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The Urgency of Developing Computational Thinking Skills Test Instruments with the Theme of Biology for High School Students

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Abstract

The effort needed to achieve optimal education in the era of the Industrial Revolution 4.0 is to develop problem-solving skills closely related to computational thinking. The type of research used is qualitative descriptive to know the urgency of developing a computational thinking skills test instrument for Biology high school students. The subject of this research is a Biology teacher spread across Banten Province. Tahapan penelitian meliputi pengambilan data melalui kuesioner, analisis data, dan penarikan kesimpulan. The research stages include collecting data through questionnaires, data analysis, and conclusions. The research results show that 57% of teachers know enough about computational thinking skills, and 71% do not know enough about indicators of computational thinking skills. However, as many as 57% of teachers had applied decomposition questions, 43% had applied pattern recognition questions, 71% had applied abstraction questions, and 71% had applied algorithm questions. The conclusion of this research is the importance of computational thinking skills in biology learning, so there is a need to develop test instruments to measure these skills in students at school.

Keywords: Computational Thinking Skills, Biology, High School Students

INTRODUCTION

The era of Industrial Revolution 4.0 requires an optimal education system that adapts to current developments. Technological growth is increasingly rapid, marked by AI (Artificial Intelligence) and IoT (Internet of Things) as the backbone of movement and interconnection between humans and machines. McKinsey Global Institute reports that almost 50% of work activities worldwide could be automated by 2030. Incorporating (computational) information processing into various aspects of life brings many benefits and conveniences to humans. At the same time, it brings new challenges for future generations to compete in the global world (Manyika *et al.*, 2017).

Efforts can be made to face future challenges by creating strategies to develop the necessary skills. The education system has integrated Information and Communication Technology (ICT) in its implementation. ICT management is very helpful in improving the quality of student learning in schools (Lai, 2020). By using ICT in learning, students can become active learners; that is, they know the information they need, why they need it, and how they get it (Suryani, 2010). In addition, ICT can create dynamic and collaborative learning to increase interaction and communication.

Learning in schools must also focus on developing the skills needed to help future generations solve various problems. Problem-solving is closely related to computational thinking, which must be developed and is very important in the learning process (Doleck et al., 2017). Computational thinking is a way of understanding and solving complex problems using computational concepts and techniques such as decomposition, abstraction, pattern recognition, and algorithms, which many experts consider to be one of the skills that support the dimensions of 21st-century education (Weese & Feldhausen, 2017). Computational thinking guides students to improve critical thinking, communicative, creative, and collaborative problem-solving skills. Additionally, computational thinking trains logical, mechanical, mathematical knowledge, combined with modern technology, computerization, and digitalization knowledge, and even forms a tolerant, open-minded, confident, and environmentally sensitive character (Kalelioğlu, 2018).

Computational thinking involves cognitive processes that cover various aspects of solving problems effectively and creatively (Wing, 2017). These cognitive processes include decomposition, which is the ability to break down complex problems into simpler parts so that they can be addressed separately; pattern recognition, namely the ability to identify patterns in a problem to determine the best solution; abstraction, as the ability to recognize general patterns and model solutions; and algorithms, which involve a systematic problem-solving process and can be adopted by various parties (Sari *et al*., 2022).

Based on the results of PISA (Program for International Student Assessment) organized by the OECD (Organization for Economic Cooperation and Development) in 2018, Indonesian students were ranked 71st out of 78 countries in the science achievement category, averaging 396. The PISA science test includes formulation problems, analyzing data, modeling problems, comparing several problems, and solving tasks with algorithms. The PISA assessment involves six levels ranging from one (low) to six (high). At levels 4, 5, and 6, some indicators include identification skills, reflection, problem formulation, interpreting data, evaluation, generalization, and using available information to solve problems. The characteristics at this level align with the category of computational thinking skills. Based on the 2018 PISA results in the field of science, the percentage of Indonesian students who reached levels 4, 5, and 6 is less than 10% (OECD, 2019). This means that students' computational thinking abilities in Indonesia are still relatively low.

Previous research regarding computational thinking assessment instruments, including research by Grover & Pea (2013), Kim et al. (2014), Shute et al. (2017), and Sondakh et al. (2020), pointed out the difficulty in quickly evaluating the impact of interventions because there is no agreement on the methods that can be used to assess computational thinking skills. As a result, assessment issues are less than in studies investigating approaches to teaching computational thinking skills. Research conducted by Satrio (2020) shows that problem-solving skills based on algorithms and abstractions using the KADIR learning model are still below average. Next is research by Supiarmo *et al*. (2021), which shows that students still use general procedures to solve problems. Students' computational thinking stages only reach the pattern recognition and decomposition stage; students are not yet able to apply abstraction in problem-solving. Students also do not have the skills in algorithmic thinking in a logical and systematic problem-solving process. Therefore, further research is needed regarding assessing computational thinking skills to answer the demands of problems in the era of the Industrial Revolution 4.0.

Based on the explanation above, it can be seen that it is essential for students to master computational thinking skills. One way to facilitate these skills is to develop computational thinking skills test instruments. A crucial first step is to know the urgency of computational thinking skills for students, especially in biology learning, where research is still limited in developing these skills. Therefore, this research aims to determine the urgency of developing a test instrument for computational thinking skills in biology for high school students.

METHOD

This type of research is descriptive qualitative (Adlini et al., 2022). Data collection was obtained through distributing questionnaires to high school biology teachers representing cities/districts in Banten Province, Indonesia. The type of instrument used is a mixed questionnaire with questions about curriculum, instruments, and forms of evaluation tests, teachers' initial knowledge about computational thinking concepts, and identifying the use of computational thinking skills test instruments in schools. Data analysis was carried out through four stages: pre-field analysis, data reduction, data presentation, and data verification (drawing conclusions) (Subagja *et al*., 2022). Pre-field analysis was carried out on data from previous preliminary studies; data reduction was carried out by summarizing and comparing the results of answers regarding high school students' Biology computational thinking skills test instruments and focusing the answers on the goals to be achieved. Data presentation is carried out by writing down the analysis results in the form of descriptions, and data verification is carried out by drawing conclusions, which are useful as reinforcement in selecting subjects and places for further research. The following is the qualitative descriptive research flow in this study (Figure 1).

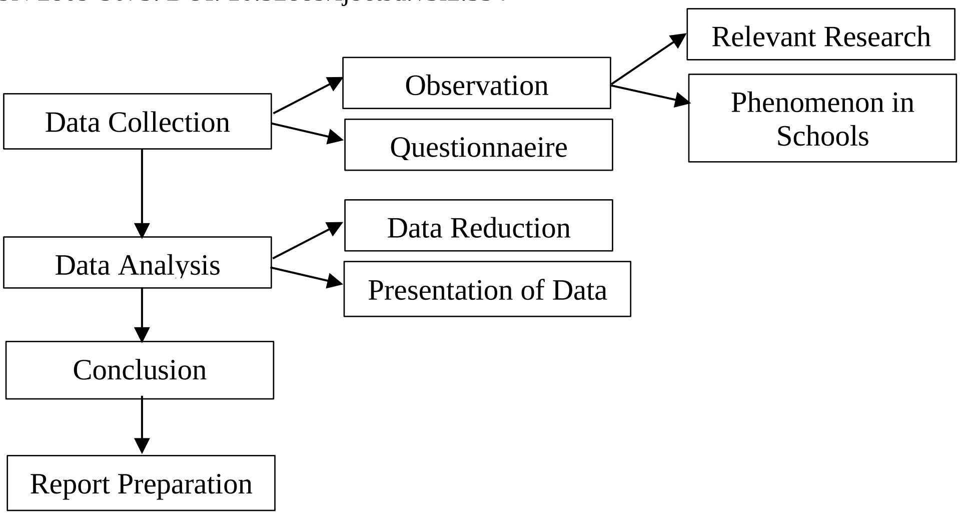

Figure 1. Descriptive Qualitative Research Flow [Source: Subagja *et al*. (2022) & Syafril *et al*. (2019) with modifications].

RESULTS AND DISCUSSION

Use of Curriculum in Schools

Based on the questionnaire results, some schools use the 2013 curriculum, the independent curriculum, or a combination of the 2013 curriculum and the independent curriculum. Two schools in Pandeglang Regency use the 2013 curriculum and the independent curriculum. One of these high schools has implemented the independent curriculum for one semester and the 2013 curriculum since the curriculum was released. Meanwhile, another one has implemented the independent curriculum for two years, intended for students in grades X and XI, while the 2013 curriculum has been implemented since the release of the curriculum and is intended for students in class. Meanwhile, one of the Serang Regency and Tangerang City schools only uses the independent curriculum. Sequentially, the two schools have implemented the curriculum for two years, starting in 2022/2023. Meanwhile, one of the schools in Tangerang Regency still uses the 2013 curriculum and has been running for six years since 2017.

Curriculum implementation is crucial to support the use of computational thinking skills test instruments in schools. The curriculum must develop students' creativity in solving problems related to computational thinking. In addition, the curriculum implemented must give students the freedom to study various aspects to explore their interests to create a deeper understanding (Amalia, 2022). In general, one of the relevant curricula for developing these skills is the independent curriculum, which can prepare students holistically by developing relevant skills to face future problems through the implementation of P5 (Strengthening Pancasila Student Profile Project).

Preparation of Evaluation Instruments by Teachers in Schools

Several teachers in Pandeglang Regency, Serang Regency, Tangerang Regency and Tengerang City prepared evaluation instruments to measure and improve students' skills in solving problems. These skills include critical, creative, innovative thinking, numeracy, and computational thinking. Some of these skills are considered by teachers to hone thinking skills, spark enthusiasm for learning, and help solve problems. So far, the instruments created by teachers can improve student learning outcomes by considering student skills, Biology material, and the use of the curriculum in its preparation. More clearly, the percentage of skills developed by teachers in compiling evaluation instruments is as follows (Figure 2).

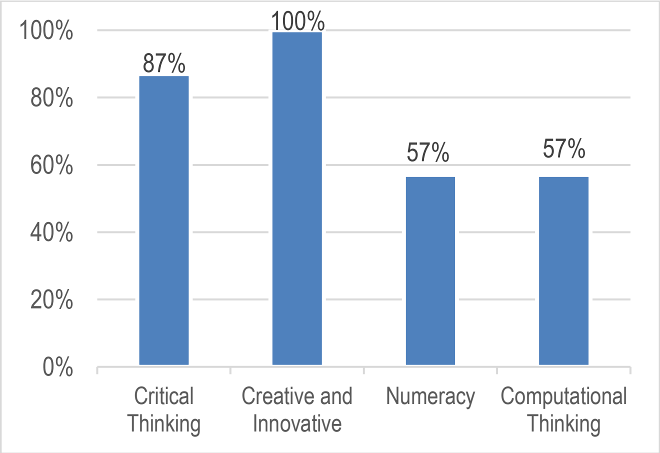

Figure 2. Percentage of Skills Developed by Teachers in Developing Evaluation Instruments

Identify Teachers' Knowledge of Computational Thinking Skills

As 29% of teachers know computational thinking skills, 57% of teachers know enough, and 14% of teachers do not know computational thinking skills. As many as 86% of teachers who know computational thinking skills assess that students' skills in computational thinking are quite good, and 14% of teachers assess that students' skills in computational thinking are not good. Indicators of computational thinking skills include decomposition, abstraction, pattern recognition, and algorithms (Blokhuis et al., 2019; Schulz et al., 2015). 29% of teachers know these four indicators, and 71% only know some. 86% of teachers have implemented some indicators of computational thinking skills into evaluation instruments, while the remaining 14% have not implemented these indicators into evaluation instruments for Biology learning.

Computational thinking skills are the skills to solve problems systematically and structured using computational concepts and principles. These skills include abstract, logical, and analytical thinking (Elfianis, 2023). Through this understanding, 57% of teachers assess that computational thinking skills are very important in learning Biology, 29% of teachers assess that computational thinking skills are important in learning Biology, and 14% of teachers assess that computational thinking skills are quite important in learning Biology.

Identification of the Use of Biology Computational Thinking Skills Test Instruments by Teachers in Schools

Identification of the use of computational thinking skills test instruments developed by teachers based on indicators of decomposition, abstraction, pattern recognition, and thinking algorithms can be seen in Figure 3.

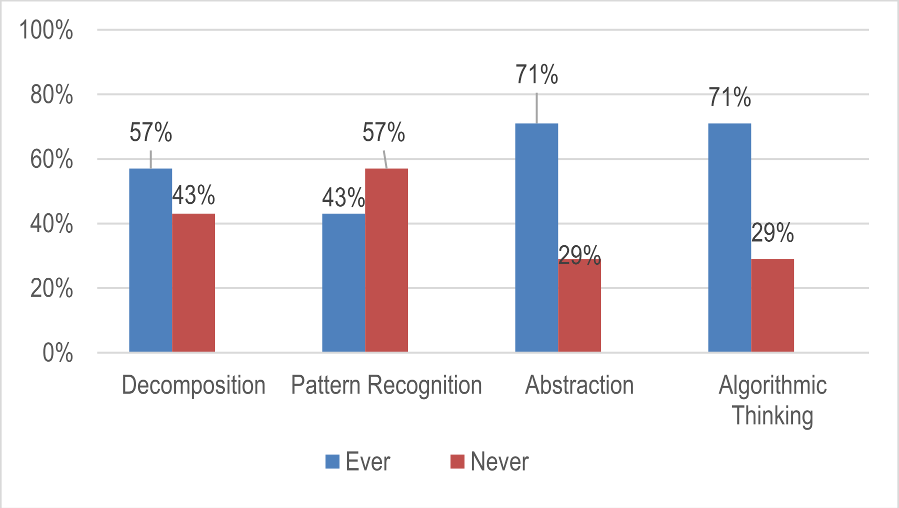

Figure 3. Percentage of Use of Computational Thinking Skills Test Instruments by Biology Teachers in Banten Province

Based on Figure 3, 57% of teachers have implemented questions that trigger students to sort large amounts of information into simpler information (decomposition), and 43% have not. Teachers who have implemented these indicators include them in tests on material about the digestive system, plant transportation, and environmental changes by providing a problem of environmental changes that occur and asking students to analyze the causes. In contrast to the pattern recognition question indicator, 43% of teachers have implemented similar questions in Biology learning, which can trigger students to recognize the pattern of solving the problem so that it helps students have an idea to work on the following problem more efficiently. In comparison, 57% of teachers have not implemented this problem. The teacher applies questions with pattern recognition indicators on material about disorders of organ systems and the structure and function of plants. By giving questions to fill in the blanks, students must know the contents of the previous question to do the next question.

71% of teachers have also implemented abstraction question indicators, namely providing complex information so that students can identify this information as more important information and develop it to answer/solve problems in questions. In comparison, 29% of teachers have not implemented these questions. These questions are used as evaluation instruments on systematic material for writing scientific papers, cell division, renewable technological innovation (renewable energy), and plant transportation. Likewise, with the algorithm question indicators, 71% of teachers have also implemented evaluations in the form of case studies, which instruct students to take steps to solve the case study and draw conclusions from the case studies provided. In comparison, 29% of teachers have not implemented these questions. The evaluation question indicators are applied to viral material, environmental changes, the respiratory system, and the dangers of smoking.

Based on the results of this research, we know that each component obtained is still far from perfect, so we need to increase this percentage by starting to assess students' CT skills. Assessing students' CT skills must use valid and reliable instruments. Many studies have developed or modified CT, including *Bebras Task, Fairy Assessment*, and *Computational Thinking Pattern Quiz* (CTP-Quiz). The *Bebras Task* is presented as question descriptions accompanied by images that aim to assess CT skills without prior knowledge of computational thinking (Dagiene & Futschek, 2008). *Fairy Assessment* is an Alice-based assessment tool that aims to evaluate whether learners have achieved sufficient content knowledge after receiving some training in CT skills (Román-González et al., 2019; Werner et al., 2012). Meanwhile, *CTP-Quiz* is a video game-based quiz that aims to test participants' ability to recognize and understand patterns in context taken from game programming and apply their knowledge to create science simulations (Basawapatna *et al*., 2011).

CT skills are important today because they help students or professionals structure problem-solving in the digital era, improve a person's thinking ability when facing challenges, and are essential 21st-century competencies (Yusup et al., 2023). These skills enable individuals to understand and use technology effectively, as well as deal with rapid and complex changes in the digital environment so that it can make things easier (Castañeda, 2023). Apart from that, mastering CT also helps develop mathematical and technical thinking skills, so students will find it easier to learn other materials after mastering CT (Lestari & Roesdiana, 2023).

CONCLUSION

Based on the data above, it can be concluded that computational thinking skills are important in learning Biology, so it is necessary to develop test instruments to evaluate these skills in students at school. This is supported by research results that computational thinking skills are needed for students as a provision in solving biology problems. However, teachers' limitations in developing test instruments have not been able to measure computational thinking skills. Several indicators of computational thinking skills test questions that teachers accidentally apply can be a reference for developing further computational thinking skills test instruments.

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