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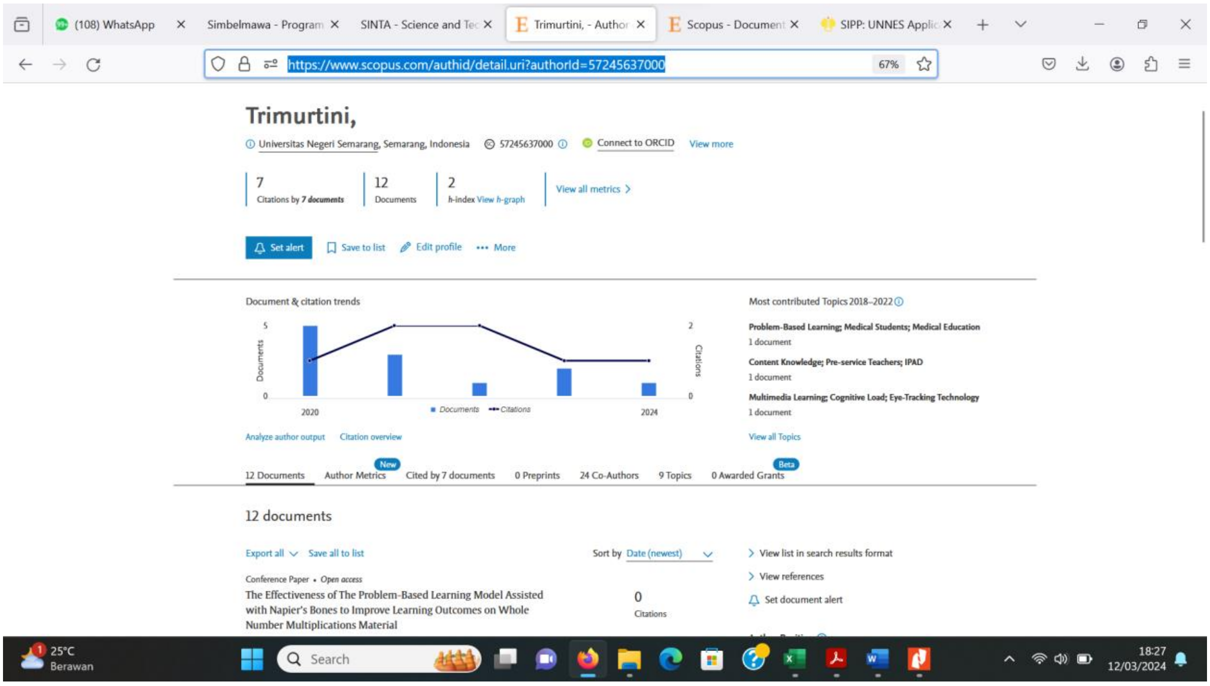

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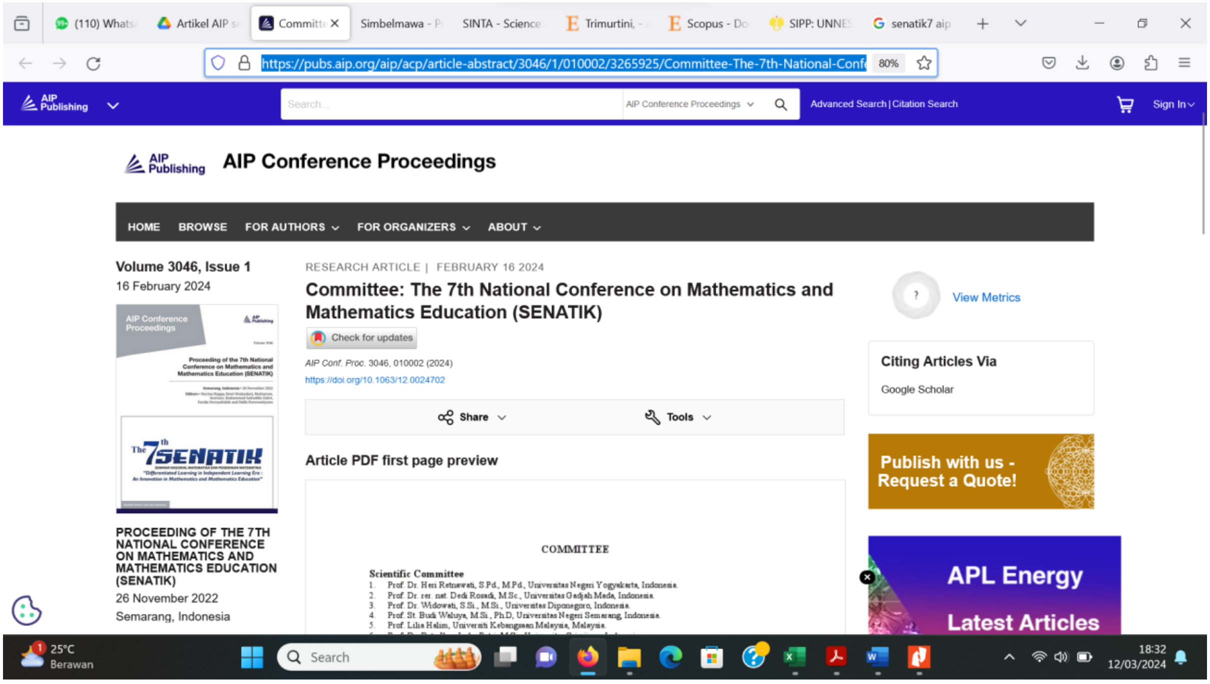

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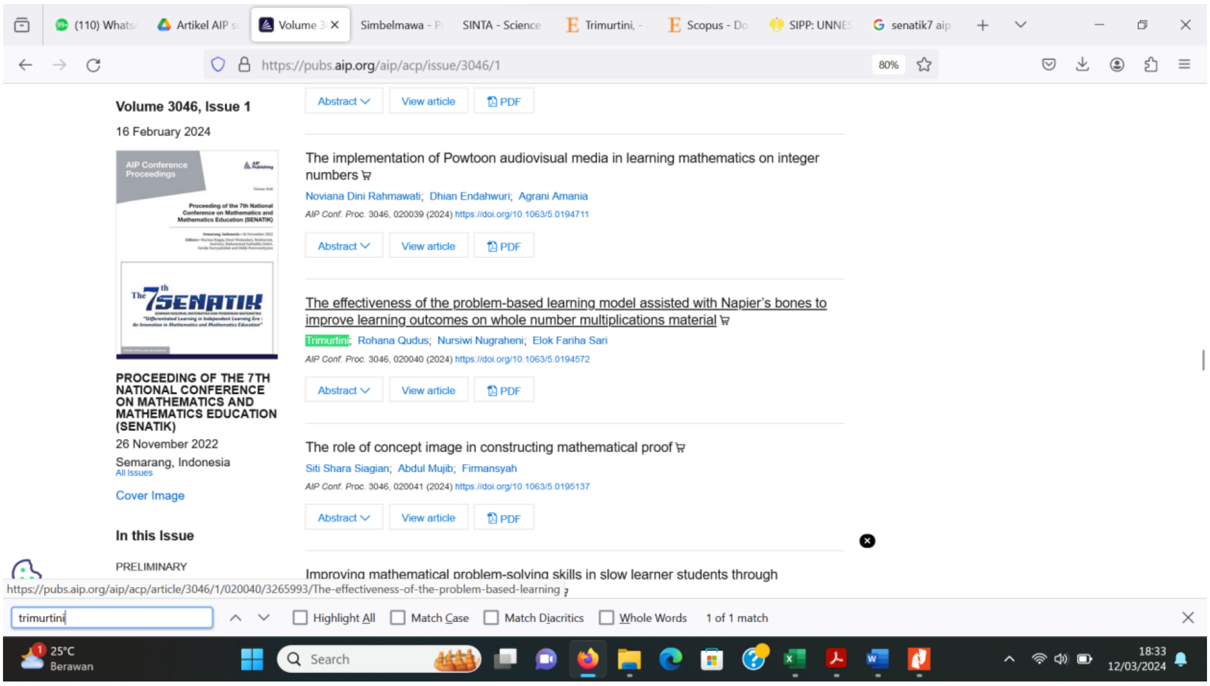

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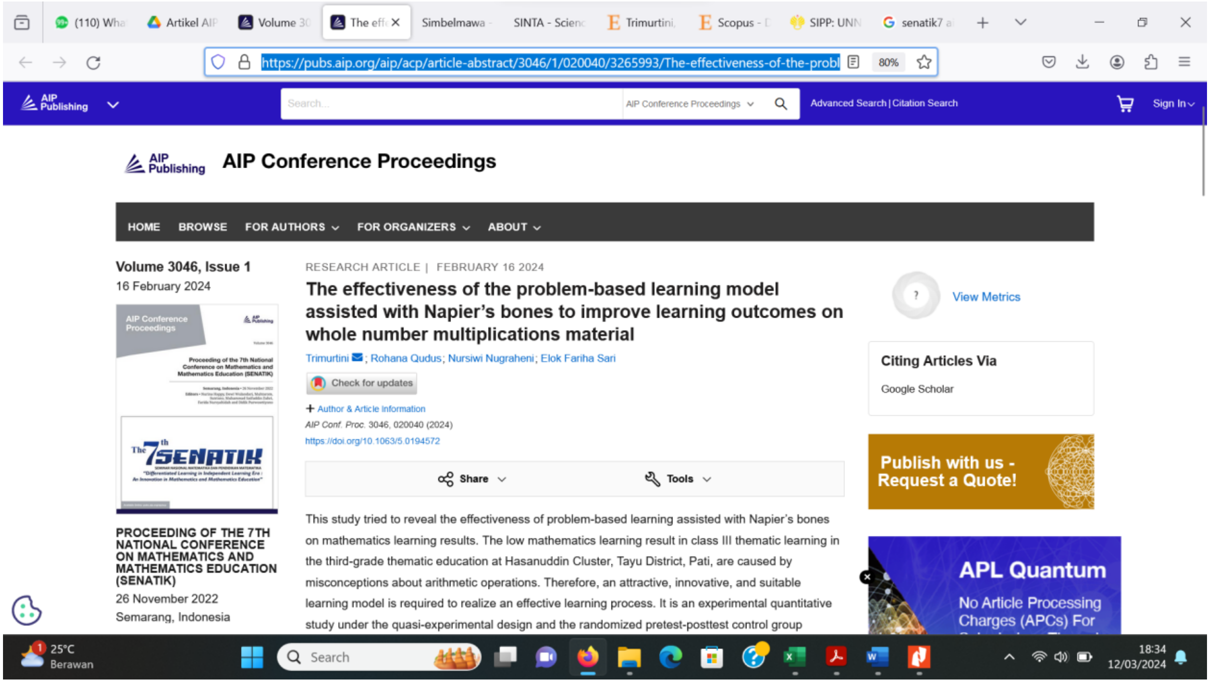

RESEARCH ARTICLE | FEBRUARY 16 2024

Preface: The 7th National Conference on Mathematics and Mathematics Education (SENATIK)

AIP Conf. Proc. 3046, 010001 (2024)
https://doi.org/10.1063/12.0024268

Preface: The 7th National Conference on Mathematics and Mathematics Education (SENATIK)

The 7th National Conference on Mathematics Education (SENATIK) was organized by the Mathematics Education Study Program of PGRI Semarang University on November 26, 2022. The theme of this seminar is "Differentiated Learning in the Era of Independent Learning: Innovations in Mathematics and Mathematics Education". The background of the theme selection is based on regulations of The Ministers of Education, Culture, Research and Technology No. 56 of 2022, one of the contents of which is the independent curriculum structure and one of the contents is differentiated learning. One of the most crucial things in the implementation of an independent curriculum in an era of independent learning is the provision of the widest possible opportunities to our students both from the elementary school level to the university level. Answering this challenge is appropriate for us as mathematics educators, practitioners and observers of mathematics to contribute our thoughts in developing innovations in mathematics and mathematics education in order to succeed the independent learning program which is about various differentiated learning innovations.

In practice, Differentiated Learning is also related to Appreciative Inquiry, because the decision to determine learning strategies in differentiated learning is taken by putting the main focus on concern for the strengths of learners and making it an asset to determine the best way of learning that can provide appropriate learning opportunities for each learner so as to build learning independence and commitment to achieving learning goals. In addition, differentiated learning is also closely related to recognizing the value of self to the cultivation of positive culture, because differentiated learning not only maximizes the potential of learners, but also provides maximum opportunities for each learner to learn various values that are important in life, which will contribute to their development holistically. These values include: the beauty of difference; mutual respect; the new meaning of success; self-empowerment; equal opportunity; freedom of learning and many other important values.

There are 134 manuscripts through the peer-review and end up with 73 papers which are published in this AIP Conference Proceeding. Together with the keynote speakers and the presenters, they shared their research results on different fields in the plenary and parallel sessions attended by more than 250 participants.

We would like to thank the speakers, Dr. Sumardyono, M.Pd. (Director of SEAMEO QITEP in Mathematics (SEAQiM), Dr. Tjaart Jan B. Estrada (Don Mariano Marcos Memorial State University (DMMMSU) Philippines), Dr. Nizaruddin, M.Si. (PGRI Semarang University). We also thank all the committees who have worked hard for the success of this seminar and finally we would like to thank those who have participated in this SENATIK VII 2022 activity.

The conference's success is achieved due to the support and commitment of many people, and we acknowledge their contribution, especially all the participants and presenters. For all participants and presenters, we hope they enjoy the conference, so they are valuable, rewarding and improving their knowledge and experiences.

Dina Prasetyowati, S.Pd. M.Pd.

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Committee: The 7th National Conference on Mathematics and Mathematics Education (SENATIK)

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RESEARCH ARTICLE | FEBRUARY 16 2024

The effectiveness of the problem-based learning model assisted with Napier's bones to improve learning outcomes on whole number multiplications material

Trimurtini; Rohana Qudus; Nursiwi Nugraheni; Elok Fariha Sari

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The Effectiveness of The Problem-Based Learning Model Assisted with Napier's Bones to Improve Learning Outcomes on Whole Number Multiplications Material

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Abstract. This study tried to reveal the effectiveness of problem-based learning assisted with Napier's bones on mathematics learning results. The low mathematics learning result in class III thematic learning in the third-grade thematic education at Hasanuddin Cluster, Tayu District, Pati, are caused by misconceptions about arithmetic operations. Therefore, an attractive, innovative, and suitable learning model is required to realize an effective learning process. It is an experimental quantitative study under the quasi-experimental design and the randomized pretest-posttest control group design. The research sample included the experimental group (RE) of class III A and the control group (RP) of class III B, randomly selected with a full selection of 34 students. The data were gathered through tests, observations, interviews, questionnaires, and documentation. The data analysis techniques include an examination of validity, reliability, level of difficulty, and discrimination. The preliminary data analysis consisted of a normality and homogeneity test. In contrast, the final study included normality, homogeneity, z-test (completeness of learning), t-test (mean difference), and n-gain test (improvement of education). The results showed that the z-test of the experimental class was $Z_{count} > Z_{table}$ (2.38>1.64), and the control class' was $Z_{count} > Z_{table}$ (1.61<1.64), meaning that the experimental class was able to reach the completeness criteria. The t-test indicated that $t_{count} > t_{table}$ (4.03>2.11), expressing that the practical course had a higher average learning score than the control. The n-gain test also denoted that the experimental class scored 0.72, higher than the control, which scored 0.49. This study concluded that problem-based learning with Napier's bones effectively escalated the third graders' learning outcomes on the multiplication of whole numbers.

INTRODUCTION

Learning results should be unveiled for future benefits; they also serve as the vital indicator of success in the designed learning process [1]. The way to determine student learning outcomes is by carrying out a series of evaluation processes to assess specific learning indicators through tests. So long as the obtained results meet the applicable standards, the outcomes are declared good. Based on the preliminary investigation, the learning implemented in class III at SDN Gugus Hasanudin, Tayu District, has yet to be entirely successful. There is a need for improvement efforts, especially in mathematics learning.

According to Lerner, several characteristics of student difficulties in learning mathematics include: 1) spatial relationship disorders, 2) visual perception abnormalities, 3) visual-motor associations, 4) perseveration, namely a child's disorder whose attention is attached to an object for an extended period, 5) difficulty recognizing and understanding symbols, and 6) disturbance of body appreciation [2]. Research conducted by Safitri *et al.* [3] implied that students faced difficulties in counting and understanding basic mathematics concepts. Mistakes in the basic concepts lead them to need help learning the next concept and determining the outcomes. Most students with mathematics learning issues are found at the higher grade levels (IV, V, VI) due to failure to master the fundamental

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concepts during the lower levels (I, II, III). It is what the researchers found in the third-grade of Elementary School Hasanuddin Cluster, Tayu District, Pati,

A series of learning strategies is required to generate students with reliable competence in problem-solving [4]. Based on the literature review, many problem-solving strategies can be applied by adjusting needs. Therefore, the researchers tried to identify the effectiveness of a learning model assisted by teaching aids on mathematics learning outcomes. The applied model was Problem-Based Learning assisted by Napier's bones for third-grade elementary school students.

Effective learning is a condition in which a learning process achieves goals and has visible results, marked by students' accomplishing the specified competencies, understanding and constructing new knowledge, fun learning, good classroom management, time, media, and learning resources.

Rahman argued that Problem-Based learning is a model using unstructured, open real problems as a context for students to develop problem-solving and critical thinking skills and build new knowledge [5]. When developing students' creativity and competence, the teacher should be able to present effective and efficient learning, following the curriculum and student mindset [6]. Concepts of the elementary mathematics curriculum are divided into three major groups: instilling basic concepts, understanding concepts, and developing skills. Students aged 7 to 13 are in the concrete-operational phase; they need concrete objects to transform an abstract concept into a real thought. Thus to achieve the goals of learning elementary mathematics, learning tools are needed to help students grasp the materials presented.

The steps of the Problem-Based Learning model, referring to Sudirman & Maru learning begin with a problem presentation- usually a contextual issue that could be analyzed from various disciplines, problem formulation, investigation of a solution, and report/product presentation [7]. In this model, students will recognize theories and formulas, solve problems numerically, and understand how close mathematics is to the real-world context.

Research by Huda [8] concluded that there is a positive influence on applying the problem-based learning model to student learning outcomes. Furthermore, [9] revealed that using a problem-based learning model assisted by manipulative materials is effectively applied in mathematics learning. It provides an experience of students' cognitive development through real problems, making students skilled at investigating, formulating solutions, and honing social communication skills. Moreover, research conducted by Yuriana & Suwardi [10] showed that using Napier's bones helped students achieve mastery standards. Another study also revealed that Napier's bones are practical and effective [11].

Further, investigated in the third graders, the Napier bones affected the outcomes and are recommended for learning multiplication [12]. The previous studies inferred that a learning model influences the success of learning activities [10]. It serves as a guide in designing classroom learning. The model selection relies heavily on the teacher; hence, they should best understand the needs of students. Choosing a proper model and teaching aid will benefit both sides, simplifying the teacher's task and assisting students' understanding [6].

Inferred from the previous studies, the advantages of the Problem-Based Learning model include: 1) training children to think creatively and innovatively by analyzing, applying, and coordinating the gained knowledge, 2) developing alertness and manners in dealing with problems, and finding solutions, 3) building solidarity, respect and tolerance towards others, and 4) stimulating complex or comprehensive thinking.

Pacelli explained that activities using Napier's bones assisted students in carrying out multiplications properly, connecting previous knowledge concepts, and helping students understand some properties of multiplication [13]. The Napier's bones is a math teaching aid with several index sticks or numbers functioning to determine multiplication results. It is named after its inventor, John Napier, a Scottish aristocrat who lived between 1550 and 1617. Its working principle is to determine the results of multiplication and addition [14]. Napier's bones, also called Napier's rods, are numbered rods that can multiply any number by a number 2-9. By placing "bones" corresponding to the multiplier on the left side and the bones corresponding to the digits of the multiplicand next to it to the right, and product can be read off simply by adding pairs of numbers (with appropriate carries as needed) in the row determined by the multiplier [14][15].

Ten bones correspond to the digits 0-9, and a particular eleventh bone represents the multiplier. The multiplier bone is simply a list of the digits 1-9 arranged vertically downward. The remainder of the bones each has a digit written in the top square, with the multiplication table for that digit written downward, with the digits split by a diagonal line going from the lower left to the upper right. In practice, multiple sets of bones were needed to multiply numbers containing repeated digits. To best understand the shape and workings of Napier's bones, see Fig. 1.

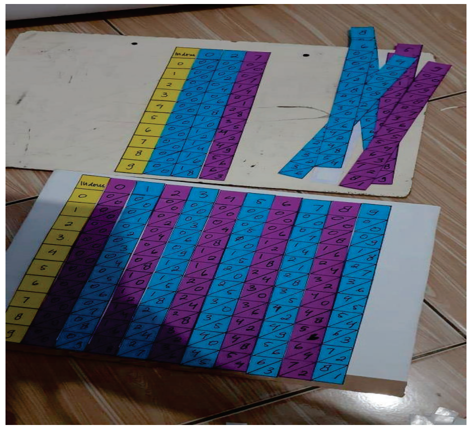

FIGURE 1. The Napier's bone.

This study tried to unfold the effectiveness of the Problem-based learning model assisted by Napier's Bone on the multiplication of whole numbers. To a further extent, the objectives of this study are:

- To test the mathematics learning outcomes of third-grade students at Elementary School Hasanuddin Cluster, Tayu District, by applying the Napier-assisted problem-based learning model in achieving the minimum completeness criteria.
- To prove that the mathematics learning outcomes in the experimental class by applying Napier's bone-assisted problem-based learning model is better than the control class', especially on multiplication of the whole number.

METHOD

This study follows the quantitative experimental research type with a quasi-experimental design. For it is an experimental study, the arranged activities aimed at knowing the effect of specific treatments under controlled conditions [16]. The treatment given in this study was using Napier's rod in the problem-based learning model Table 1.

TABLE 1. The experimental research design.

Group	Pretest	Free Variables	Posttest
(R)E	O1	X	O2
(R)P	O3	-	O4

The research sample included the experimental group (RE) of class III A and the control group (RP) of class III B, selected randomly. The treatments (X) given to the RE included using Napier's rod and problem-based learning, while RP implemented traditional learning. Traditional learning in this study is a learning model used by teachers in everyday learning by using a general model without adjusting the suitable model based on the nature and characteristics of the subject matter. Before the treatment, pretests (O1 and O3) were done on both groups to find out that the two classes had the same tendency. After four-time treatments, posttests (O2 and O4) were carried out to reveal the effect of the given treatments. Instrument trials were carried out at grade III of SDN Bendokaton Kidul and SDN Purwokerto 01, consisting of 16 students each. The data collection techniques included tests, observations, interviews, reflection questionnaires, and documentation. The data were analyzed using the item analysis consisting of validity, reliability, discriminating power and difficulty level, normality, homogeneity, and hypothesis test. The latter includes the completeness test of learning outcomes (Z-test), the average difference (T-test), and the mean-increase test (N-gain test).

The outline of the research results is divided into three parts; (1) the completeness test results; (2) the different test results; and (3) the average-increase test results. The treatments were given for four meetings, following the syntax of the problem-based learning model. The learning stages included observing and orienting students to problems, questioning, and finding solutions to the problems.

The first meeting discussed multiplications by horizontal repeated addition involving units-units and units-tens, the nature of the commutative arithmetic operation, and its properties. Natural objects were used as the media, and the researcher explained directly. Simple unit-unit multiplications were shown in this meeting; for instance, $3 \times 4 = 4 + 4 + 4 = 12$ was completed using repeated addition and modest prop; the teachers showed three baskets containing four candies, and the students counted them.

The second meeting delivered long- and short-stacked multiplications and the nature of distributive operations involving units-tens, tens-tens, and units-hundreds operations. As the items were getting harder, the researchers stimulated the use of teaching aid by proposing questions. Under guidance, the students were directed to solve the items using Napier's bones.

The first two meetings were discussed in the third meeting as the introduction to the next level of operations involving units-hundreds and tens-hundreds. The solutions remained to use horizontal and long- and short-stacked multiplications. At this meeting, the students could independently employ Napier's rod and discuss the items with their group mates.

RESULT AND DISCUSSION

The Napier's rods were distributed to the students in the fourth meeting. There was no new thing introduced but the re-discussion of the previous materials. Nevertheless, the students' independence was apparent, and the discussions were seen getting more effective.

Student learning outcomes data were obtained through posttests. The experimental group's average value was 88.48, and the control was 85.29. To test the mathematics learning outcomes of third-grade students at Elementary School Hasanuddin Cluster, Tayu District, by applying the Napier-assisted problem-based learning model in achieving the minimum completeness criteria, we need to make a hypothesis. The hypothesis 1 test examined the completeness of mathematics learning outcomes. The z-test resulted that the experimental class obtained $Z_{count} = 2.3816$, and the control class scored $Z_{count} = 1.6195$. On the other hand, the Z_{table} , which tested the one-sample proportion with a significance level of 0.05, resulted in 1.645, making the experimental class' $Z_{count} > Z_{table}$. It indicated that the experimental class achieved 75% learning mastery criteria, while the control class' $Z_{count} < Z_{table}$, or having under 75% mastery learning.

To prove that the mathematics learning outcomes in the experimental class by applying Napier's bone-assisted problem-based learning model is better than the control class', especially on the multiplication of the whole number, we need to do a hypothesis test of the average value and N-gain test. Hypothesis 2 tested the average value of mathematics learning outcomes. The data were examined using the polled variance type t-test and resulted in $t_{count} = 4.037$ and $t_{table} = 2.110$ with DF = 32 and a significant level = 5%; thus, $t_{count} > t_{table}$, meaning that Ha was accepted. It concluded that the experimental class's average learning outcomes were more significant than the control class. If we want to know the effectiveness of the learning model applied in both classes, we need an N-gain test. The N-gain test scored 0.72 for the experimental class, categorized as high, and 0.49 for the control class, categorized as moderate. The following Table 2 summarizes the N-gain test results.

TABLE 2. The recapitulation of hypothesis test results.

No	Test		Experimental Class	Control Class
1	Hypothesis Test 1	Z-table	1.645	1.645
		Z-count	2.3816	1.6195
2	Hypothesis Test 2	t-table	2.110	
		t-count	4.0379746835	
		N-Gain Score	0.72 (52%)	0.49 (39.40%)
		Category	high (effective)	moderate (ineffective)

Soleh in Wandini & Banurea argued that mathematics is considered the most difficult of the various subjects taught in schools, even for those who do not have learning issues. This stigma is primarily caused by the characteristics of mathematics, its abstract objects, concepts, and tiered principles, as well as numerous procedures that manipulate forms. Therefore, teaching aid is strongly needed, supported by an appropriate learning model [17].

Based on Hudoyo in Wandini & Banurea learning mathematics should be better started by introducing contextual problems [17]. Then students should be gradually guided to master mathematical concepts and practice creative thinking skills to find solutions. Relevant teaching media and information technology help achieve effective learning media. Napier's bones have been proven to help students understand a mathematical concept, which impacted their problem-solving skills and improved assessment results. Parallel with this study, Merdja & Agnes proved that student learning outcomes in working on multiplications increased after using Napier's rod [18]. Similarly, Ratnawati *et al*. showed the validity of Napier's Bones teaching aid in the arithmetic operations for third-grade elementary school students, meaning that it suits the materials presented and the level of student development [11]. It was also declared effective in assisting students working on multiplications, as seen from the test results.

CONCLUSION

The implications of research involving Napier's Bones media can increase students' understanding of completing multiplication arithmetic operations through direct experience to have a meaningful learning impact for a student. The research results and discussion indicated that the experimental class accomplished 75% mastery learning with more excellent average learning outcomes and higher n-gain scores than the control class. In other words, the Problem-Based Learning assisted by Napier's Bones was effectively applied to the third grade of Hasanuddin Cluster, Tayu District, Pati.

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