs a mental count by first creating a visual image of the abacus in the head, then mentally moving the abacus beads as if moving an actual abacus bead with a finger. This mental rule has shown that the student can think very quickly and precisely (Peter Bryant, 2016). This research is also consistent with research conducted Jamil et al. (2023), the learning method involves students actively and stimulates the brain by developing intelligence to improve achievement and ability to solve mathematical problems.

Recent studies by Goffin et al. (2019) and Kozanoglu & Abedin (2021) also shows that the mental abacus-arithmetic learning method can develop the right brain. Students, the computing process takes place in the human left brain because the mathematical notation is processed into speech, while students who study arithmetic using the mental abacus learning method will imagine the abacus in their right brain. The student does not process sentences in calculating. This study has been proven by Xu & Zhong (2018) in Japan who has measured the brain waves of students while carrying out mental arithmetic using an electroencephalography (EEG) device. Bhavya et al. (2022) has stirred up the importance of the use of an abacus in his article entitled "Ancient Abacus: Elegant, Accurate, Fun to Operate: Bead Counting Still Counts in Computer Age". This easy-calculating tool has attracted worldwide attention. Rey et al. (2020) argues that Asian countries such as Singapore, Taiwan, China, and even Indonesia are also influenced by the current use of abacus. Many private academies, for example, the UCMAS Mental Arithmetic Academy, ALOHA and TODAYS originating from China and Taiwan have grown like mushrooms in Indonesia. Starting in 2005, abacus-mental arithmetic has been included in the first-year mathematics curriculum. The implementation of this mental abacus-arithmetic will be a new issue that will attract public attention. However, the study of abacus-mental arithmetic to improve the ability to solve mathematical problems in Indonesia is still lacking and needs to be implemented. In the researchers Medinda Romlah (2017) shows the mean value of student learning outcomes using the abacus method 64.4. This value is far below the standard criteria value that has been set in elementary school mathematics lessons.

The Elementary School Curriculum, which was fully launched in 1983, aims to develop the potential and talents of students. The focus is given to the mastery of 3M basic skills, namely reading, writing, and calculating. For mathematics subjects too, emphasis is given to mastery of numbers and basic operations (add, reject, divide, and divide) in stage one. According to the Silinskas et al. (2020), the mastery of basic mathematical skills in Stage One was found to be unsatisfactory. This problem becomes even more critical as the student progresses to the more

complex Stage Two. Therefore, the methods of teaching mathematics that are practiced now need to be improved by taking other methods such as abacus-mental arithmetic which have been used extensively and triumphantly in China, Japan, Taiwan, and Korea (Thu et al., 2021). According to Hope and Sakib et al. (2020) a study by the Cockcroft Report on mental arithmetic in England has reported that most adults and children are unable to figure out easy problems mentally. For example, 45 samples aged 17 years are not allowed to mentally cross the numbers 90 with 70, that is, arrogantly. This study was carried out based on the theory of cognitive development by Li et al. (2020), Samarakoon et al. (2020) and Kantar et al. (2020) Teaching aids such as the abacus play an important role in effectively conveying the concept of mathematical numbers. This view is in line with the study of Cecchetti et al. (2020), Suzaki et al. (2020), and Ishiguro et al. (2020) who showed that the use of the abacus in childhood would provide concrete experiences to help them solve mathematical problems and reinforce the concept of numbers. The practical work method using the abacus is an appropriate method used to encourage students to be actively involved and fun in learning arithmetic concepts, especially young children. According to the study of Dawnay & Sheppard (2023), students who are proficient in using the abacus will have a mental picture, namely the visualization of the abacus beads in their heads. Thus, these students will think with symbols or language at symbolic levels to solve mathematical problems. Therefore, the impression of mastering abacus skills has contributed to the cognitive development of a learner. The ability to solve mathematical problems is considered a mathematical understanding by Legesse et al. (2020). He has identified four categories of knowledge that affect the ability to solve mathematical problems. The first is the source, namely the knowledge of the student's mathematical principles. Second, students also need heuristics that involve broad problem-solving skills. The third is source control, namely the ability of students to choose the information they need. The final knowledge is the student's belief system in problem situations.

This research is very urgent to be carried out because previous research stated that the mental mastery of some elementary school students in Indonesia is weak, slow, and inappropriate. Mastery problems among elementary school students who have studied mental abacus arithmetic were found to be low. This is an urgent matter to research because there is a gap between theory, expectations, and reality. This research aims to provide a comparative picture of problem-solving abilities between students who study abacus mental arithmetic and students who do not study abacus mental arithmetic. Apart from that, this research also wants to compare the two groups of students from aspects of symbolic items to problem items. This research also wants to find out whether there is a relationship between problem-solving ability and abacus-arithmetic mental performance. This research wants to answer the following questions; Is there a difference in the ability to solve mathematical problems between students who study mental abacus-arithmetic and students who do not study mental abacus-arithmetic? Is there a difference in the ability to solve mathematical problems with symbolic objects between students who study mental abacus arithmetic and students who do not study mental abacus arithmetic? Is there a difference in the ability to solve mathematical problems between students who study abacus mental arithmetic and students who do not study abacus mental arithmetic? Is there a relationship between mental abacus arithmetic performance and mathematical problem-solving ability?.

B. METHODS

The research method used is a quantitative method with ex-post facto or causal-comparative studies (Skamp, 2022). The research subjects were 70 elementary school students. The research was conducted at the State 02 elementary school and the East Jakarta Strada private elementary school. The sample was selected based on the level and class that had been taught the abacus method, in elementary schools selected from each class. 70 students were selected from each class who had studied mathematics using the abacus method. The research was conducted from February 2023 to the end of June 2023.

Data collection technique. Data was collected based on two tests that had been carried out, namely (a) a mathematics learning outcomes test; and (b) a mental arithmetic learning outcomes test. The group consisted of a sample who attended school but all studied abacus mental arithmetic at school. A total of 70 people were taken as samples in this study. Mathematics exam questions are built based on the exam schedule to determine the validity of the content. Then the questions were developed based on learning measures from Indonesian mathematics textbooks. The format of the mathematics questions was similar to the format of the School Progress Assessment exams administered at the study schools (2003 and 2004). The test questions are in the field of arithmetic, namely addition and positive numbers less than 100 and counting. The questions in the mathematics exam are divided into two types, namely symbolic questions and question questions. This math exam contains 30 short questions. Schools do not practice group sampling (streaming). The instruments used in this research are as shown in Table 1.

Table 1. Form of ex-post facto study

The modifier does not lean	Pem may change leaning
Group 1	Achievement ability to solve math problems
Group 2	Mental arithmetic achievements

Group 1 consists of students who study mental abacus-arithmetics at a private academy while group 2 consists of students who do not study mental abacus-arithmetics at a private academy. A sample of students was selected from existing Year One students for comparison. Students studying mental abacus-arithmetics with students not studying mental abacus-arithmetics are independent modifiers. Also learning modifiers are achievements in the ability to solve mathematical problems and mental arithmetic. Mental arithmetic exam. Like the provision of the Year One math exam, the content of the mental arithmetic exam questions is also developed based on the schedule for determining the exam to determine the validity of the content. Then the mental arithmetic exam items were built based on the size of the lesson from the mental arithmetic textbook that will be taught in 2005 in Indonesia and the size of the UCMAS Academy mental arithmetic book. The UCMAS Academy subject syllabus was chosen because according to the Indonesian Legesse et al. (2020), UCMAS has been the party responsible for controlling the training for abacus-mental arithmetic teachers in Indonesia since 1998. The mental arithmetic exam contains 30 short questions.

Study Hypothesis. HO1: There is no significant difference between the ability to solve mathematical problems among students who study mental abacus-arithmetic and students who do not study mental abacus-arithmetic, HO2: There is no significant difference between

mental arithmetic achievement among students who study mental abacus-arithmetic and students who do not study mental abacus-arithmetic, HO3: There is no significant difference between students who study mental abacus-arithmetic and students who do not study mental abacus-arithmetic in their ability to solve mathematical problems with symbolic items, HO4: There is no significant difference between students who study mental abacus-arithmetic and students who do not study mental abacus-arithmetic in the ability to solve mathematical problems and problem items, and HO5: There is no significant relationship between mental abacus-arithmetic achievement and ability to solve mathematical problems.

Data Analysis and Gains. Data were analyzed using the Social Science Statistics Package (SPSS) version 25.0 (Sakaria et al., 2023). Correlation techniques, minimum analysis, standard exclusion, and t-test at the 0.05 level of significance in statistical inference are used to test the hypothesis. The t-exam was conducted to compare the achievement of the mathematics exam between students who studied mental abacus-arithmetic and students who did not study mental abacus-arithmetic. The value of t = 2.79 is significant at $p < 0.05$. This shows that there is a significant difference in the mathematics achievement of Year One between students who study mental abacus-arithmetic and students who do not study mental abacus-arithmetic.

C. RESULT AND DISCUSSION

The The results of this study indicate that the ability to solve mathematical problems among students who study mental abacus-arithmetics is higher than students who do not study mental abacus-arithmetics. This finding proves that students who have an abacus-mental arithmetic background seem to have a stronger principle in the concept of numbers, which then helps them in solving mathematical problems at school. The ability to keep the number-guessing process in mental images is an advantage and privilege possessed by students who study mental abacus arithmetics. Students studying mental abacus-arithmetic benefit from abacus proficiency training by being able to count two-digit numbers up to five lines more accurately than students who are not studying mental abacus-arithmetic. They show higher skills, especially in calculating numbers that are more than two digits, as shown in Table 2.

Table 2. Achievement of math exams and mental arithmetic exams

Gathering	Min exam math	Min exam arithmetic mentally	Min problem math items symbol	Min problem math items
Pupil studying abacus- mental arithmetic	78.41	82.74	87.79	68.56
Students who do not learn abacus- mental arithmetic	68.77	64.27	74.20	65.33

To compare the achievement of mental abacus-arithmetic tests between students who study mental abacus-arithmetic and students who do not study mental abacus-arithmetic, the t value obtained is 3.44 and is significant at $p < 0.05$. The results of this analysis show that there is a significant difference in mental arithmetic achievement between students who learn abacus-mental arithmetic and students who do not learn mental abacus - arithmetic. Comparisons were also made for the achievement of mathematics exams in symbolic items. The value of the t-test is 3.20 and is significant at $p<0.05$. This means that there is a significant

difference in achievement of symbolic items between students who study mental abacus arithmetic and students who do not study mental abacus arithmetic. The achievement of the mathematics exam for problem items was also compared using the t-exam. The t value is 0.87 and is not significant at p <0.05. The results of this analysis show that there is no significant difference in the achievement of problem items between students who study mental abacus-arithmetic and students who do not study mental abacus-arithmetic. Pearson's correlation was calculated to determine the relationship between mental arithmetic achievement and mathematical achievement. For students studying mental abacus-arithmetic's, the value of r = 0.68 is significant at the Level p < 0.05 (two-tailed test). For students who did not study the abacus-arithmetic's, the value of r was slightly lower, namely r = 0.65 and significant at the Level p < 0.05 (two-tailed test). These findings indicate that there is a significant relationship between mental arithmetic achievement and Year One math achievement among students who study abacus-mental arithmetic and students who do not study abacus-mental arithmetic.

This research found that the two groups of students did not have significant differences in terms of their ability to solve questions. This means that the computational difficulties mastered by students studying mental abacus arithmetic do not help improve problem-solving abilities. The ability to complete questions is related to various other skills, for example, language ability and understanding. The semantics or meaning of mathematical language is much different from the language used in other subjects. Therefore, apart from computational abilities, language proficiency and understanding play a very important role in solving problems. The findings of this study also show that there is a positive and significant relationship between students' performance in first-grade mental arithmetic and mathematics tests. This means that students who perform well in mental arithmetic are likely to achieve high performance in the Year One mathematics exam for both learning sample groups. However, the research results show that this relationship is moderate (r = 0.68, for the group of students who studied mental abacus-arithmetic, with r = 0.65 for the group of students who did not study mental abacus-arithmetic). This may be caused by socio-economic background factors and sample intelligence which are beyond the control of this study. Mental abacus-arithmetic is an important and necessary basic skill in the elementary school mathematics curriculum. Mental arithmetic skills not only help students from a computational standpoint but are also useful when checking math answers. This view is in line with research conducted in Taiwan and Japan. In summary, abacus-arithmetic mental proficiency practice is important for improving mathematics performance. This is in line with previous research with the government's hope of including abacus arithmetic learning into the elementary school mathematics curriculum and is a wise step (Piñero Charlo et al., 2022).

The results of the research show that there is a positive and significant relationship between students' mental arithmetic learning achievement and first-grade mathematics exam achievement. This means that knowledge and mental skills of abacus-arithmetic are considered important to improve the ability to solve mathematical problems, especially symbolic items. In this regard, mathematics teachers must be equipped with mental abacus-arithmetic skills not only through community service training but are required in university training programs. This will help mathematics teachers to be more willing and confident in teaching mental abacus arithmetic with better and more effective techniques. The findings of this study also show that

learning mental abacus arithmetic does not help the ability to solve problems. Therefore, other skills such as reading proficiency and comprehension need to be given more attention during the mathematics teaching and learning process. This is because students who are adept at counting may not necessarily be able to solve the questions. In other words, learning abacus mental arithmetic needs to emphasize mastery factors such as language proficiency and comprehension skills in addition to computational mastery. The ability to solve mathematical problems can be improved. The abacus-mental arithmetic contest between college schools in Indonesia has been advocated by the Teacher Education Department and the Indonesian Ministry of Learning (Uljaevna & Shavkatovna, 2021; Zhou et al., 2020; Bhavya et al., 2022).

Considering the importance of mental abacus arithmetic, this research proposes that the Ministry of Education and teachers as Education can suggest matching mental abacus arithmetic with schools in Indonesia, with the hope of increasing awareness about the importance of mental abacus arithmetic among students, teachers, parents, and the community. Apart from that, the Teacher Education Sector and universities need to emphasize mental abacus-arithmetic training programs in higher education training to make it more comprehensive and dynamic. Because the success or failure of an innovation program depends on the teacher. If teachers can master the skills efficiently attract and motivate students to learn abacus mental arithmetic. This study has provided clues regarding several areas of further investigation that may be undertaken in the future. As is known, this research sample is limited to only one area. In the future, studies like this must be carried out in a wider scope so that the study results can be generalized to all countries. In addition, research samples should include students from different backgrounds and locations so that stronger comparisons of results can be obtained. In this study, students who studied abacus-mental arithmetic and students who did not study abacus-mental arithmetic were compared in terms of problem-solving abilities as measured by the Classroom mathematics exam and the mental arithmetic exam. It is recommended that the same research be carried out to compare the two groups of students in terms of their adequacy in solving mathematical problems, reading ability, spatial intelligence, and logical intelligence. The same study can also be carried out to identify other possible changes that may be related to learning abacus – mental arithmetic such as students' socio-economic background, loose intellectual abilities, loose academic performance in mathematics or other subjects at school, attitudes towards mathematics, language and science and student concepts. This research only uses ex-post facto due to mass limitations. Therefore, it is recommended to expand the research further using experimental, brainstorming, and attention methods. This research also has weaknesses, namely the limitations of research in elementary schools. This research has a weakness in the question of whether learning abacus-mental arithmetic is worth learning for all students at all levels including middle school and high school. This research cannot provide an answer to this question. Therefore, it is recommended that researchers, teachers, and educational institutions as well as the Ministry of Education of the Republic of Indonesia conduct investigations to identify abacus-arithmetic mental skills and problems related to them in other elementary school, middle school, and high school students.

D. CONCLUSION AND SUGGESTIONS

This research only provides a comparative picture between students who study mental abacus arithmetic and students who do not study mental abacus arithmetic in terms of their ability to solve mathematical problems. Research findings also show that abacus-arithmetic mental abilities are related to the ability to solve elementary school mathematics problems. Persistent efforts are needed from all parties so that the application of mental abacus-arithmetic learning is successful in improving students' mathematics achievement in elementary schools. This research hopes that mastery of abacus-arithmetic mental skills will give students confidence in solving mathematical problems. In this way, students will feel comfortable learning mathematics and can improve their ability to solve mathematical problems. This study examined elementary school students who studied abacus-mental arithmetic and students who did not study abacus-mental arithmetic compared in terms of problem-solving abilities as measured by the Class Mathematics exam and the mental arithmetic exam. It is recommended that the same research be carried out to compare the two groups of students in terms of their adequacy in solving mathematical problems, reading ability, spatial intelligence, and logical intelligence.

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