Jurnal Ilmiah KURSOR
Menuju Solusi Teknologi Informasi
Vol. 12, No. 2, Desember 2023

ISSN 0216 – 0544
e-ISSN 2301– 6914

IMPLEMENTATION OF PROBLEM-BASED LEARNING MULTIMEDIA WITH FIND AND SORT QR CODE GAMES TO IMPROVE STUDENT'S COMPUTATIONAL THINKING SKILLS

[a]Dwi Fitria Al Husaeni, [b]Eka Fitrajaya Rahman, [c]Erna Piantari

[a,b,c] Departemen Pendidikan Ilmu Komputer, Universitas Pendidikan Indonesia, Bandung, Indonesia
E-mail: dwifitriaalhusaeni@upi.edu, ekafitrajaya@upi.edu,erna.piantari@upi.edu

Abstract

This research aims to evaluate the effectiveness of using and developing problem-based multimedia learning with the find and sort QR code game to improve students' computational thinking (CT) skills in object-oriented programming learning using a web-based digital platform. Research and Development Methods and quasi-experimental research pretest-posttest control group design were used in this research. The research subjects were 140 students of SMK Negeri 1 Cimahi and SMK Negeri 11 Bandung, Indonesia. The research stages are 1) problem analysis, 2) development, and 3) evaluation. The research results showed that there was an increase in students' CT skills after being given the action. The increase in the average value of student learning outcomes in the experimental class was greater than in the control class. The increase in student learning outcomes in the experimental class occurred significantly based on the results of the t test. The average CT score of students increased from 52.29 (pretest) to 83.14 (posttest). The order of increasing CT components based on the n-gain value is 1) abstraction (0.67); 2) pattern recognition (0.64); 3) decomposition (0.52); and 4) algorithm design (0.26). Student responses to multimedia learning in this research were very good with a score of 84.95%.

Key words: Computational Thinking, Experimental Demonstration, Object Oriented Programming, QR Code.

INTRODUCTION

Problem Based Learning (PBL) is a learning model where allows students to be directly involved in problem solving and authentic learning [1]. In obtaining information, developing, and understanding the subject, students learn how to construct, investigate and organize problems, collecting and analyze data, compile facts, and construct an argument regarding problem solving, work individually or collaborate in solving problems [2]. The PBL model is the recommended learning models that implemented in the Merdeka Curriculum in Indonesia [3]. The PBL model focuses on the problems presented by the teacher and students solving these problems with all their knowledge and skills from various sources they can obtain [4].

Uses of PBL model is basically used to improve students' problem-solving abilities. However, in improving and training problem-solving skills there are many techniques that can be used, one of which is Computational Thinking (as known as CT). CT is a technique for solving complex problems using concepts of computer science such as problem simplification, pattern recognition, ignoring unimportant problem characteristics, arranging steps and solving them logically and systematically [5]. CT is one of an important competency for students to have [6]. This is because, students in this day will not only work

in fields related to and affected by computing, but students will also have to deal with computing in everyday life and a growing global economy [7]. CT can assist students in developing process of problem-solving that are not limited to computational computer science, the application of CT is broader, CT can help solve problems in everyday life including analysis to think mathematically, technically, and scientifically [8].

At present there have been many studies examining CT abilities, including research on developing a comprehensive assessment of middle school students' CT abilities [9]. In addition, there are several studies that have developed methods to improve students' CT skills, such as the use of educational robotics [10] the use of partial pair programming [5], the use of visual programming learning [11], use of flipped-classroom instructions [12], and use of STEM-Based Learning Activities [13]. Other methods used by previous researchers to improve students' CT abilities include the use of collaborative learning techniques [14], design-based learning [15], mind mapping approaches [16], Scientific Literacy-Based Teaching [17] and project based learning [18]. Based on several studies, it is known that the final result obtained by researchers is that students' CT abilities can increase. similar to the research results of Prajuabwan and Worapun (2023) where STEM-based activity methods had a positive effect on student learning achievement and computational thinking skills.

However, there has been no research that has developed a problem-based learning multimedia by applying the PBL model in a coherent and systematic manner based on the syntax of the model by using object-oriented programming learning integrated into Website Quick Respond (QR) Code Learning technology which allows interaction between the students and system through a combination of descriptive, audio-video, visual, QR Code games, and formative quizzes.

Therefore, this research was conducted to help facilitate a learning process to improve students' CT skills more efficiently and effectively. The digital learning innovation presented in this study is the development of PBL multimedia with the QR Code Game. QR codes are used as an effort to integrate technology into the learning process to attract creative students and be able to deal with the implications of the industrial revolution 5.0. QR codes are used as a mini game aid called find and sort, as one of the application's features. The use of QR Codes can facilitate the problem-based learning process with the CT approach. QR codes help present problem-based material through the CT process easily without students knowing it directly. In addition, students can study with different problem patterns based on the QR Code they get. Students think more actively to connect or solve their own problems based on the pattern of problems they get.

The purpose of this research is to test the effectiveness of using and developing problem-based learning multimedia with find and sort QR code games to improve students' CT skills in learning object-oriented programming using a web-based digital platform. This study to analysis of learning outcomes, CT skills, and the effectiveness of learning multimedia is carried out through a process of surveys, tests, and quiz review results provided on the website that has been created. This research is expected to help students carry out learning that trains CT skills as a problem solving technique. Thus, students' CT abilities can increase in preparation for economic growth and the industrial revolution 5.0.

MATERIAL AND METHODS

This study used the Research and Development (as known as R&D) method with the Analyze, Design, Development, Implement, evaluate (ADDIE) learning multimedia development model. This research used quasi experimental research pretest-posttest control group design (see **Table 1**). The research was conducted on 140 students of SMK Negeri 1 Cimahi and SMK Negeri 11 Bandung, Indonesia.

Table 1. One-Group Pretest-Posttest

Group	Pretest	Treatment	Posttest
Experiment	O_1	X_1	O_2
Control	O_1	X_2	O_2

with O_1 is the value before being given the action or the pretest value, X_1 is treatment or learning activity for group experiment, X_2 is treatment or learning activity without multimedia find and sort QR Code game and O_2

is the value after being given the action or the posttest value.

Figure 1 shows the research procedure. This research consists of three stages, namely the preliminary study, the development, and the evaluation stage. The preliminary study phase was carried out through literature studies and field studies. The development study stage was carried out by developing a learning multimedia design by applying the ADDIE multimedia development model approach. Meanwhile, the evaluation phase is carried out by processing and analyzing research data. Quantitative approach is used in this research. Data processing is done by statistical calculations.

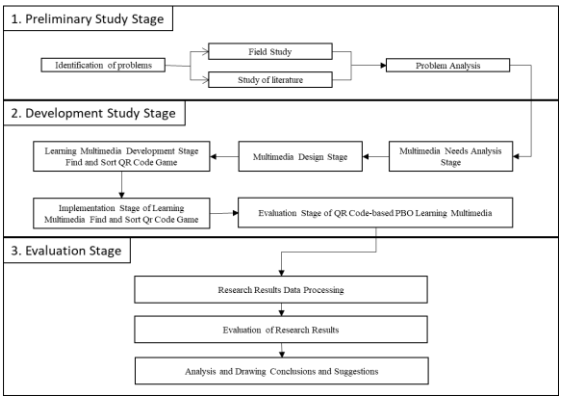


Fig 1. Research procedure

Analysis of Students' Problems and Needs

Analysis of needs identification is carried out through literature and field studies. The literature studies were conducted on similar cases that had been studied by other researchers. The field study was carried out in two ways, namely distributing questionnaires to 26 students who had studied object-oriented programming (PBO) and interviews with productive PPLG class X teachers at SMKN 1 Cimahi as well as teachers, heads of departments, and vice principals of curriculum at SMKN 1 Cimahi and SMKN 11 Bandung to get information about the learning process, curriculum, and other information about learning the Basics of Software Development and Games on OOP elements.

The analysis of learning difficulties results in Figure 2 show that the most difficulty in learning PBO is in inheritance material, namely 76.9% of respondents and the least in special method material, namely 34.6% of respondents. As many as 53.8% of respondents had difficulty learning classes, objects, attributes, methods, and packages. 46.2% of respondents had difficulty learning encapsulation, and 42.3% of respondents had difficulty learning polymorphism. Therefore, in this study material restrictions were carried out to inheritance material.

We analyze the factors that cause students to have difficulty understanding the material. It is known that 80.8% of respondents stated that the learning process carried out was not interactive and interesting which caused boredom. These results are in accordance with the research of Nugraha and Nugraha [19], that the factors that cause low student learning outcomes are the tendency for students to feel bored, lack of motivation and low interest in learning. In addition, 73.1% of respondents stated that the learning media used were too monotonous (package books and power points) and 42.3% of respondents thought that the way the teacher delivered the material was not interesting. The use of learning multimedia is one of the teacher's tools to attract interest and increase student learning motivation [20]. Thus, the selection and use of appropriate learning media needs to be done.

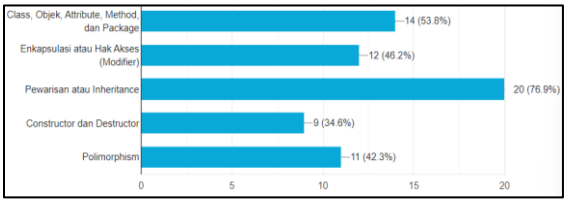


Fig 2. Students' learning difficulties in object-oriented programming materials

Learning Multimedia Development

At the development stage, web-based learning multimedia development activities were carried out, using the PHP programming language by utilizing the Codeigniter 3 framework. In addition, application trials and media expert validation were also carried out at this stage. The trial phase is carried out with the aim that the application can run properly and media expert validation is carried out to test whether the multimedia that has been made is valid or not. Blackbox testing with the type of functional testing is used for testing.

Figure 3 shows the SBPBO application interface that has been developed in this study. In the SBPBO application several features for presenting problems through video (Figure 4)

and material via pdf and QR codes (Figure 5), as well as making a find and sort QR Code Game (Figure 6) as a simple game-based learning tool that makes learning more interactive and fun. Other activities that students can do in the SBPBO application are viewing announcements, top 10 score boards, grades menu, profiles, changing passwords, and logout menus, learning (Pre-Test, Material, and Post-Test), assignment menus, quiz menus in the form of formative tests, help menus, guide menus, and developer information menus.

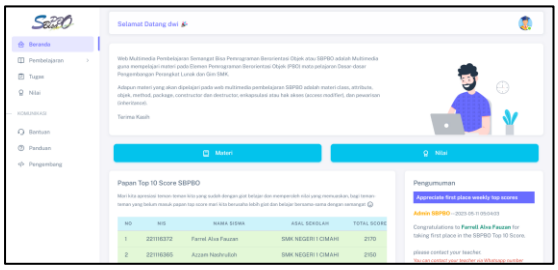


Fig 3. SPBO application interface

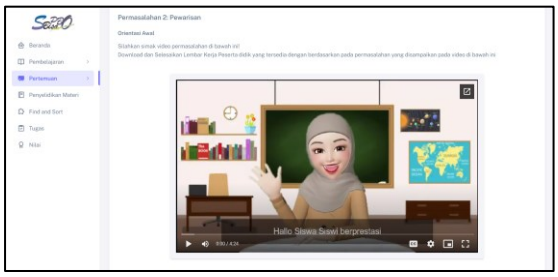


Fig 4. Presentation of problems via video

Fig 5. Presentation of material via pdf and QR code

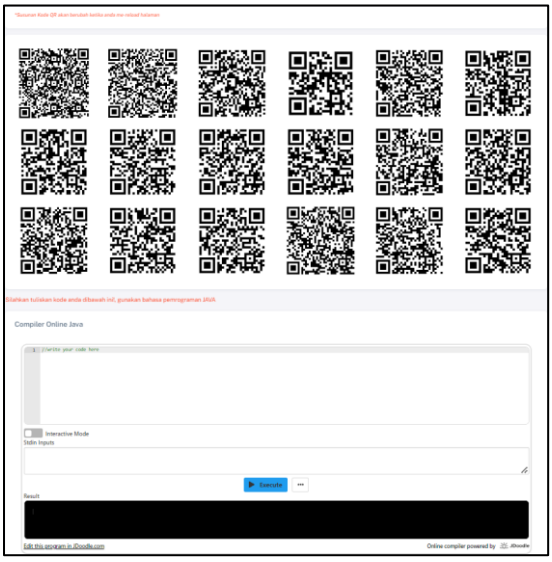


Fig 6. Find and sort QR code game feature

Evaluation Stage

The evaluation phase to analyze and evaluate improvements to errors that occur during the implementation process or trial of QR Code-based PBO learning multimedia. The evaluation stage is carried out on materials and media through expert validation. The results of the material expert validation where the material used is included in the "Very Good" category with an average percentage of 86.7%. Table 2 shows the results of media expert validation where the value for presentation design is 96.7%, ease of interaction is 96.7%, accessibility is 100%, and reuse is 95%. The average result of media expert validation for SBPBO learning multimedia is 97.1% and can be categorized as "Very Good". Based on the validation results, many materials and media are feasible and valid to be implemented in schools.

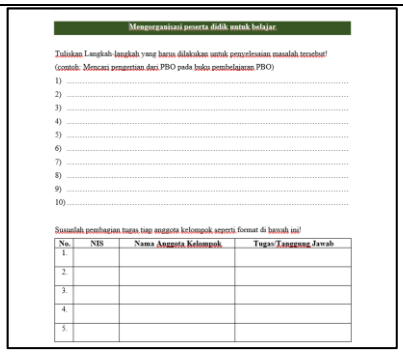
Implementation of Problem-Based Learning Multimedia Find and Sort QR Code Game

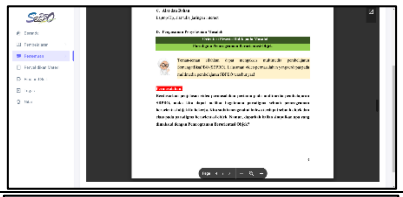
The learning action was carried out in 4 meetings. Each meeting is carried out in the stages of pretest - action - posttest, so that the initial and final abilities of each meeting can be measured. Table 3 shows the learning steps that apply problem-based learning multimedia through find and sort QR code games.

Table 2. Media Validation Results by Experts.

Aspect	Ideal Score	Results	Percentage
Presentation Design • Creative and Innovative • Communicative • Superior	30	29	96.7%
Ease of Interaction • Ease of Navigation • Consistent and predictable interface • Quality of the help interface features	30	29	96.7%
Accessibility • The ease of learning media is used by anyone • Learning media design accommodates mobile learning	20	20	100%
Reuse • Learning media can be reused to develop other learning • Compliance with international standards and specifications	20	19	95.0%
Total			97.1%

Table 3. Application of Multimedia Find and Sort QR Code Game

PBL Syntax	Stages in Media	Result
Problem Orientation		At this stage students observe the problems in the video. The video presented relates to the material studied at the meeting. The problems presented are related to PBO material in everyday life. At this stage students are trained to make an abstraction of the problems conveyed implicitly or explicitly.
Learning Organization	 	At this stage students are required to arrange steps, prepare materials/tools, and divide tasks, to solve the problems described earlier. Students are required to submit the results of this learning organization to be evaluated by the teacher. File collection is provided in the SBPBO learning multimedia. Students are trained to be able to solve problems with strong planning and thinking, as well as systematic steps. Learners are trained to share tasks as efficiently and effectively as possible.

PBL Syntax	Stages in Media	Result
Guiding individual/group investigations	  	Students carry out the process of investigating material or collecting material data related to problem solving.
Develop and Present Masterpiece		Students carry out final discussions to produce solutions to problems, then students compile reports on results and collect them in the SBPBO learning multimedia. Thus, each work or findings are ready to be presented. Students can develop answers to the results of discussions on the problem solving answer form independently..
Analysis and evaluation of the problem solving process		Students/groups present their findings and present them in front of the class. After that an independent evaluation process is carried out to measure the ability of each student.

The process of implementing the Find and Sort QR Code Game game has several stages carried out by students namely.

(i). Students/groups read directions or work instructions contained in the SBPBO application.

(ii). Students/groups scan the QR code displayed on a computer monitor screen using their respective devices.

(iii). Students/groups get several commands from the results of scanning the QR code that must be completed, the commands presented consist of correct and incorrect orders, so students are required to re-select the commands that have been obtained.

(iv). Learners/groups record/copy/document every command obtained from the scanned QR code

(v). Students with their groups discuss the commands that must be used, the orders that must be made, arrange the orders to the formulation of the final answer from the commands that have been obtained.

(vi). Students collect the results of problem solving on the collection form that has been provided.

RESULT AND DISCUSSION

Analysis of Computational Thinking Evaluation Results during the Learning Process

Observation process of learning is carried out to find out whether during the learning process in solving a problem presented, students apply the principles of each CT component as a problem-solving technique. Observations were made using an evaluation instrument from Mueller et al. [21]. Table 4 shows the results of a questionnaire observing the process of solving problems using CT by

students in groups during the process of learning.

Based on the results shown in Table 4 the aspects assessed include the ability to think algorithms, decomposition, generalization/ inference, abstraction, incremental thinking, evaluation, debugging and testing, reusing and remixing, and modularization. The average result of group 1 observation was 91.33% in very good category, group 2 was 91.73% in very good category, group 3 was 94.63% in very good category, group 4 was 95.73% in very good category, group 5 is 98.89% in the very good category, group 6 is 95.18% in the very good category, and group 7 is 93.70% in the very good category. In addition, the overall average of the observations for each group is 95.03% and is included in the very good category. The learning process for all groups of students has implemented CT thinking steps in solving the problems presented in the SBPBO learning multimedia "very well". This shows that the learning methods and steps are considered appropriate. The more appropriate the method used by the teacher in teaching, the more effective it will be in achieving learning objectives and the ability of students can increase [22].

Learning Outcomes

The scores of all students experienced an increase in the average test score. The average value of learning outcomes between control and experimental students is different. Higher increases occurred in the experimental class. The average learning outcomes of control and experimental class students are shown in Figure 7. It is known that the average pretest score for PBO material in the control class is 42.74 and in the experimental class is 50.71. Meanwhile, the average posttest score for PBO material in the control class was found to be 74.49 and in the experimental class, it was 88.04. This shows that students' understanding and ability to solve the PBO problems presented have increased after carrying out PBO learning actions by applying PBL in both the control and experimental classes. However, differences in improvement occurred between the control and experimental classes.

Based on the gain value, the largest increase occurred in the experimental class which used problem-based multimedia learning find and sort QR Code Game, namely 37.32, including in the "Medium" category when compared to the control class, the gain value was 30.36, including in the "Low" category.

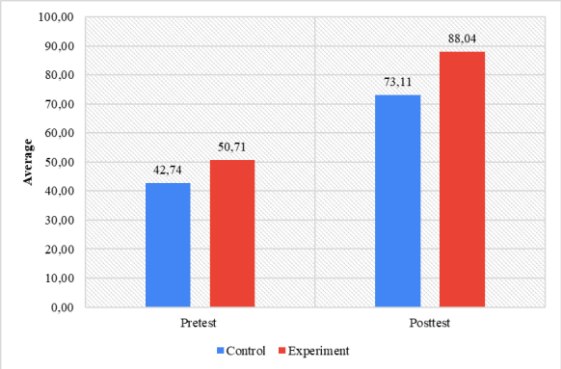


Fig 7. Average pretest and posttest scores for PBO material

We conducted an in-depth analysis of the learning outcomes of the experimental class. Figure 8 shows the average pretest and posttest scores for PBO material for each meeting. It is known that at meeting 1 the pretest score was 82.86 and the posttest score increased to 92.57, meeting 2 the pretest score was 56.57 and the posttest score increased to 88.57 , meeting 3 the pretest score was 81.40 and the posttest score increased to 98.86, while meeting 4 the pretest score was 86.97 and the posttest score increased to 94.29. These results indicate that the understanding level and ability of students in solving CT problems in PBO material has increased at each meeting. This means that the increase in students' understanding using multimedia learning find and sort QR Code games increases consistently at each meeting.

The improvement of students' CT abilities occurred well after learning using the find and sort QR code game because the used of learning multimedia can increase motivation of learning, therefore learning outcomes can also increase [23,24]. The use of gamification in learning helps students to stimulate critical thinking and children's creativity [25].

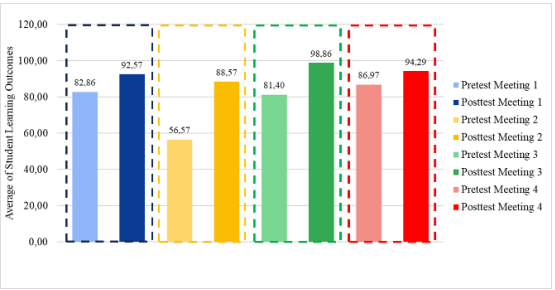


Fig 8. Average pretest and posttest scores for PBO material at each meeting

Figure 9 shows the results of the Paired Sample T-test of pretest and posttest data for experimental class students on PBO material. Based on the results of the t-test calculation, the value of Sig. (2-tailed) of 0.000 <0.05, so there is a significant increase [26]. Thus there is a significant difference in increasing the average learning outcomes of students before and after the learning action using SBPBO learning multimedia on the pretest and posttest data of PBO material.

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pretest	50.7143	70	20.93011	2.50163
	Posttest	88.0357	70	7.62448	.91130

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Pretest & Posttest	70	.132	.278

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	Pretest - Posttest	-37.32143	21.31255	2.54734	-42.40323	-32.23963	-14.651	69	.000

Fig 9. Pretest and posttest t-test results for PBO material.

Apart from using t-test analysis, we carried out n-gain analysis to determine the improvements that occurred before and after using the find and sort QR Code Game media. The Gain Test is used to measure increases in science process skills and cognitive learning outcomes between before and after learning [27]. Table 5 shows the Gain test results of the PBO material test. Based on the results of the gain test on the PBO material, it is known that all groups experienced an increase in their scores. Students in the lower group have the highest gain scores, meaning that the difference between the posttest score and the pretest score is large, the increase in the ability of students in the lower group can be seen to be higher than in the upper group and middle group.

Results of Increasing Students' Computational Thinking Ability of Experimental Class

Figure 10 shows the mean pretest and posttest CT values. Based on Figure 10, it is known that the average student score has increased where before the learning action was carried out the average CT ability value of students was 52.29 and after the learning action was carried out the average student CT ability increased to 83.14.

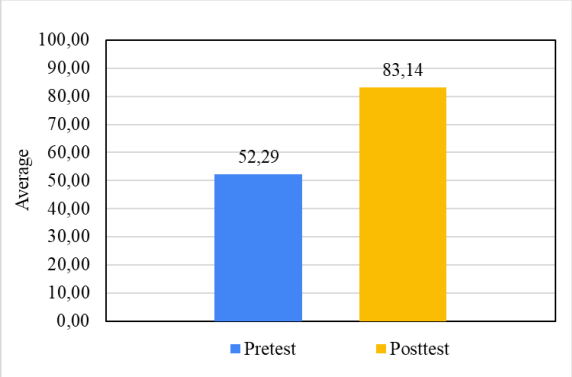


Fig 10. Average pretest and posttest CT

We performed n-gain calculations to measure the increase in science process skills and learning outcomes between Pre and Post learning [28]. Table 6 shows the calculation of the N-Gain pretest and posttest CT where the gain value of students' CT abilities is 0.58 or 57.63%. These results indicate that students' CT abilities have increased in the "moderate" category. In addition, the effectiveness of improving students' CT skills can be categorized as "effective enough".

Figure 11 shows the pretest and posttest averages for each CT component. The CT components analyzed were decomposition, pattern recognition, abstraction, and algorithm design [29]. Based on the average calculation results in Figure 11, it is known that there is an increase the average of students' CT abilities from each CT component. In the decomposition component, the average value of students' CT ability increased from 63.71 to 82.57. Students' CT ability in the pattern recognition component has increased, namely the initial average value of 57.43 and the final average value of 84.57. Students' CT ability in the abstraction component has increased, namely the initial average value of 47.43 and the final average value of 82.57. In addition, students' CT ability in the algorithm design component also increased from an average score of 66.86 to 87.14. These results indicate that an increase in students' CT skills occurs in each CT component.

This increase in CT abilities has a direction that is in accordance with the results of research conducted by Jonasen and Gram-Hansen [30], where CT and PBL both represent concepts aimed at solving problems and understanding problems, the PBL approach has great potential for gaining CT abilities for students at various

levels of education. Apart from that, Banic and Gamboa [31] in their research found that the use of problem-based learning models combined with visual design can improve students' CT abilities.

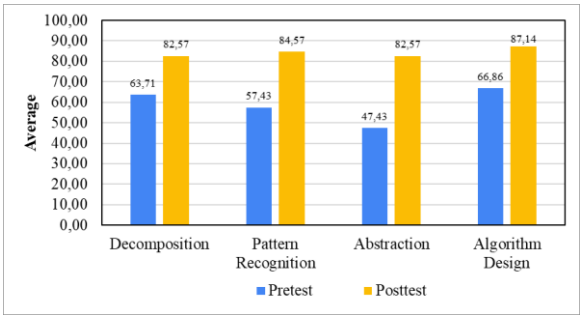


Fig 11. Average pretest and posttest for each CT component

Table 7 shows the results of the gain test for each CT component. It is known that the gain value for the decomposition component is 0.52 with the "Medium" improvement category and the effectiveness of the "Less Effective" increase. In the pattern recognition component, the gain value obtained is 0.64 with the "Medium" improvement category and the effectiveness of the "Effective Enough" increase. In the abstraction component the gain value obtained is 0.67 with the "Medium" improvement category and the effectiveness of the "Effective Enough" increase. Whereas in the algorithm design component, the gain value obtained is 0.26 with the category of "Medium" increase and the effectiveness of the increase "Not Effective".

These results indicate that all categories of improvement in each CT component are in the moderate category. Meanwhile, in the aspect of the effectiveness of the increase between the components experienced differences. The greatest increase in CT ability occurred in the abstraction component with a fairly effective increase in effectiveness. The pattern recognition component is in second place with the effectiveness of increasing quite effectively the same as the abstraction component. The algorithm design component is the component that has the lowest number of improvements. Meanwhile, the decomposition component is in third place.

Student Responses to Multimedia Find and Sort QR Code Game

The student response questionnaire used refers to the Technology Acceptance Model (TAM) [32, 33]. Based on Table 8, the results of the questionnaire responses to media of learning obtained aspects of perceived use of 83.52%, aspects of perceived ease of use of 89.90%, and aspects of user acceptance of 81.43%. The average percentage value obtained from the results of students' responses to the SBPBO learning multimedia was 84.95% which was included in the "Very Good" category.

The results of this research show that there is an influence of implementing game-based multimedia learning about finding and sorting QR codes on improving students' CT skills. Multimedia learning helps in increasing students' learning motivation [34, 35]. Improving students' CT skills as a problem solving technique because the PBL model can help students be directly involved in learning to solve authentic problems [36]. The use of problem-based learning models combined with multimedia learning helps improve students' CT abilities [30, 31]. Object-oriented programming materials have contributed to improving students' CT skills. PBO material requires students to have CT skills and learn how to understand and recognize a problem, then think systematically to find a solution to the problem and realize it in the form of a programming language [37], thus further supporting the achievement of improvement. student.

Table 4. Results of the CT observation questionnaire during the learning process

Assessment Aspects	Number of Items	Ideal Score	Percentage of Score Acquisition (%)						
Group			1	2	3	4	5	6	7
Algorithmic Thinking	2	10	100	100	100	100	100	100	100
Decomposition	1	5	100	100	100	100	100	100	100
Generalization	3	15	93.3	100	100	93.3	100	93.3	100
Abstraction	3	15	100	93.3	100	100	100	93.3	100
Incremental Thinking	4	20	90.0	85.0	90.0	95.0	95.0	90.0	80.0

Evaluation	1	5	80.0	100	80	80.0	100	100	80.0
Testing and Debugging	3	15	93.3	93.3	86.7	93.3	100	100	93.3
Reusing and Remixing	4	20	95.0	90.0	95.0	100	95.0	90.0	90.0
Modularization	2	10	100	100	100	100	100	90.0	100
Average			91.33	95.73	94.63	95.73	98.89	95.18	93.70
Final Average						95.03			

Table 5. PBO Material Test Gain Test Results.

Group	Description	*Pretest*	*Posttest*	Gain	Category
Upper group	Average	77.16	90.24	0.57	Medium
	Standard Deviation	9.58	5.13	-0.05	Low
	Maximum Value	92.50	97.50	0.67	Medium
	Minimum Value	62.50	77.50	0.40	Medium
Middle group	Average	42.76	86.45	0.76	High
	Standard Deviation	8.36	9.20	0.01	Low
	Maximum Value	60.00	100.00	1.00	High
	Minimum Value	30.00	47.50	0.25	Low
Lower group	Average	22.75	89.00	0.86	High
	Standard Deviation	3.43	3.37	0.00	Low
	Maximum Value	27.50	95.00	0.93	High
	Minimum Value	17.50	85.00	0.82	High

Table 6. CT Value Gain Test Results

Pretest Average	Posttest Average	N-Gain	N-Gain Percentage	Category	Interpretation of Effectiveness
58.86	84.21	0.58	57.63%	Medium	Effective enough

Table 7. Gain Test Results for Each CT Component

CT Components	Pretest Average	Posttest Average	N Gain Score	N Gain Score (%)	Category	Effectiveness
Decomposition	63.71	82.57	0.52	51.97	Medium	Less effective
Pattern Recognition	57.43	84.57	0.64	63.76	Medium	Effective enough
Abstraction	47.43	82.57	0.67	66.85	Medium	Effective enough
Algorithm Design	66.86	87.14	0.26	26.23	Medium	Ineffective

Table 8. Result of Questionnaire Student Responses to SBPBO Learning Multimedia

No.	Assessment Aspects	Number of Items	Ideal Score	Score Acquisition	Percentage (%)
1.	Perceived Use (PU)	6	1050	877	83.52
2.	Perceived Ease to Use (PEU)	6	1050	944	89.90
3	Acceptance of IT (AU)	2	350	285	81.43

CONCLUSION

This research shows that the learning process using problem-based multimedia learning with the find and sort QR code game can train students' problem-solving abilities and help students get used to solving problems using computational thinking techniques. Based on the comparison results in the experimental and control classes, it is known that the increase in the average value of learning outcomes was higher in the experimental class. The average pretest score for PBO material was 42.74 in the Control Class and 50.71 in the Experimental Class. Meanwhile, the average post test score for PBO

material was 74.49 in the Control Class and 88.04 in the Experiment Class. Based on the gain value, the largest increase occurred in the experimental class with the "Medium" improvement category, while the increase in pretest and posttest scores in the control class was in the "Low" category. Based on an in-depth analysis of the learning outcomes of the experimental class, it is known that the average increase in student learning outcomes occurred significantly based on the results of the t-test. In addition, the students' average CT score increased from 50.71 (pretest) to 88.04 (posttest). The order of increasing CT components based on the n-gain value is 1) abstraction (0.67); 2) pattern recognition (0.64); 3) decomposition (0.52); and 4) algorithm design (0.26). The advantage of using QR codes is that there is interaction between students and learning multimedia not only individually, but also as a group. Students are trained to be able to work together with their group members, so that the most efficient ways and methods are found in solving the problems presented in the QR code. Students are trained to be able to divide tasks between group members as well as possible, so that the QR code scanning process is faster and does not take up much time. In formulating the final answer, students discuss to combine the commands obtained by each group member, so that they become a unified whole.

REFERENCES

[1] M. Bi, Z. Zhao, J. Yang, and Y. Wang. "Comparison of Case-Based Learning and Traditional Method in Teaching Postgraduate Students of Medical Oncology." Medical Teacher, vol. 41, no. 10, pp. 1124-1128, 2019.

[2] H. Deniş-Çeliker, and S. Dere. "The Effects of The Problem-Based Learnıng Supported by Experiments in Science Course: Students' Inquiry Learning and Reflective Thinking Skills." Journal of Science Learning, vol. 5 no. 1, pp. 14-27, 2022.

[3] K. Kasman, and S. K. Lubis. "Teachers' Performance Evaluation Instrument Designs in the Implementation of the New Learning Paradigm of the Merdeka Curriculum." Jurnal Kependidikan: Jurnal Hasil Penelitian Dan Kajian Kepustakaan Di Bidang Pendidikan, Pengajaran Dan Pembelajaran, vol. 8, no. 3, pp. 760-775, 2022.

[4] S. Juleha, I. Nugraha, and S. Feranie. "The Effect of Project in Problem-Based Learning on Students' Scientific and Information Literacy in Learning Human Excretory System." Journal of Science Learning, vol. 2, no. 2, pp. 33-41, 2019.

[5] X. Wei, L. Lin, N. Meng, W. Tan, and S. C. Kong. "The Effectiveness of Partial Pair Programming on Elementary School Students' Computational Thinking Skills and Self-Efficacy." Computers & Education, vol. 160, pp. 104023, 2021.

[6] A. Reskianissa, A. W. Sakti, and N. N. Azizah. "TikTok Platform to Train Middle School Students' Computational Thinking Skills in Distance Learning." ASEAN Journal of Educational Research and Technology, vol. 1, no. 1, pp. 79-86, 2022.

[7] M. Bower, L. N. Wood, J. W. Lai, K. Highfield, J. Veal, C. Howe, and R. Mason. "Improving the Computational Thinking Pedagogical Capabilities of School Teachers." Australian Journal of Teacher Education, vol. 42, no. 3, pp. 53-72, 2017.

[8] N. I. Zakaria, and Z. H. Iksan. "Computational Thinking among High School Students." Universal Journal of Education Research, vol. 8, no. 11A, pp. 9–16, 2020.

[9] E. Polat, S. Hopcan, S. Kucuk, and B. Sisman. "A Comprehensive Assessment

of Secondary School Students' Computational Thinking Skills." British Journal of Educational Technology, vol. 52, no. 5, pp. 1965-1980, 2021.

[10] S. Atmatzidou, and S. Demetriadis. "Advancing Students' Computational Thinking Skills Through Educational Robotics: A Study on Age and Gender Relevant Differences." Robotics and Autonomous Systems, vol. 75, pp. 661-670, 2016.

[11] L. Zhao, X. Liu, C. Wang, and Y. S. Su. "Effect of Different Mind Mapping Approaches on Primary School Students' Computational Thinking Skills During Visual Programming Learning." Computers & Education, vol. 181, pp. 104445, 2022.

[12] D. Gong, H. H. Yang, and J. Cai. "Exploring the Key Influencing Factors on College Students' Computational Thinking Skills Through Flipped-Classroom Instruction." International Journal of Educational Technology in Higher Education, vol. 17, no. 1, pp. 1-13, 2020.

[13] P. Prajuabwan, and W. Worapun. "The Use of STEM-Based Learning Activities to Promote Computational Thinking of Grade 5 Students." Journal of Education and Learning, vol. 12, no. 4, pp. 118-127, 2023.

[14] Echeverría, Leovy, Ruth Cobos, and Mario Morales. "Improving the Students Computational Thinking Skills with Collaborative Learning Techniques." IEEE Revista Iberoamericana de Tecnologias del Aprendizaje, vol. 14, no. 4, pp. 196-206, 2019.

[15] Jun, SooJin, SeonKwan Han, and SooHwan Kim. "Effect of design-based learning on improving computational thinking." Behaviour & Information Technology vol. 36, no. 1, pp. 43-53, 2017.

[16] L. Zhao, X. Liu, C. Wang, and Y. S. Su. Effect of different mind mapping approaches on primary school students' computational thinking skills during visual programming learning. Computers & Education, vol. 181, p.104445, 2022.

[17] F. Fakhriyah, S. Masfuah, and D. Mardapi. "Developing Scientific Literacy-Based Teaching Materials to Improve Studentsâ€™ Computational Thinking Skills." Jurnal Pendidikan IPA Indonesia, vol. 8, no. 4, pp. 482-491, 2019.

[18] Bertacchini, Francesca, Carmelo Scuro, Pietro Pantano, and Eleonora Bilotta. "A project based learning approach for improving students' computational thinking skills." Frontiers in Robotics and AI, vol. 9, pp. 720448, 2022.

[19] D. Y. Nugraha, and D. Nugraha. "The Correlation between Learning Motivation and Learning Outcomes on Mathematics Subjects in XII Science Class Senior High School 4 Bone." Anatolian Journal of Education, vol. 6, no. 1, pp. 157-166, 2021.

[20] E. Wulandari. "Penerapan Model Problem Based Learning Pada Pembelajaran IPA Siswa Kelas V SD." Kalam Cendekia PGSD Kebumen, vol. 1, no. 1, pp. 1-6, 2012.

[21] J. Mueller, D. Beckett, E. Hennessey, and H. Shodiev. "Assessing Computational Thinking Across the Curriculum." Emerging Research, Practice, and Policy on Computational Thinking, vol. 2017, pp. 251–267, 2017.

[22] Z. Yu, M. Gao, and L. Wang. "The Effect of Educational Games on Learning Outcomes, Student Motivation, Engagement and Satisfaction." Journal of Educational Computing Research, vol. 59, no. 3, pp. 522-546, 2021.

[23] Y. D. Puspitarini, and M. Hanif. "Using Learning Media to Increase Learning

Motivation in Elementary School." Anatolian Journal of Education, vol. 4, no. 2, pp. 53-60, 2019.

[24] D. F. Al Husaeni, E. N. Q. Budisantoso, M. A. Urwah, N. N. Azizah, P. Z. Dinata, S. Apriliany, and H. Siregar. "The Effect of Using Web-Based Interactive Learning Media for Vocational High School Students to Understanding of Looping: Qualitative Approach." Journal of Science Learning, vol. 5, no. 1, pp. 115-126, 2022.

[25] L. Heliawati, L. Lidiawati, and I. D. Pursitasari. "Articulate Storyline 3 Multimedia Based on Gamification to Improve Critical Thinking Skills and Self-Regulated Learning." International Journal of Evaluation and Research in Education, vol. 11, no. 3, pp. 1435-1444, 2022.

[26] H. Marina, and S. Ridlo. "The Effectiveness of Flipped Classroom to Improve Students' Concept Understanding and Self Efficacy During the Covid-19 Pandemic." Journal of Biology Education, vol. 10, no. 1, pp. 70-76, 2021.

[27] S. S. Edie, H. N. Safitri, D. Alighiri, D., L. M. E. K. Sari, P. Marwoto, and R. S. Iswari. "The effect of using bomb calorimeter in improving science process skills of physics students." Journal of Physics: Conference Series, vol. 983, no. 1, pp. 012205, 2018.

[28] M. I. M. Hidayat, and H. Subekti. "Promoting Science Process Skills and Learning Outcomes Through Cybergogy Approaches with PhET Media for Junior High School Students." Jurnal Pijar Mipa, vol. 17, no. 4, pp. 499-506, 2022.

[29] K. Fry, K. Makar, and J. Hillman. "M in Computational Thinking: How Long Does it Take to Read a Book?." Teaching Statistics, vol. 45, pp. S30-S39, 2023.

[30] A. Banic, and R. Gamboa, "Visual design problem-based learning in a virtual environment improves computational thinking and programming knowledge." 2019 IEEE Conference on Virtual Reality and 3D User Interfaces (VR), pp. 1588-1593, 2019.

[31] T. S. Jonasen, and S. B. Gram-Hansen. "Problem Based Learning: A Facilitator Of Computational Thinking." Proceedings of the 18th European Conference on e-Learning: ECEL, pp. 260-7, 2019.

[32] S. S. Al-Gahtani, and M. King. "Attitudes, Satisfaction and Usage: Factors Contributing to Each in the Acceptance of Information Technology." Behaviour and Information Technology, vol. 18, no. 4, pp. 277-297, 1999.

[33] N. Sulistianingsih, S. Kusumadewi, and K. Kariyam. "Analysis of Dialogue Technique Acceptance of Diagnosis Based Clinical Decision Support System." Jurnal Ilmiah KURSOR, vol. 8, no. 1, pp. 1-12, 2015.

[34] R. S. Nuzulismah, H. B. Santoso, and P. O. H. Putra. "E-learning Adoption Readiness in Secondary Education of Developed and Developing Countries: A Systematic Literature Review." Jurnal Ilmiah Kursor, vol. 11, no. 4, pp. 165-178, 2022.

[35] B. Rahmat, and B. Nugroho. "Deep Learning-Based Object Recognition Robot Control Via Web and Mobile Using an Internet of Things (IoT) Connection." Jurnal Ilmiah Kursor, vol. 10, no. 4, 2020.

[36] F. Nuraini. "Penggunaan Model Problem Based Learning (PBL) untuk Meningkatkan Hasil Belajar IPA Siswa Kelas 5 SD." E-Jurnal Mitra Pendidikan, vol. 1, no. 4, pp. 369-379, 2017.

[37] V. Panggayuh. "Pengaruh Kemampuan Metakognitif Terhadap Prestasi Akademik Mahasiswa pada Mata Kuliah

Pemrograman Dasar." JIPI (Jurnal Ilmiah Penelitian Dan Pembelajaran Informatika), vol. 2, no. 1, pp. 20-25, 2017.