JPPIPA 9(5) (2023)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

Analysis of Biology Teacher's Computational Thinking Skills in Environmental Learning

Donna Karolina Br Surbakti[1], Topik Hidayat[2*], Widi Purwianingsih[2], Ari Widodo[2], Bambang Supriatno[2]

[1] Master of Biology Education Study Program, Faculty of Mathematics and Natural Sciences, Indonesian University of Education, Indonesia
[2] Department of Biology Education, Faculty of Mathematics and Natural Sciences, Indonesian University of Education Indonesia

Received: March 13, 2023
Revised: May 21, 2023
Accepted: May 25, 2023
Published: May 31, 2023

Corresponding Author:
Topik Hidayat
topikhidayat@upi.edu

DOI: 10.29303/jppipa.v9i5.3411

Abstract: Computational Thinking Skills are needed in learning. These skills must be owned by teachers and students with the aim that the demands contained in the curriculum can be achieved. One way that can be done is with a training program. The research objective was to determine the effect of training on the computational thinking skills of teachers and students in learning. The method used in this research is quasi-experimental research. The sampling technique used purposive sampling. The research sample consisted of 6 teachers and 167 students. The instrument used was a questionnaire in the form of a test given to the teacher and a student response questionnaire to learning. The results of data analysis regarding the questionnaire show that the teacher's computational thinking skills based on 4 indicators obtained an average percentage score of 75% (decomposition), 78% (pattern recognition), 83% (abstraction), and 77% (algorithm). To train students' computational skills, teachers usually train the following abilities: problem decomposition, usually teachers get used to giving complex problems, think algorithms, teachers apply problem-based learning, collaborative, cooperative, and project-based, pattern recognition, teachers use innovative learning media and abstract thinking, the teacher gives high-order thinking questions, and literacy and numeracy questions. And for the results of data analysis through questionnaires, students' responses to learning obtained an average value of 79%, with these results the learning process based on computational thinking skills that have been implemented is included in the interesting category.

Keywords: Computational Thinking Skills; Learning; High School Biology Teacher; Training

Introduction

In the era of the industrial revolution 4.0, efforts are needed to create an education system that can adapt to the times. This can be seen from the pace of technological development known as Information and Communication Technologies (ICT). So efforts are needed from these challenges that will be faced by future generations to be able to compete globally. Efforts that can be made to meet these challenges are to create strategies that can develop the required competencies. The right strategy is developed, namely to train students to have a variety of skills needed in the learning process and problem-solving. One of these skills is computational thinking skills.

Computational thinking skills are a tool that can develop students' problem-solving skills and creativity that are integrated with technological developments. Computational thinking skills can also be interpreted as an important thinking model for every student (Li et al., 2020). Computational thinking skills aim to train the ability to develop solutions from solving problems in the form of algorithms. According to Wing (2017) computational thinking skills do not mean thinking the same as a computer, but the abilities included the ability to think cognitively in solving problems effectively and innovatively. The ability to think cognitively includes: problem reformulation namely the ability to decompose complex problems into simple problems so that they are easy to solve, recursion namely the ability to build a system in stages based on information obtained

How to Cite:
Surbakti, D.K.B., Hidayat, T., Purwianingsih, W., Widodo, A., & Supriatno, B. (2023). Analysis of Biology Teacher's Computational Thinking Skills in Environmental Learning. *Jurnal Penelitian Pendidikan IPA*, *9*(5), 2604–2612. https://doi.org/10.29303/jppipa.v9i5.3411

previously, problem decomposition namely the ability to solve problems based on the steps that have been prepared, abstraction namely the ability to model important parts of complex problems in other problems, system testing namely the ability to take one directed action to get a solution to the problem faced. Based on this opinion, it is clear that computational thinking skills are very important for a teacher to be able to teach and train their students. At first learning computational thinking was informal learning but now it has shifted to formal learning because every student must participate in this at school. In learning computational thinking, it is also necessary to have an assessment that aims as an evaluation tool in the education system (Morris & Liu, 2019).

The importance of computational thinking education in the 21st century cannot be avoided, because digital computing technology is an essential component of today's needs (Morris & Liu, 2019). This is very closely related to the era of the industrial revolution 4.0 which also emphasizes that every field uses computerized principles (Ansori, 2020). At present, there is a need for concern for education, especially with router science (García-Peñalvo, 2018). Computational thinking skills can be used as a way to understand and solve a problem that is complex by using computer science techniques and concepts, namely decomposition, pattern recognition, abstraction, and algorithms which according to experts is one of the abilities that is very helpful, especially on the educational dimension of the 21st century. In Computational Thinking skills, students will be directed to have critical, creative, and communicative thinking skills and skills to collaborate in solving problems. Computational Thinking skills can also hone logical, mathematical, and mechanical knowledge which will later be combined with modern knowledge regarding technology, digitalization, and computerization and can even form an attitude of self-confidence, open-mindedness, and tolerance as well as an attitude of sensitivity towards the surrounding environment (Kalelioglu, 2018).

Wing (2006) defines Computational Thinking skills as an approach to solving problems, designing systems, and understanding other people's behavior by describing basic concepts in computing. From this statement it can be concluded that Computational Thinking skills are an analytical way of thinking, a mathematical thinking approach, in general, can be used in solving a problem, and there is a general engineering thinking approach that allows for designing and evaluating complex and intricate systems, as well as a scientific thinking approach in general. General understanding of the computing abilities, intelligence, mind, and behavior of other people.

Computational thinking is a method that can be used in solving problems by applying or involving techniques that can be used by software engineers (Malik et al., 2019). Computational thinking skills do not mean computer thinking skills, but computational thinking skills, namely one's skills in formulating problems in the form of computational problems and finding solutions to problems computationally in the form of algorithms or compiling appropriate steps used to solve the problem. The techniques that can be used in computational thinking according to Ioannidou et al. (2011) are as follows: (1) Decomposition: namely the ability to solve complex problems into simple problems. (2) Pattern recognition: namely the ability to know general similarities and differences that aim to make it easier to make predicting problems. (3) Generalization of patterns and abstractions (abstraction): namely the ability to filter the information obtained into important or unimportant information so that this important information will be used in solving similar problems. (4) Algorithm design (algorithms): namely the ability to arrange appropriate steps in solving problems.

Meanwhile, to measure computational thinking skills, their some indicators and according to Barr et al. (2011) as follows: ability to solve problems using computers and other devices; ability to organize and analyze data; ability to represent data through abstraction using a model or simulation, the ability to find solutions through algorithmic thinking; ability to identify, analyze, and implement solutions from the steps that have been prepared effectively and efficiently; and ability to generalize solutions in dealing with different problems.

The practical advantage that will be obtained with the habit of Computational Thinking for students is that it can help students improve their problem problem-solving, improve logical thinking, and analytical abilities and all these advantages are the key to success in being able to face the demands of the 21st century (Hunt, 2014). Because the rapid development of technology and communication has changed economic conditions and escalated existing competition. So, the task of a teacher must prepare individuals who are ready to face the challenges of the times and have skills that are ready to be used in the real competition of globalization and industrialization (Ansori, 2020).

Method

The research design used was the pre-experimental one-group pre-post test design. According to Cresswell (2010), this r, research design is a design that is used in one group of subjects which at the beginning of the activity will be given a pretest, then proceed with treatment, and end with giving a posttest. The research design is described as Table 1.

Table 1. Research Design with *Nonequivalent Control Group Design*

Pre-test	Treatment	Post-test
O_1	X_1	O_2

The population used in this study were high school biology teachers who are members of the subject teacher consultation and students of SMA Bandung and Cimahi for the 2022/2023 academic year. The technique in this study used a purposive sampling technique. The selected sample is teachers who have high, medium, and low pretest score categories, totaling 6 teachers and 167 students. To collect research data, measurement instruments are needed. The measurement instruments used in this study used the Computational Thinking instrument which aims to measure teachers' computational thinking skills, response questionnaires to learning, and interviews. The measurement instruments are in the form of tests and questionnaires to measure the computational thinking skills of teachers and students in learning which are distributed online via google forms. In this research, the data used is in the form of qualitative and quantitative descriptive data. For qualitative data was obtained from the results of the teacher's answers related to tests and interview results, while quantitative data was obtained from student response questionnaires to learning. The tests used in this study were judged by expert lecturers, for the questionnaire given to students in the form of a likert scale.

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Table 2. Teacher Personal Data

Name	Gender	Teacher Experience	Education Background
Teacher A	Female	>15 Years	Master in education management (S2) teacher is certified
Teacher B	Female	6-10 Years	Biology (S2) certified teacher
Teacher C	Female	>15 Years	Biology education (S1) teacher is certified
Teacher D	Female	>15 Years	Masters in education management (S2) teachers are certified
Teacher E	Female	1-5 Years	Biology (S1) teachers are not certified
Teacher F	Male	6-10 Years	BiologyIn biology (S1) the teacher is not certified

The research procedure to be carried out is divided into several stages, namely the preparation stage of the research plan, the research implementation stage, as well as the data processing stage, and the preparation of the research report. Each stage in this research will be explained as follows:

Preparation and Planning Stage

The preparatory stage in this research includes preliminary studies, literature studies, and the preparation of instruments. The following describes each stage: (1) Preliminary study. Preliminary studies in research include interviews and direct observation of schools. Interviews were conducted with biology teachers to find out how the biology learning process was going on and how the teacher's teaching experience was, what problems occurred during class learning, and to identify and formulate problems that occurred. (2) Literature study. Literature studies are carried out in research by reviewing journals, books, and reports from previous studies. (3) Preparation of instruments. The instruments used in the research will be prepared and compiled by the researcher. The instruments to be used are computational thinking skills in the form of questionnaires and student response questionnaires in learning.

After the preparation of the instruments, judgment is then carried out by experts to validate the contents of the instruments used in the study with the aim that the instruments used can be said to be valid instruments and can be used in subsequent studies.

Research Implementation Stage

The research implementation stage is the stage for carrying out Computational Thinking skills training activities with biology teachers. The training is carried out using a participatory method, namely by involving participants in training activities. c. Data Processing and Research Report Compilation Stage. At the stage of data processing and preparation of research reports is the stage for processing questionnaire data regarding Computational Thinking skills and student response questionnaires to learning.

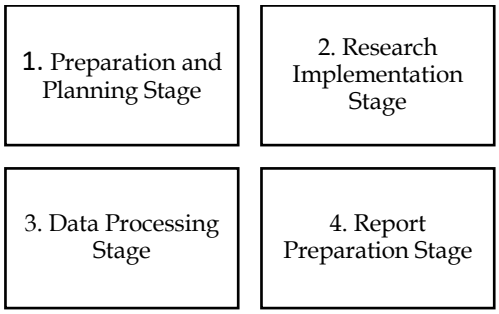

Figure 1. Research Procedure

Data collection techniques in this study were used to collect research data in the form of interviews, questionnaires in the form of tests, and student response questionnaires to learning. The following will explain in detail the data collection techniques used in this study:

Interview

The interviews in this study were conducted at the beginning before the training activities were held. The instrument used is based on an interview guide sheet which aims to further identify teachers' computational thinking skills. The data collected is in the form of a teacher's perspective on computational thinking skills and the integration of teachers' computational thinking skills in learning.

Test

The test used in this study is a type of instrument in the form of an open questionnaire given to teachers after attending training. The use of this test instrument aims to measure the computational thinking skills of teachers. The data collected from the distribution of the test is the teacher's knowledge and computational thinking skills in learning according to the available indicators, namely decomposition, pattern recognition, abstraction, and algorithms.

Questionnaire

The student response questionnaire to learning is the supporting data used in this study. Which aims to assess how students respond to learning after the teacher attends computational thinking skills training. Thus it will be known more deeply the results of the integration of computational thinking skills into learning, especially in environmental learning.

Data analysis and processing techniques in this study were based on collected data. The data is in the form of quantitative and qualitative data. To analyze the computational thinking skills of biology teachers obtained through the use of computational thinking instruments. Quantitative and qualitative descriptive analysis, as well as data triangulation, was carried out from the teacher's entry on the results of the questionnaire given. Through the questionnaire data, it will be known how the teacher's computational thinking ability in learning. Besides that, it will also get what elements the teacher has related to computational thinking skills. Following are the elements contained in computational thinking skills according to some experts can be seen in table 3.

Table 3. Elements of Computational Thinking Skills

Elements	Definition
Abstraction	The ability to decide what information about an entity/object is known to be stored and what information should be ignored (Wing, 2017)
Generalization	The ability to formulate solutions in general terms so that they can be applied to different problems (Selby & Woollard, 2014)
Decomposition	The ability to solve complex problems into small or simple parts that are easier to understand and solve (Wing, 2017)
Algorithms	The ability to design a series of operations/actions in stages (step by step) on how to solve a problem (Selby & Woollard, 2014)
Sequencing	The ability to place actions or processes in the correct order (Selby & Woollard, 2014)
Flow of control	The ability to sort the order in which instructions/actions are executed (Selby & Woollard, 2014)
Debugging	Ability to identify, delete, correct, and errors (Selby & Woollard, 2014)

Result and Discussion

Teacher Questionnaire Results Data Related to Computational Thinking Skills in Learning

Computational thinking skills are an important component for every student for successful learning in today's digital era. Integrating computational thinking into the curriculum is the right method to do (Kite et al., 2021). The results of qualitative descriptive data analysis regarding teachers' computational thinking skills used a questionnaire with a total of 13 questions. The questions contained in the questionnaire have been adapted to the indicators contained in computational thinking. This question is also closely related to the teacher's ability to train students to have problem problem-solving and find solutions to the problems given. In computational thinking skills, there are four indicators, namely problem decomposition, algorithmic thinking, pattern recognition, and abstraction and generalization (Lee et al., 2012). Based on the answers that have been given by the teacher, it can be explained in detail how the computational thinking skills possessed by the teacher during learning. The results of the test instrument trials obtained the following results:

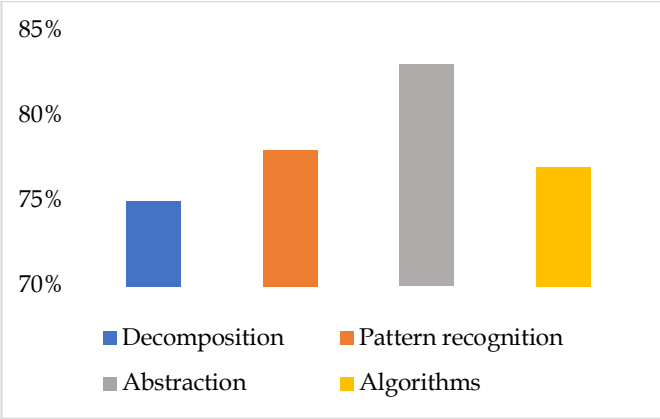

Figure 2. Average Percentage of Computational Thinking Skills

Problem Decomposition

Problem decomposition is the skill to break down large information/data into small parts so that it will be easier to understand, solve, develop, and evaluate separately. So that the complexity of the problems or information/data found will be easy to understand (Csizmadia et al., 2015). From the results of the answers to the questionnaires that have been collected, it is obtained that the percentage of an average score is 75% which is classified as a good category (Arikunto, 2010). It can be concluded that the way the teacher trains students to be able to understand and solve the problems given is by giving simple problems first then the teacher will give complicated problems so that in this way it will be easy for students to describe and identify related information that was previously known and asked of the problems given. In addition, students will be trained to be able to decompose complex problems into simple problems and students will be able to eliminate things that are not important and use things that are important in solving a problem. Students' skills in the problem decomposition stage can be assessed through group discussion activities because there are significant differences if students work collaboratively and students who work alone (Shute et al., 2017).

Pattern recognition

Pattern recognition is a skill in identifying, understanding, and developing a pattern or relationship to understand data or the right strategy is used with the aim that it is easy to understand and can strengthen abstract ideas (Csizmadia et al., 2015). From the results of the answers to the questionnaires that have been collected, it is obtained that the percentage of an average score is 78% which is classified as a good category (Arikunto, 2010). It can be concluded that the way the teacher trains students is to be able to determine the pattern of work on a given problem, to be able to find new patterns in solving problems and to be able to predict the preparation of problem-solving plans using innovative learning media such as Augmented Reality, Canva, Using this learning media will train students' ability to solve problems given by understanding the pattern first.

This is supported by a statement that states that at the pattern recognition stage students will recognize the context of the problem to solve it and will find the right pattern to use. So that teachers are required to get used to this in learning so that students are more creative and critical and have time efficiency and time to think shorter than before (Mufidah, 2018). The implementation of computational thinking skills in learning, especially at the pattern recognition stage, will stimulate students' interest and students will know the benefits of the systems contained in computers and be able to collaborate in learning (Kong et al., 2018).

Abstraction and Generalization

Abstraction is a skill in making meaning from the data that has been found and understanding what the implications are. Meanwhile, generalization is a skill that is owned to solve problems quickly based on previous similar problem-solving (Csizmadia et al., 2015). The results of the answers to the questionnaire that has been collected obtained an average percentage score of 83% which is classified as a good category (Arikunto, 2010). It can be concluded that the way the teacher trains students to be able to design an action to solve a problem, be able to find a solution to a given problem and be able to make conclusions from solving a given problem by giving questions that train higher-order thinking skills questions that train literacy and numeracy skills, and questions that train students' processing skills. This is supported by a statement that states that in the abstraction stage students will be able to identify the appropriate patterns used so that it will make it easier to identify the concepts and contexts contained in a given problem. So that students' ability to solve problems holistically and comprehensively will be trained (Fajri et al., 2019). Students' abilities at the abstraction and generalization stages will train students to use various appropriate methods and be able to modify them so that they will train their computational thinking conceptual skills in a learning context (Yadav et al., 2017).

Algorithmic Thinking (Algorithms)

Algorithmic thinking is skill-oriented to the ability to understand and analyze a problem. Apart from that, you will also be trained in the ability to develop steps to get an appropriate solution to the given problem, as well as find other steps as an alternative to solving the given problem (Doleck et al., 2017). From the results of the answers to the questionnaires that have been collected, it is obtained that the percentage of an average score is

77% which is classified as a good category (Arikunto, 2010).

It can be concluded that the way the teacher trains students to be able to solve a problem in a structured way, knows students have solved a problem according to a plan that has been prepared, trains students to be able to think systematically and gradually in solving a given problem, and trains students to be able to identify and find the solution of a problem by implementing a variety of strategies. Teachers apply problem-based learning, collaborative learning, cooperative learning, and project-based learning. By implementing this learning strategy, students' ability to think algorithmically will be trained and improved from before. This is supported by the statement that algorithmic thinking is needed in the context of problems that arise several times, from this repetition it will show that students have been able to process the dimensions of thinking algorithmically (Fajri et al., 2019). Based on the assessment framework (Wong & Jiang, 2019) states that thinking algorithms will train students to be able to understand, analyze, and create the problems given. By assessing how essential the problem is to be solved.

Data on Student Responses to Learning that Trains Computational Thinking Skills

The learning activities used by the teacher in the classroom will use processes that can train students' computational thinking skills. Assessment of these learning activities will use a student response questionnaire, which aims to find out how students respond to learning activities. Based on the results of the assessment of student responses to learning, can be seen in the Figure 3.

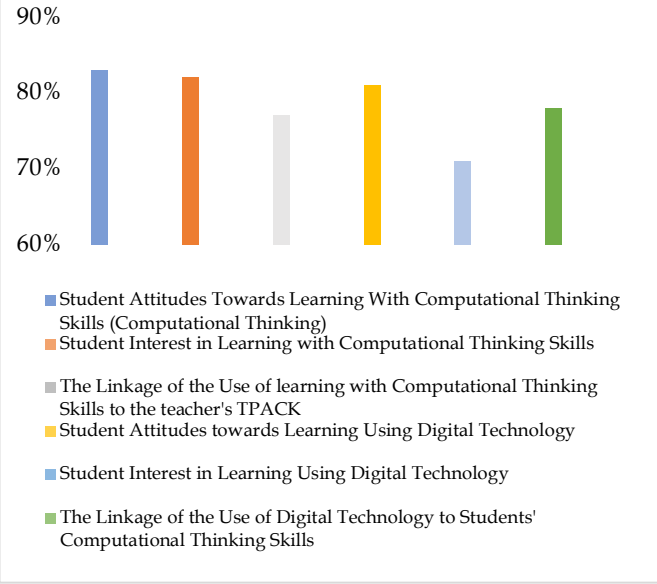

Figure 3. Average Results of Student Responses to Learning

Figure 3 shows the average results of student responses in several aspects of learning that have previously been compiled by researchers. There are 6 aspects of assessment in the student response questionnaire, namely: 1) Aspects of student attitudes towards learning with computational thinking skills (Computational Thinking) with an average value of 83%, 2) aspects of student interest in learning with computational thinking skills (Computational Thinking) with a value an average of 82%, 3) aspects of learning relatedness with computational thinking skills (Computational Thinking) to teacher TPACK with an average value of 77%, 4) aspects of students' attitudes towards learning using digital technology with an average value of 81%, 5) aspects of students' interest in learning using digital technology with an average value of 71%, 6) aspects of the relevance of the use of digital technology to students' computational thinking skills with an average value of 78%. Based on several aspects of the student response questionnaire assessment, an average value of 79% was obtained. According to Riduwan (2015) the percentage of students' responses to learning with a value of 79% is in the range of 61-80%, including in the interesting category. So it can be concluded that learning activities by practicing computational thinking skills and the use of technology are considered attractive by students.

Aspects of Student Attitudes Towards Learning With Computational Thinking Skills (Computational Thinking)

The results of the analysis of research data using a questionnaire on student responses to learning aspects of students' attitudes towards learning by using computational thinking skills obtained an average value of 83%. Based on the categorization that has been formulated Riduwan (2015) it belongs to the very interesting category, thus it is concluded that the learning process based on students' computational thinking skills can train students to be able to think computationally. Learning based on computational thinking skills facilitated by teachers in class helps students to understand the material presented easily. Students also think that the general description explained by the teacher at the beginning of learning helps students to know the outline of the material and the learning objectives to be achieved.

Aspects of Student Interest in Learning with Computational Thinking Skills

The results of the analysis of research data on aspects of student interest in learning by using computational thinking skills as a whole obtained an average value of 82%. Referring to the categorization of scores Riduwan (2015), it belongs to the very attractive category. In the learning process, students have a high interest because the teacher has used learning with

computational thinking skills so that students do not feel bored with the learning activities that are followed in class. By applying learning activities based on computational thinking skills, students think that presentation and discussion activities will train their speaking skills, and train their ability to express their opinions.

Aspects of the Linkage of Learning with Computational Thinking Skills to the Teacher's TPACK

The results of the analysis of research data on aspects of the linkage of learning with computational thinking skills (Computational Thinking) on the teacher's TPACK as a whole get an average value of 77%. Referring to the categorization of scores Riduwan (2015), it belongs to the interesting category. In this aspect, teachers who have used digital technology to train students' computational thinking skills already have a deep awareness and sensitivity to the importance of training students' computational thinking skills with the help of digital technology. The teacher also considers that applying computational thinking skills in learning will make the learning process more innovative and creative. When learning is based on computational thinking skills, it is easier for students to understand and understand all the explanations given by the teacher because the teacher has used digital technology that supports it, and there are also differences from previous learning activities.

Aspects of Student Attitudes towards Learning Using Digital Technology

The results of research data analysis on aspects of students' attitudes towards learning using digital technology as a whole get an average value of 81%. Referring to the categorization of scores Riduwan (2015), it belongs to the very attractive category. Students' attitudes towards learning with computational thinking skills are very influential in student responses to the learning process. Students think that learning with the help of technology will help students understand the material studied in more depth. With learning that uses digital technology students can also find new knowledge that they have not gotten from previous learning. And with learning that uses technology students get the opportunity to learn material delivered by the teacher anywhere and anytime without being limited by time.

Aspects of Student Interest in Learning Using Digital Technology

The results of research data analysis on aspects of student interest in learning using digital technology as a whole get an average value of 71%. Referring to the categorization of scores Riduwan (2015), it belongs to the interesting category. By learning using digital technology students have a highly enthusiastic attitude compared to learning that does not use digital technology. Students assume that teachers who have used digital technology during learning are teachers who always follow curriculum developments. And students are also very interested in participating in discussion and question-and-answer activities when teachers use digital technology in learning.

Aspects of the Linkage of the Use of Digital Technology to Students' Computational Thinking Skills

The results of research data analysis on aspects of the use of digital technology on students' computational thinking skills as a whole get an average score of 78%. Referring to the categorization of scores Riduwan (2015), it belongs to the interesting category. Students' responses to learning using digital technology have a lot of influence, one of which is training students' computational thinking skills. When teachers use digital technology and demand students to have computational thinking skills, it will be easier for students to find solutions to a problem given by the teacher. And when learning takes place the teacher has directed students to have computational thinking skills by the skill requirements, especially in today's 21st century.

Conclusion

Based on the results of the research and discussion that has been presented, it can be concluded that the increase in the computational thinking skills of teachers and students is very influential after training. From the results of data analysis using test instruments distributed to teachers after training, it shows that teachers' computational thinking skills based on 4 indicators obtained an average percentage score of 75% (decomposition), 78% (pattern recognition), 83% (abstraction), and 77% (algorithm). And for the results of data analysis using a student response questionnaire to learning, an average value of 79% is obtained, with these results, the learning process based on computational thinking skills that have been implemented is included in the interesting category. The learning process based on computational thinking skills with the help of digital technology can increase students' interest in learning. So training in computational thinking skills has an effect on increasing the computational thinking skills of teachers and students in learning.

Acknowledge

This research was fully funded by the UPI grant in 2023 (SK number: 535/UN40/PT.01.02/2023), for which we are grateful.

Author Contributions

The authors confirm their contribution to the paper as follows: the influence of training and case studies. B. Author, C. Author,

D. Author, E. Author; as an instructor at training: A. Author; data collection: A. Author; analysis and interpretation of result: A. Author, B. Author, C. Author; draft manuscript preparation. All authors reviewed the results and approved the final version of the manuscript.

Funding
This research was funded by UPI grant in 2023 (SK number: 535/UN40/PT.01.02/2023).

Conflicts of Interest
The authors declare no conflict of interest.

Reference

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