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PROBLEM SOLVING APPROACH AND LEARNING MEDIA BASED ON VBA FOR EXCEL AS AN EFFORT TO IMPROVE THE MATHEMATICAL COMMUNICATION SKILLS OF ELEMENTARY SCHOOL STUDENTS

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Abstract
Digital technology is one of the strongest driving forces in the modern economy, requiring the mastery of 21st-century skills. These skills can be developed through mathematics, as its learning process enhances students' strategic thinking. Mathematics should be taught from the elementary level to equip students with logical, analytical, systematic, critical thinking, and communication skills. Mathematical communication is especially important for elementary students to understand, express ideas, model problems, and find solutions. However, current evidence shows that students' mathematical communication skills remain relatively low, partly due to the limited use of learning models and classroom activities designed to foster such abilities. One potential solution is the use of a problem-solving approach supported by VBA for Excel-based learning media. This combination can improve students' mathematical understanding and enhance their 21st-century skills, particularly in mathematical communication. The use of VBA-based media provides students with visual and interactive tools to solve and communicate various mathematical problems. This study aims to examine the effectiveness of the problem-solving approach and VBA for Excel media in improving elementary students' mathematical communication skills. A quasi-experimental method was used, applying a Pretest-Posttest Control Group Design in two classes at a public elementary school in Bandung, with sampling through Non-Probability Sampling techniques. The results showed that this approach effectively improved students' mathematical communication skills. Moreover, the learning media helped optimize the learning process and received positive feedback from students.
Keywords: *Problem solving; VBA Excel; mathematical communication skills*

Abstrak
Teknologi digital merupakan salah satu kekuatan pendorong paling kuat dalam ekonomi modern yang memerlukan keterampilan Abad-21. Keterampilan tersebut dapat diperoleh melalui matematika, karena pembelajarannya dapat mengembangkan pemikiran strategis siswa. Pembelajaran matematika perlu diberikan dari sekolah dasar untuk membekali siswa dengan kemampuan berpikir logis, analitis, sistematis, kritis, serta kemampuan komunikasi. Kemampuan komunikasi matematis sangat penting bagi siswa SD untuk memahami dan menuangkan ide, memodelkan permasalahan dan menyelesaikannya. Siswa dengan kemampuan komunikasi matematis yang baik mampu menyelesaikan dan mengevaluasi permasalahan matematika. Namun saat ini diketahui bahwa kemampuan komunikasi matematis pada siswa SD relatif rendah, yang disebabkan belum diterapkannya model pembelajaran dan aktifitas kelas yang dapat mengembangkan kemampuan komunikasi matematis siswa. Salah satu solusinya adalah menggunakan pendekatan *problem solving* dan media pembelajaran berbasis *VBA for Excel.* Pendekatan ini dapat meningkatkan kemampuan siswa dalam memahami matematika dan mengembangkan keterampilan Abad-21, khususnya kemampuan komunikasi matematis secara efektif. Penggunaan media pembelajaran berbasis *VBA for Excel* dapat memberikan gambaran kepada siswa dalam menyelesaikan dan mengomunikasikan berbagai permasalahan matematika. Tujuan dari penelitian ini adalah mengetahui efektivitas dan peningkatan kemampuan komunikasi matematis siswa SD yang menggunakan pendekatan problem solving dan media pembelajaran berbasis *VBA for Excel*. Metode penelitian yang digunakan adalah kuasi eksperimen dengan *Pretest-Posttest Control Group Design* pada 2 kelas di salah satu Sekolah Dasar Negeri di Kota Bandung, dengan Pengambilan sampel menggunakan *Non-Probability Sampling*. Hasil penelitian menunjukkan bahwa Pendekatan *problem solving* dan media pembelajaran berbasis *VBA for Excel* dapat meningkatkan kemampuan komunikasi matematis siswa SD. Media dapat mengoptimalkan pembelajaran dan mendapatkan respon positif dari siswa.
Kata Kunci: Problem solving; VBA Excel; kemampuan komunikasi matematis

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Introduction

Digital technology is one of the most powerful driving forces in the modern economy that makes the world of work a mathematized environment, so that 21st Century skills are needed to deal with it (Sugandi et al., 2021). Even the modern world of work requires broader skills, namely the ability to solve non-routine problems, complex communication competencies, and verbal and quantitative literacy (Szabo et al., 2020). These skills can be acquired and taught through mathematics, because learning can develop students' strategic thinking through the ability to think, discuss, and express ideas (Fitri & Pertiwi, 2024; Szabo et al., 2020). Mathematics learning needs to be given starting from elementary school to equip students with the ability to think logically, analytically, systematically, critically, innovatively, creatively, as well as communication and collaboration skills (Putri & Musdi, 2020). Communication in mathematics learning encourages mathematical analysis and becomes a means to express mathematical ideas or thoughts as an intellectual activity (Aini et al., 2020; Asikin et al., 2021; Suri et al., 2022).

In their learning, students need to develop their skills in mathematical communication, especially regarding the formation of mathematical language, conceptual understanding, and internalization of learning content (Koskinen & Pitkäniemi, 2022; Ziegler et al., 2018). This ability is closely related to students' ability to express mathematical ideas, understand, interpret, assess or respond to mathematical ideas and use terms, notations, and symbols to present mathematical ideas (Pratiwi et al., 2020; Purbaningrum & Palupi, 2022; Suri et al., 2022). Mathematical communication is the process of expressing and understanding mathematical ideas and concepts using mathematical symbols and rules (Rusdi et al., 2020; Winggowati & Herman, 2023). NCTM (2000) explains that mathematical communication skills (MCS) refer to the ability to, (1) organize and connect their mathematical thinking through communication; (2) communicate their mathematical thinking logically and clearly to peers, teachers, and others; (3) analyze and evaluate the mathematical thinking and strategies used by others; and (4) use the language of mathematics to express mathematical ideas correctly.

MCS can be evaluated through several aspects, namely (1) students' ability to transform situations, pictures, diagrams, or concrete objects into mathematical language, symbols, ideas, or models; (2) the ability to explain mathematical ideas, situations, and relationships both orally and in writing; (3) skills in listening, discussing, and expressing mathematical thinking in written form; (4) the ability to understand written mathematical representations; and (5) the ability to restate mathematical explanations or paragraphs using their own words (Sumarmo, 2010). MCS are very important for elementary school students because they allow students to understand and express ideas, model problems and solve them (Suyani & Wulandari, 2020; Winggowati & Herman, 2023; Zain & Ahmad, 2021). The ability to express and understand mathematical concepts well through mathematical communication is an important skill that must be developed by students in learning mathematics effectively (Putri et al., 2020). Students who have good mathematical communication skills will be able to solve and evaluate mathematical problems (Winggowati & Herman, 2023). However, it is currently known that MCS, especially in elementary school students, are relatively low (Melinda & Zainil, 2020; Syamsyiah et al., 2022; Zain & Ahmad, 2021). This is because classroom learning has not implemented learning models

and classroom activities that can develop students' MCS (Melinda & Zainil, 2020; Syamsyiah et al., 2022; Zain & Ahmad, 2021).

To improve students' MCS, several strategies, approaches and learning models are needed that are appropriate to the existing problems (Aini et al., 2020; Putri & Musdi, 2020). Mathematics learning is not only about mathematics conceptually, but also stimulates MCS through creative and innovative learning activities (Rohid & Rusmawati, 2019). Skills are needed in choosing the appropriate context and learning media, and to focus student communication on relevant things so that learning becomes more meaningful (Koskinen & Pitkäniemi, 2022). One solution to improving elementary school students' MCS that can be applied is to use a problem solving approach and learning media based on Visual Basic for Application (VBA) in Microsoft Excel.

The problem-solving approach (PSA) is an approach that presents learning materials by making problems as a starting point for discussion to be analyzed and applying previously acquired knowledge to obtain the right solution in problem solving (Aedi, 2020; Amran et al., 2020; Zebua et al., 2022). Problem solving enables students to learn by engaging with tasks through a series of processes such as observing, analyzing information, interpreting, planning, drawing conclusions, and reflecting (Susilawati et al., 2024). This approach aims to encourage students to be active, both individually and in groups, in finding solutions to mathematical problems in learning (Fitriani et al., 2022). This approach can improve students' ability to understand mathematics and develop 21st Century skills, especially effective MCS (Amran et al., 2020; Szabo et al., 2020). In addition, research on the use of the problem-solving approach in improving students' MCS is still very minimal and has tended to decline in recent years, but the citation rate is high (Syamsyiah et al., 2022). This shows that this topic is very strategic for further research.

Active and effective learning can be obtained through the use of digital learning media that can make students interested and foster interest in learning in students (Tiarawati, 2024). Digital learning media provides students with an overview of solving various problems related to mathematics (Bernard et al., 2018). One of the learning media that can be used is VBA for Excel-based learning media, because it can support students' motivation, resilience, and interest in learning (Linda et al., 2020; Nurhayati & Chotimah, 2020; Pertiwi et al., 2021). VBA is a development of the Visual Basic programming language applied to certain applications, especially Microsoft Excel, which can be used in mathematical functions to organize image objects interactively (Bernard, 2018; Pertiwi et al., 2023; Wicaksono, 2014). The use of VBA can be applied widely, because the data processing process is carried out through user settings with automatic, simple and easy-to-do function definitions, and is open to use in many data processes (Barreto, 2024; JIN, 1999; Pertiwi et al., 2023).

The use of VBA for Excel provides advantages to users because the images and components are interactive, low cost, and can be accessed by various devices (Bernard & Senjayawati, 2019; Pertiwi et al., 2023; Rohaeti et al., 2020). Several studies have explored the development of VBA for Excel as a learning media; however, these studies have been limited to certain approaches and basic skills. This study offers a new breakthrough by integrating VBA for Excel with a PSA to enhance MCS. With its potential and novelty, the use of the PSA and VBA for Excel-based learning media is projected to be able to improve the MCS of elementary school students effectively. So this study was conducted to find out this empirically.

Research Methods

The research method used is a quasi-experimental method with a Pretest-Posttest Control Group Design. This research design compares changes between groups (experimental and control) through different instructional interventions (Valente & MacKinnon, 2017). The research was conducted at a public elementary school in Bandung City, involving two classes: Class VI-A as the experimental group, which was taught using a PSA and learning media based on VBA for Excel; and Class VI-B as the control group, which received conventional instruction. The indicators of MCS used were a combination of indicators according to Lestari & Yudhanegara (2019) & Sumarmo (2010) which were adjusted, namely (1) stating mathematical situations into mathematical models and solving them; (2) stating mathematical ideas into pictures, mathematical models and solving them; (3) stating everyday events into mathematical models and solving them; (4) compiling questions about the given situation accompanied by reasons; and (5) stating mathematical models (pictures) into ordinary language and solving them. Sampling used Non-Probability Sampling, which is a technique that does not provide equal opportunities for each element (member) of the population to become a sample member. The instruments provided were in the form of 5 descriptive MCS test questions, observation sheets, and student response questionnaires, with sample instruments as follows.

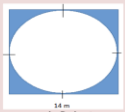
Indikator Komunikasi Matematis	Butir Soal
Menyatakan situasi matematik ke dalam model matematika dan menyelesaikannya **Materi Lingkaran**	Perhatikan gambar di bawah ini!  Gambar di atas adalah sketsa tanah Pak Agus yang akan ditanami pohon di sekeliling taman yang berbentuk lingkarannya. Jika jarak antar pohon 1 m. Buatlah model matematika untuk menghitung banyak pohon yang akan ditanam di sekeliling taman dan selesaikan!
Menyusun Pertanyaan terhadap situasi yang diberikan disertai alasan **Materi Pecahan**	Pak Yono mempunyai sepetak tanah yang luasnya 80 m². $\frac{1}{4}$ bagian tanah tersebut akan dibuat kolam ikan, $\frac{1}{8}$ bagian dibuat kandang ayam dan $\frac{3}{8}$ bagian ditanami mangga dan sisanya ditanami rambutan. a. Buatlah pertanyaan matematika dari situasi di atas! Selesaikan pertanyaan matematika yang sudah kamu buat disertai alasan atau langkah-langkahnya!

Figure 1. Sample of MCS Test Instrument

No	Kesimpulan	SS	S	TS	STS
1	Saya menyukai pelajaran matematika				
2	Saya merasa belajar matematika kurang menyenangkan				
3	Saya memahami materi pecahan yang dijelaskan oleh guru				
4	Saya mereka kurang mengerti dengan materi lingkaran yang diajarkan				
5	Saya bersemangat mengikuti pembelajaran menggunakan media pembelajaran berbasis ICT				
6	Saya malas mengikuti pembelajaran menggunakan media pembelajaran berbasis ICT				
7	Saya memperhatikan dengan sungguh-sungguh penjelasan guru tentang pecahan dan lingkaran menggunakan ICT				
8	Saya mengobrol dengan teman sebangku ketika guru sedang menjelaskan materi pecahan dan lingkaran				
9	Saya tertarik dengan pembelajaran matematika menggunakan media pembelajaran berbasis ICT				
10	Saya bingung ketika belajar menggunakan media pembelajaran berbasis ICT				

Figure 2. Sample Student Response Questionnaire

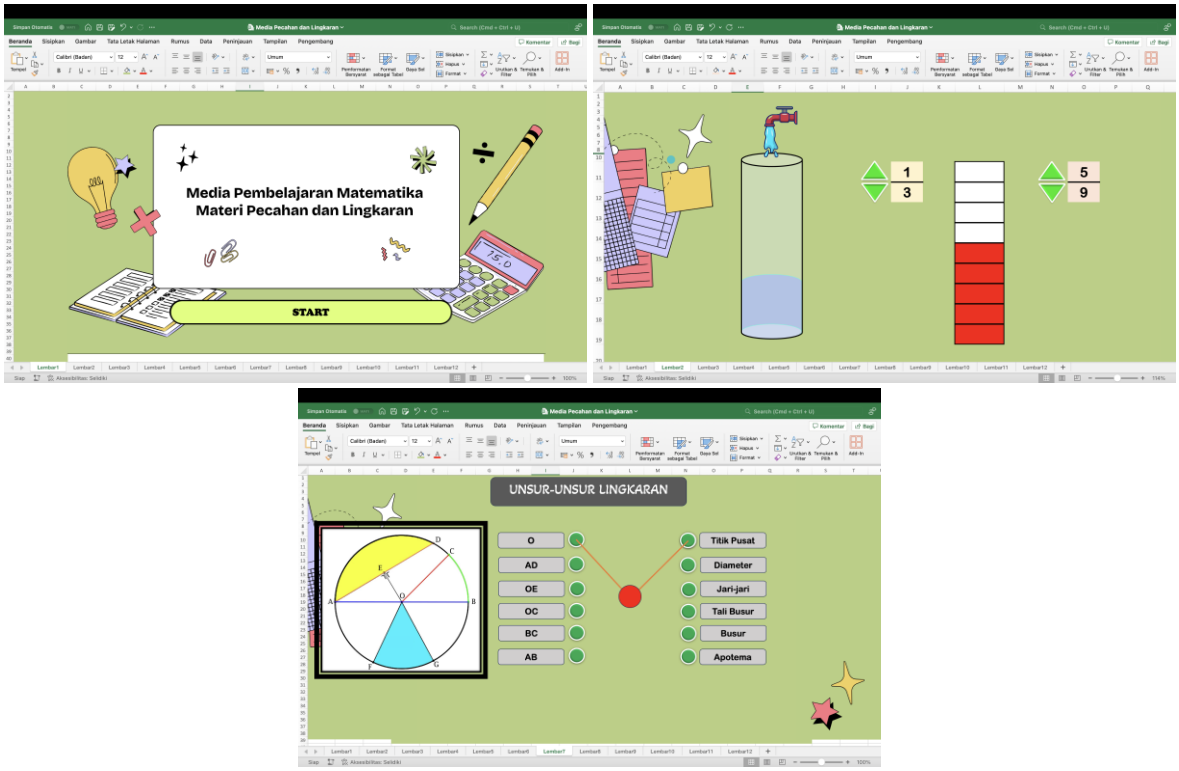


Figure 3. Sample of VBA for Excel Based Learning Media

The data in this study were processed using descriptive and inferential statistics using Microsoft Excel and SPSS software. The criteria are as follows.

$$Normalized\ Gain\ (g) = \frac{final\ score\ test - initial\ score\ test}{ideal\ maximum\ score - initial\ test\ score}$$

The level of normalized gain scores according to Meltzer (2002) is grouped into the following three categories.

Table 1. Gain Test Score

The Size of Gain	Interpretation
0,70 ≤ N-Gain ≤ 1	High
0,30 ≤ N-Gain < 0,70	Medium
0 ≤ N-Gain < 0,30	Low

The criteria for learning effectiveness used refer to Sugandi et al., (2021), namely as follows.

Table 2. Interpretation Criteria for Learning Effectiveness

Interval	Kategori
81% - 100%	Very Effective
61% - 80%	Effective
41% - 60%	Quite Effective
21% - 40%	Less Effective
0% - 20%	Very Ineffective

The hypothesis statistic on this research is,

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Ho : There is no improvement in mathematical communication skills of students whose learning uses a problem solving approach and learning media based on vba for excel with those who use regular learning

Ha : Improvement of mathematical communication skills of students whose learning uses a problem solving approach and learning media based on vba for excel better than those who use regular learning

Results and Discussion

At the beginning of the meeting, students were given a Test of Logical Thinking (TOLT) to determine the cognitive stage of students. This was done as a basis for creating the nuances of VBA for Excel-based learning media. The TOLT results are in Table 3.

Table 3. Percentage of Cognitive Stages Using TOLT Test

TOLT Subject	n	Tahap Kognitif Siswa					
		Concrete		Transition		Formal	
		f	%	f	%	f	%
Problem Solving	30	27	90	3	10	0	0
Scientific	30	28	93,33	2	6,66	0	0
Total	60	55	91,67	5	8,33	0	0

Based on Table 3, the two most dominant classes are still in the concrete thinking stage. This is the basis for creating nuances of learning media that support the thinking stage of students who are still in the concrete stage. In VBA Excel-based learning media, images, nuances, and usage practices are used that students often find in everyday life. Efforts to overcome the low MCS of elementary school students by using the PSA and VBA for Excel-based learning media based on the instruments that have been provided have obtained the following results.

Table 4. Pretest, Posttest and N-Gain of Students' MCS and Questionnaire Responses in Both Learning

Skills	**Stat.**	**Experimental Class (*Problem Solving*)**				**Control Class (*Scientific*)**			
		Pretes	**Postes**	***(g)***	**n**	**Pretes**	**Postes**	***(g)***	**n**
MCS	$\bar{x}$	12,33	25,40	0,51	30	11,80	21,80	0,37	30
	%	32,46	66,84			31,05	57,37		
	s	2,73	3,07			3,50	3,21		
Effectiveness		Effective				Quite Effective			
Ideal Maximum Score for MCS = 38									

Based on Table 4 at the beginning of the learning, the pretest results of the experimental class' MCS were greater than the control class. Then after the learning of both classes was given, the posttest results showed that the experimental class was greater than the control class. Likewise, the n-gain of the experimental class was higher than the control class. When viewed from the results of the effectiveness level after both classes received learning, namely the experimental class was in the effective criteria and the control class was quite effective. To see the significance, an inferential statistical test was carried out with the results in Table 5.

Table 5. MCS Data Processing

Variabel	Pendekatan	Sig (2-tailed)	Sig (1-tailed)	Interpretasi
Pretes MCS	PSA SA	0,513	0,257	$MCS_{PS} = MCS_{S}$
Postes MCS	PSA SA	0,001	0,000	$MCS_{PS} > MCS_{S}$
N-Gain MCS	PSA SA	0,001	0,000	N-Gain MCS_{PS} > N-Gain MCS_{S}

Based on the data in Table 5, it is known that the initial abilities of the two classes did not differ significantly. After learning, the achievement of MCS of students in the experimental class was significantly better than the control class. In addition, the increase in MCS of students in the experimental class was significantly better than the control class. Furthermore, data analysis was carried out on students' achievements and difficulties in completing each question item.

Table 6. Percentage of Students' Achievement of MCS Scores

Mathematical Communication Indicators	SMI	Experimental Class		Control Class	
		Percentage	Criteria	Percentage	Criteria
Expressing mathematical situations into mathematical models and solving them (Circle Material)	8	55,00	Low	52,50	Low
Expressing mathematical ideas into pictures, mathematical models and solving them (Circle Material)	8	58,33	Medium	56,67	Medium
Expressing everyday events into mathematical models and solving them (Circle Material)	6	88,89	High	63,33	Medium
Composing questions about given situations with reasons (Fraction Material)	8	68,33	Medium	59,17	Medium
Expressing mathematical models (pictures) into ordinary language and solving them (Fraction Material)	8	69,17	Medium	56,67	Medium

Based on Table 6, it is known that both classes are still low on the indicator of stating mathematical situations into mathematical models and solving them. While for the indicator of stating daily events into mathematical models and solving them, the experimental class is better than the control class with a high category. For other indicators, both classes are in the medium criteria. Figure 4 presents a sample of student errors in solving MCS problems.

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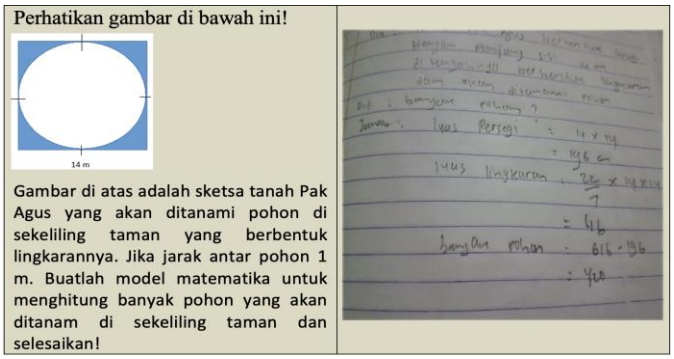

Figure 4. Sample of Student Errors in Solving MCS Problems

Based on the image above with the indicator stating the mathematical situation into a mathematical model and solving it, students are mistaken in understanding the meaning of the problem where students are confused by the image of the area marked with color.

Table 7. Data on the Results of the Experimental Class Student Response Questionnaire

No	Categori	Average	Percentage	Interpretation
1.	Enthusiastic and interested in learning mathematics through ICT	2,82	70,39%	Effective
2.	Dare to try new things and have the ability to overcome difficulties	2,78	69,43%	Effective
3.	Can understand learning materials with ICT	2,98	74,58%	Effective
4.	Dare to express opinions and can interact with others	2,91	72,75%	Effective
	Overall	2,84	71,09%	Effective

In the data in Table 7, students were given a questionnaire to see their responses to learning using the PSA and VBA for Excel-based mathematics learning media. Based on the research data, it shows that in an effort to improve the MCS of elementary school students, the learning outcomes of students who use the PSA and VBA for Excel-based learning media are better. The syntax of the PSA is able to support students' ownership of MCS. These results are in line with research conducted by (Hermawati, 2023; Refiyeti, 2023; Suri et al., 2022) which shows that the PSA using digital learning media, such as VBA for Excel, can improve the MCS of elementary school students.

Findings during learning using VBA media based on Microsoft Excel are that student motivation is getting better. This is proven by the increasing number of students who pay attention when presenting concepts and communication during learning becomes multidirectional, namely students with students or students with teachers. This is because VBA-based media presents mathematical concepts that are more interactive through animation, simulation, and automatic practice questions (Bernard et al., 2021; Chotimah et al., 2018).

VBA-based media supports exploration-based learning and gamification which makes learning more challenging and provides a more dynamic learning experience (Maharjan et al., 2022). During learning, students feel interested in participating in learning because learning while playing in mathematics learning is something that they have rarely encountered so far.

During learning, most students feel like trying to answer the practice questions presented because with VBA-based media for Microsoft Excel there is a direct feedback feature so that students' understanding of the concept becomes more complete (Rahayu et al., 2019). However,

there are still some students who do not dare to try repeatedly because VBA-based media for Microsoft Excel is something new for them. Therefore, teachers in learning using ICT-based media, one of which is VBA media, are very necessary to build student confidence with various strategies according to conditions in class (Hardman, 2019).

Some things that need to be considered by teachers when using ICT-based learning media, one of which is the VBA application, namely the need for teacher skills in developing media with the VBA application (Rahayu & Arga, 2019). This is because in using the VBA application to create learning media, a programming language is needed. The availability of infrastructure such as laptops or projectors in the classroom is also a consideration for teachers because when learning using ICT-based media, it will certainly be more effective if there are supporting infrastructure. Although the VBA application for Microsoft Excel has the advantage of not requiring an internet network and teacher accessibility to the Excel application is certainly very easy because Microsoft Excel is used by teachers to use in learning activities or other teacher administration (Rahayu et al., 2020).

Conclusion

The PSA and VBA for Excel-based learning media can overcome the low MCS of elementary school students. The learning outcomes of students who use the PSA and VBA for Excel-based learning media are superior to students who use regular learning. Media can optimize learning because it can improve students' hard skills and soft skills, and students provide positive responses to the impact of using ICT.

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