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CT TEST: A POWERFUL TOOL FOR ASSESSING COMPUTATIONAL THINKING SKILLS IN BIOLOGY

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Abstract.

This research aims to create a tool for assessing students' computational thinking (CT) skills in relation to biology concepts. The study followed a research and development approach, utilizing a modified 4D design model, with the dissemination phase excluded. Various data collection techniques were employed, including observations, literature reviews, documentation, surveys, interviews, and tests. The findings showed that the developed instrument was valid, having been evaluated by three experts. The material expert rated it at 95%, the assessment and evaluation expert at 88%, and the linguist at 90%. In terms of readability, the instrument scored 75%, indicating a "good" rating. The overall validity of the instrument was found to be 0.70, placing it in the high validity range, while its reliability score was 0.82, reflecting a very high level of dependability. The assessment of students' computational thinking skills in biology revealed that 25% of students scored in the low range, 28% in the medium range, and 57% in the high range. Specifically, significant improvements were observed across several components CT skills: decomposition skills 30%, pattern recognition 20%, algorithmic 15%, and abstraction 7%. From these findings, it can be concluded that the CT test tool is both valid and appropriate for evaluating students' computational thinking skills.

Keywords: biology; computational thinking skills; CT Test

***CT TEST*: ALAT YANG SESUAI UNTUK MENILAI KETERAMPILAN BERPIKIR KOMPUTASI DALAM KONSEP BIOLOGI**

Abstrak. Studi ini bertujuan untuk mengembangkan instrumen untuk mendeteksi keterampilan berpikir komputasi siswa pada konsep Biologi. Penelitian ini menggunakan metode penelitian dan pengembangan dengan desain 4D yang dimodifikasi tanpa diseminasi. Metode pengumpulan data yang digunakan meliputi observasi, tinjauan pustaka, dokumentasi, kuesioner, wawancara, dan tes. Hasil penelitian menunjukkan bahwa instrumen yang dikembangkan dinyatakan valid setelah divalidasi oleh 3 ahli, dengan persentase rata-rata kelayakan masing-masing sebesar 95% dari ahli materi, 88% dari ahli penilaian dan evaluasi, dan 90% dari ahli bahasa. Sementara itu, uji keterbacaan instrumen menghasilkan persentase 75% yang termasuk dalam kategori baik. Secara keseluruhan, nilai validitas instrumen adalah 0,70, yang tergolong dalam kategori validitas tinggi, sementara nilai reliabilitas instrumen adalah 0,82, yang termasuk dalam kategori reliabilitas sangat tinggi. Hasil keseluruhan menunjukkan bahwa keterampilan komputasi siswa pada konsep biologi sebesar 25% siswa mengalami kategori rendah, 28% siswa mengalami kategori sedang, dan 57% siswa mengalami kategori tinggi. Secara spesifik, perbaikan yang signifikan diamati pada beberapa komponen keterampilan berpikir kritis (CT): keterampilan dekomposisi 30%, pengenalan pola 20%, algoritma 15%, dan abstraksi 7%. Dari temuan ini Berdasarkan hasil tersebut dapat disimpulkan bahwa instrumen Tes CT yang dikembangkan layak dan dapat mendeteksi keterampilan berpikir komputasi pada siswa.

Kata Kunci: biologi; keterampilan berpikir komputasional; *CT Test*

I. INTRODUCTION

Computational thinking is a problem-solving and decision-making method rooted in concepts and techniques from computer science. It emphasizes approaching problems in a way that makes them solvable by computers or through automation (Li *et al*., 2020) Several core components define computational thinking, including (Gretter & Yadav, 2016; Mauludyah *et al*., 2023;

Abidi *et al*., 2023; Munawarah *et al*., 2021): 1) Decomposition involves breaking down a complex problem into simpler, more manageable components; 2) Pattern Recognition, the ability to detect recurring patterns or similarities in a problem, enabling the creation of rules or strategies for solving related challenges; 3) Abstraction, which focuses on isolating the essential aspects of a problem while disregarding unnecessary details; and 4) Algorithm, which refers to the development of systematic, step-by-step procedures to address a given problem.

Various techniques are frequently employed to assess students' computational abilities, such as open-ended questions, diagnostic tests, prediction-observation-explanation activities, interviews, essays, and drawings. However, each method has its own set of drawbacks. For example, computational interviews can provide in-depth insights into students' thinking but are time-consuming when trying to interview a large number of students (Iannone & Simpson, 2015). On the other hand, essays allow for quicker assessment of more comprehensive responses from multiple

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students, However, they demand considerable time and effort for evaluation. An essay test usually consists of a single question, which may feature narrative descriptions, images, graphs, or diagrams. The benefits of essay-based assessments include: (1) minimizing the likelihood of random guessing; and (2) being easier to organize and evaluate compared to other assessment types, making them highly suitable for use in classrooms (Susongko, 2010).

To start their analysis, the researchers examined the biology textbook from SMAN 4 Tasikmalaya, selecting pertinent content that could be utilized in creating CT test items. Following this, they conducted a second literature review to explore additional materials that might align with the indicators of Computational Thinking. For this purpose, they adapted essay-based questions from the work of Sa'diyyah *et al*., (2021), These researchers, who specialized in developing computational assessment tools for mathematics, subsequently conducted an initial multiple-choice test with the XII MIA 5 class. The pre-research findings revealed a proficiency rate of 39.8%, placing students in the moderate category, indicating that this sample was suitable for further evaluation of their computational abilities.

A review of existing literature revealed several limitations in using multiple-choice assessments to evaluate students' computational skills. These included low accuracy levels and the tendency for students to guess, which hindered the ability to effectively measure key components of computational thinking, such as decomposition, pattern recognition, algorithms, and abstraction (Veronica *et al*., 2022).

One effective way to address the limitations of multiple-choice tests is by converting them into essay-based assessments. As a result, essay instruments are viewed as more suitable for evaluating students' computational skills. The key advantage of using essay tests is their ability to capture a more nuanced understanding of student knowledge, providing a clearer and more detailed insight into the depth of students' computational thinking (Hogan & Mishler, 1980; Troia *et al*., 2023).

Extensive research and development on Computational Thinking (CT) assessment tools have been carried out in physics and chemistry. However, there has been limited progress in the development of similar tools for biology, especially for high school students. However, biology presents unique challenges for the integration of computational thinking due to its emphasis on complex systems and the often-abstract nature of biological processes, which differ from the more structured and quantifiable challenges found in disciplines like physics or mathematics in STEM (Hunter, 2017). To address this gap, the researchers aimed to create a CT assessment instrument tailored to biology concepts, using an essay format, which was named the CT Test. The uniqueness of the CT Test lies in its ability to measure students' computational thinking skills in biology with the help of diagrams and images. Additionally, this instrument includes not just one topic but eight different biology topics, as shown in Table 4, whereas computational thinking tests in other fields typically focus on only one topic. This research and development aim to evaluate the feasibility and efficacy of the CT instrument in assessing students' computational skills within the realm of biology.

II. RESEARCH METHOD

This study follows a research and development approach, employing the 4D model (Define, Design, Develop, and Disseminate) proposed by Thiagarajan *et al*., (1973). However, the dissemination phase was not implemented in this research, as noted by Hamdani & Hasanah, (2022) and Nastiti & Nasir, (2016). The reason I did not conduct the dissemination phase is because my primary focus is on the development and testing of the product or prototype produced. I prioritize the define, design, and develop stages to ensure the effectiveness and quality of the developed product or system.

A. Research Procedure

The first phase of this study is the Define stage, which includes conducting a front-end analysis, analyzing students, reviewing the concepts, performing task analysis, and defining learning objectives. The second phase is the Design stage, where test standards are developed, media and formats are chosen, and the initial design is created. The third phase is Develop, which includes expert reviews and product testing. The result of this research is a Computational Thinking assessment instrument designed to measure students' computational abilities.

B. Data Source

This study draws data from three types of experts: subject material experts, assessment experts, and linguist experts. Two field trials were conducted: the preliminary field trial and the final field trial. The preliminary trial focused on assessing the instrument's readability and was conducted with 32 students in class XII MIA-4. The final trial aimed to evaluate the instrument's effectiveness in measuring students' computational skills and involved a total of 66 students from classes XI MIA-1 and MIA-4.

C. Data Collection and Analysis

This research utilized various data collection methods, including literature reviews, surveys, interviews, tests, and documentation. For the data analysis, the validators were given an assessment rubric to evaluate the instrument's relevance and content. The feedback from the expert validators was subsequently analyzed using simple calculation of percentages. The product feasibility criteria based on expert judgment results are presented in Table 1.

TABLE 1. Criteria of Product Feasibility

Category		Score %
Very Infeasible	:	<21
Infeasible	:	21-40
Adequate	:	41-60
Feasible	:	61-80
Very Feasible	:	81-100

(Source: Septianingsih *et al*., 2023)

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The validity and reliability analysis of the instrument was performed using ANATES version 4.2. The categorization results for both validity and reliability are shown in Table 2 and Table 3.

TABLE 2. Category of Validity

Category		Score
Very High	:	0.80 < rxy ≤ 1.00
High	:	0.60 < rxy ≤ 0.80
Medium	:	0.40 < rxy ≤ 0.60
Low	:	0.20 < rxy ≤ 0.40
Very Low	:	0.00 < rxy ≤ 0.20
Not Valid	:	rxy ≤ 0.00

(Source: Guilford, 1956)

TABLE 3. Category of Reliability

Category		Score
Very High	:	0.80 < rxy ≤ 1.00
High	:	0.60 < rxy ≤ 0.80
Medium	:	0.40 < rxy ≤ 0.60
Low	:	0.20 < rxy ≤ 0.40
Very Low	:	0.00 < rxy ≤ 0.20
Not Valid	:	rxy ≤ 0.00

(Source: Guilford, 1956)

The student feedback questionnaire was adapted from Masriyah, (2006), and the respondent scores were computed by percentages calculation of students' responses each item. The table of components and the linearization of the CT test content act as a reference for categorizing respondent responses. The table outlining the CT test components is shown in Table 4.

TABLE 4. Components of CT test

No.	Component	Material
1	DPAA systematic	Circulatory system
2	DPAA systematic	Genetics
3	DPAA unsystematic	Circulatory system
4	DPAA unsystematic	Ecosystem
5	Decomposition	Ecosystem
6	Decomposition	Excretion System
7	Pattern Recognition	Heredity
8	Pattern Recognition	Growth and Development
9	Abstraction	Biodiversity
10	Abstraction	Psychotropics

III. RESULTS AND DISCUSSION

The development of CT test instruments using the 3D model resulted in the following outcomes.

A. Define

Following problem identification and data collection, the researchers opted to develop a Computational Thinking assessment tool aimed at evaluating students' computational skills within the context of biology concepts. This instrument is based on a multiple-choice test previously developed for Physics concepts (Daenuri Anwar et al., 2023). During the defining phase, the researchers undertook several steps: 1) Selecting high school students who had studied the relevant biology concepts as the study participants, 2) Ensuring the instrument aligned with both biology concepts and the components of Computational Thinking, 3) Designing the test with 10 questions, and 4) Incorporating content related to topics such as the cardiovascular system, urinary system, genetics, heredity, biodiversity, ecosystems, psychotropic substances, and growth and development.

B. Design

The design process for the Computational Thinking assessment tool includes the following steps: 1) Developing a question framework that defines core competencies, Computational Thinking components, and assigns question numbers to each indicator, 2) Choosing the test format, which is essay-based because it better suited to capture students' responses in greater depth with a wider range of scores based on their answers, compared to multiple-choice questions, which only assign a score of 1 for correct answers and 0 for incorrect ones. Additionally, multiple-choice questions may lead students to guess answers rather than choose based on their own knowledge. Furthermore, with essay questions, it is easier to detect similarities in students' answers that may indicate cheating (Oermann, 1999; Walstad, 2006)., 3) Formulating the actual CT test questions, as shown in Figure 1, and 4) Finalizing the initial design of the assessment tool focused on biology concepts.

1. Answer this question correctly!
Mrs. Prilly is currently suffering from anemia and needs a blood transfusion, but the hospital has run out of blood bags. The hospital suggests that family members may help by donating blood. Given that the father has blood type A, the first child has blood type O, the second child has blood type AB, the third child has blood type A, and the fourth child has blood type B, who among them can donate blood to Mrs. Prilly?

Figure 1. CT Test Format

As shown in Figure 1, the CT test format features a single question prompt, which may be presented as a discourse, case study, phenomenon, or diagram. The question prompt can include various types of schemas, such as food web diagrams, diagrams illustrating organ structure and function, inheritance charts, tables showing seedling growth and development, among others.

C. Develop

Throughout the development phase, product testing is carried out to evaluate the instrument's effectiveness in assessing students' computational abilities. This testing involves both internal and external assessments. Internal evaluations are conducted through expert reviews, involving subject material experts, assessment expert, and linguist experts. The results of these evaluations are presented as percentages in Figure 2.

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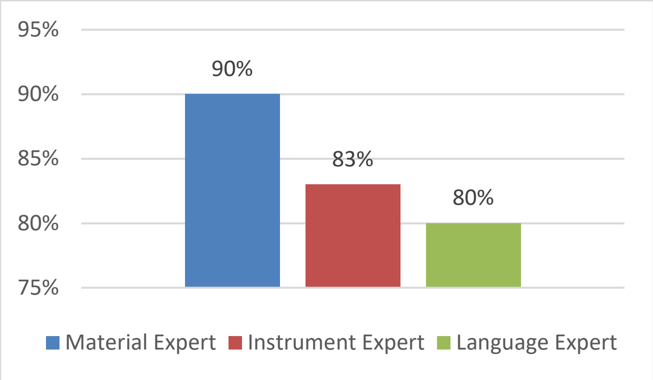

Figure 2. Percentage from Expert Judgement

As shown in Figure 2, the material expert show that the material received a score of 90%, categorized as "very feasible" or "valid." The assessment and evaluation expert rated it 83%, also placing it in the "very feasible" or "valid" category. The language expert assigned a score of 80%, which is likewise considered "very feasible" or "valid." These expert validation categories follow the criteria outlined by Arikunto, (2009) and Septianingsih *et al.*, (2023). Based on the evaluations from all three experts, it can be concluded that the CT test instrument is both feasible and valid. However, revisions are needed in line with the experts' recommendations.

The next stage of product testing involves external trials, which are divided into an initial and a final field trial. The goal of the initial field trial is to evaluate the readability of the CT test instrument. This trial was conducted with 32 students from class XII MIA-4. To assess readability, students filled out an online questionnaire through google forms. The findings from the readability test are presented in Figure 3.

As shown in Figure 3, the instrument's average readability score is 68%, which falls into the "good" category, suggesting that the CT test for biology concepts is generally understandable to students. However, based on student feedback, several improvements were needed. Students requested additional time, such as 2 extra minutes per question type, and reported challenges in answering the questions because some concepts had not been covered in their studies. After conducting personal interviews, students clarified that while they had studied the concepts, they struggled to recall them due to the length and complexity of the questions. Additionally, some terminology, such as scientific names that required translation into Indonesian, was unfamiliar. When creating questions, it is crucial to ensure clarity, completeness, and accurate spelling to help students comprehend the material (Ayudia *et al.*, 2016). In response to these suggestions, the researcher revised the CT test instrument prior to the final trial.

The final trial took place in classes XI MIA-1 and XI MIA-4, with a total of 66 students participating. The aim of this trial was to determine whether the instrument is effective and suitable for measuring students' computational thinking abilities. The results indicated a validity score of 0.70, which is categorized as high or good validity. The reliability score was 0.80, indicating high reliability (Guilford, 1956). High validity and reliability are essential in research to ensure that the findings are credible and that the data is both valid and dependable (Sugiono, 2015). The results are presented in Figure 4.

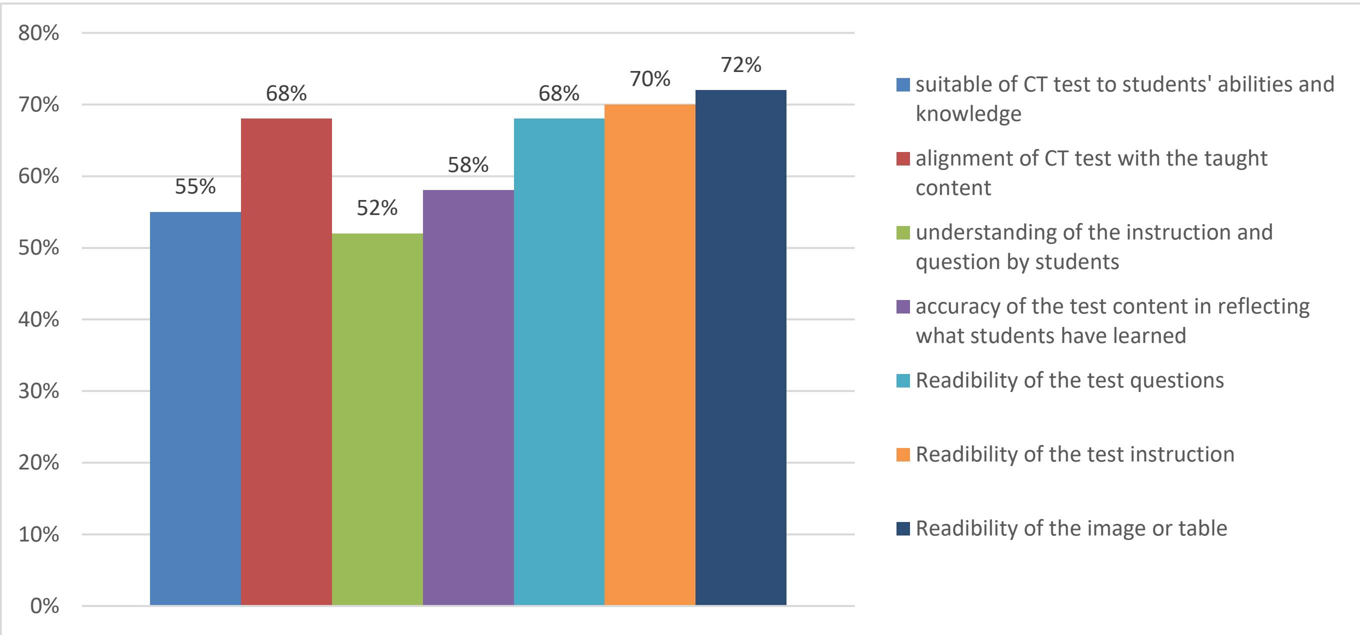

Figure 3. Percentage of readability questionnaire results for the computational thinking instrument

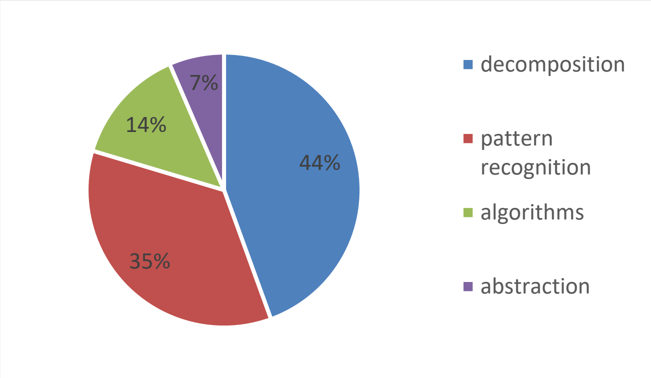

Figure 4. Percentage of students computational thinking skills

According to Figure 4, the distribution of computational thinking abilities in biology for classes XI MIA-1 and MIA-4 is as follows: 48% of students demonstrated decomposition skills, 38% exhibited pattern recognition abilities, 15% showed proficiency in algorithms, and 7% displayed abstraction skills. The notably low percentage of abstraction skills (7%) suggests that students may struggle with conceptualizing and generalizing biological principles. This could be attributed to the complexity of abstract biological concepts, which often involve understanding the relationships between various systems or processes that are not directly observable. Concepts such as evolution, ecosystems, or metabolism require the ability to think at a higher level, which includes constructing mental models or generalizing from specific cases. Additionally, in order to understand these abstract concepts, students need to integrate information from different disciplines and relate it to concepts they have already learned. Therefore, teaching these concepts may require a more focused approach, such as using simpler analogies, model-based learning, or visualizations to help students develop their abstract thinking skills. Limitations in teaching that are more contextual or experience-based could also contribute to students' difficulty in developing these abstraction skills (Bilbao *et al.*, 2021).

The CT test instrument developed in this study covers 8 concepts. The data from the final field trial reveal that the level of achievement for each computational thinking indicator varies across the different concepts. This suggests that the instrument developed is effective in assessing computational thinking skill indicators. The results show that as the complexity of the computational thinking components increases, the difficulty level also rises, leading to a decrease in the percentage of student achievement (Daenuri Anwar *et al.*, 2023).

The researcher also conducted interviews with three biology teachers to obtain their insights on the instrument being developed. From these interviews, it was revealed that the teachers had never used computational thinking tools before, which may result in students not developing these critical skills (Angeli & Giannakos, 2020; Kale *et al.*, 2018; Tripon, 2022). Furthermore, the diagnostic tools currently used by the teachers are primarily focused on assessing learning outcomes based on the content they have taught, such as multiple-choice tests, essays, practicums, and interviews (Aprilindiana *et al.*, 2023; Darling-Hammond, 2006; Irwansyah *et al.*, 2023). Additionally, the teachers do not engage students in linking the concepts they learn to computational thinking components, which could lead to a lack of these essential skills. Without instruction, practice, and assessment of computational thinking, students are unlikely to master these skills, leaving them unprepared for the challenges of the 21st century (Gretter & Yadav, 2016; Selby, 2015).

From the trials conducted, it can be concluded that as students' computational thinking abilities decrease, the difficulty level of the computational thinking components increases. It is essential for teachers to evaluate and integrate training that helps students approach problems using computational thinking components. By employing computational thinking instruments, teachers can assess the overall performance of students across these components (Chen *et al.*, 2017; Pérez-Suasnavas *et al.*, 2023; Zhong *et al.*, 2016). In interviews with three biology teachers, they emphasized the importance of this instrument for every biology topic and recommended that it be used regularly, both as a pre-test and post-test, before introducing core biological concepts which mean that CT test can be integrated into regular classroom practices by using it as a formative assessment tool to evaluate students' critical thinking skills during biology lessons. Additionally, it could be incorporated into professional development programs for biology teachers to enhance their ability to foster computational thinking in their students. One limitation of the CT test in essay format is the time required for grading essay-based assessments. To address this, automated scoring tools or rubric-based evaluation systems could be implemented to streamline the grading process and ensure timely feedback for students.

IV. CONCLUSION

The computational thinking assessment tool developed in this study is a descriptive test that covers eight key concepts: the circulatory system, excretory system, genetics, ecosystems, heredity, growth and development, biodiversity, and psychotropic drugs. This instrument was created using the 4D research method, excluding the dissemination phase. Validation from three experts confirmed that the tool is suitable for use. The readability score of the instrument was 68%, which falls within the "good" category, indicating that the instrument is clear and usable. The overall validity score was 0.7, categorizing it as highly valid, while the reliability score was 0.8, which is considered very high. The instrument effectively measures students' computational thinking abilities. The key factors influencing students' computational skills include consistent practice in problem-solving during lessons and being trained to approach problems in a systematic manner.

REFERENCES

Abidi, M. H., Cahyono, H., & Susanti, R. D. (2023). Analysis of students’ computational thinking ability in solving contextual problems. *Mathematics Education Journal*, *7*(2), 216–224.

Angeli, C., & Giannakos, M. (2020). Computational thinking education: Issues and challenges. *Computers in Human Behavior*, *105*, 106185.

Aprilindiana, B. U., Dewi, A. F. K., Rahma, F. F., & Damariswara, R. (2023). Analisis keterampilan mengajar mahasiswa dalam tugas mata kuliah strategi perencanaan dan pembelajaran. *Pedagogia: Jurnal Ilmiah Pendidikan*, *15*(1), 21–24.

Arikunto, S. (2009). *Evaluasi Program Pendidikan*. Bumi Aksara.

Ayudia, Suryanto, E., & Waluyo, B. (2016). Analisis kesalahan penggunaan bahasa indonesia dalam laporan hasil observasi pada siswa SMP. *Basastra: Jurnal Penelitian Bahasa, Sastra Indonesia dan Pengajarannya*, *4*(1).

Bilbao, J., Bravo, E., García, O., Rebollar, C., & Varela, C. (2021). Study to find out the perception that first year students in engineering have about the computational thinking skills, and to identify possible factors related to the ability of abstraction. *Heliyon*, *7*(2), E06135.

Chen, G., Shen, J., Barth-Cohen, L., Jiang, S., Huang, X., & Eltoukhy, M. (2017). Assessing elementary students' computational thinking in everyday reasoning and robotics programming. *Computers & Education*, *109*, 162–175.

Daenuri, A., E., Sarwi, S., Rusilowati, A., Subali, B., Isnaeni, W., & Mindyarto, B. N. (2023). Development of computational thinking skill instrument of prospective physics teachers. *ISET: International Conference on Science, Education and Technology*, 202–207.

Darling-Hammond, L. (2006). Assessing teacher education. *Journal of Teacher Education*, *57*(2), 120–138.

Gretter, S., & Yadav, A. (2016). Computational thinking and media & information literacy: an integrated approach to teaching twenty-first century skills. *Techtrends*, *60*(5), 510–516.

Guilford, J. P. (1956). *Fundamental Statistic in Psychology and Education*. Mc Graw-Hill Book Company Inc.

Hamdani, N. F., & Hasanah, R. (2022). Pengembangan media pembelajaran ipa berbasis adobe animate cc pada materi sistem pencernaan manusia untuk SMP/MTS. *Edu Sains: Jurnal Pendidikan Sains & Matematika*, *10*(2), 224.

Hogan, T. P., & Mishler, C. (1980). Relationships between essay tests and objective tests of language skills for elementary school students. *Journal of Educational Measurement*, *17*(3), 219–227.

Hunter, P. (2017). Tackling the great challenges in biology. *Embo Reports*, *18*(8), 1290–1293.

Iannone, P., & Simpson, A. (2015). Students' views of oral performance assessment in mathematics: straddling the 'assessment of' and 'assessment for' learning divide. *Assessment And Evaluation in Higher Education*, *40*(7), 971–987.

Irwansyah, A. I., Lukman, N., & Suherman. (2023). Pengaruh model pembelajaran blended learning dan kreativitas siswa terhadap hasil belajar IPA siswa kelas VII. *Bioeduscience*, *7*(1), 51–59.

Kale, U., Akcaoglu, M., Cullen, T., Goh, D., Devine, L., Calvert, N., & Grise, K. (2018). Computational what? Relating computational thinking to teaching. *Techtrends*, *62*(6), 574–584.

Li, Y., Schoenfeld, A. H., Disessa, A. A., Graesser, A. C., Benson, L. C., English, L. D., & Duschl, R. A. (2020). Computational thinking is more about thinking than computing. *Journal For STEM Education Research*, *3*(1), 1–18.

Masriyah. (2006). *Penyusunan Non-Tes*. Universitas Terbuka.

Mauludyah, Y. R., Aristya Putra, P. D., & Ahmad, N. (2023). penerapan LKPD berbasis engineering design process (EDP) pada pembelajaran IPA terhadap computational thinking skill dan hasil belajar siswa. *Edusains: Jurnal Pendidikan Sains dan Matematika*, *11*(1), 34–43.

Munawarah, Tahlah, S. Z., Angriani, A. D., Nur, F., & Kusumayanti, A. (2021). Development of instrument test computational thinking skills IJHS/JHS based RME approach. *Mathematics Teaching Research Journal*, *13*(4), 2021.

Nastiti, L. R., & Nasir, M. (2016). Pengembangan LKS berbasis saintifik pada materi alat- alat optik dan efektivitasnya terhadap hasil belajar kognitif fisika siswa. *Edusains: Jurnal Pendidikan Sains Dan Matematika*, *4*(1), 49–56.

Oermann, M. (1999). Developing and scoring essay tests. *Nurse Educator*, *24*(2), 29–32.

Pérez-Suasnavas, A.-L., Salgado-Proaño, B., Cela, K., & Santamaría, J. L. (2023). Computational thinking as instrument to evaluate student difficulties in higher education: Before and during pandemic analysis. *The International Conference on Advances an Emerging Trends and Technologies*, 193–207.

Sa'diyyah, F. N., Mania, S., & Suharti, S. (2021). Pengembangan Instrumen Tes Untuk Mengukur Kemampuan Berpikir Komputasi Siswa. *Jurnal Pembelajaran Matematika Inovatif*, *4*(1).

Selby, C. C. (2015). Relationships: Computational thinking, pedagogy of programming, and bloom's taxonomy. *Acm International Conference Proceeding Series*, *09-11-November-2015*, 80–87.

Septianingsih, M., Kurnia, D., & Hikmah, N. (2023). Pengembangan multimedia interaktif berbasis platform genially pada subtema penghematan energi. *Pedagogia: Jurnal Ilmiah Pendidikan*, *15*(1), 34–38.

Sugiono. (2015). *Metode penelitian dan pengembangan (Research and Development)*. Alfabeta.

Susongko, P. (2010). Comparison of the effectiveness of the essay test and testlets through the graded response model (GRM) application. *Jurnal Penelitian Dan Evaluasi Pendidikan*, *14*(2), 269–288.

Thiagarajan, S., Semmel, D. S., & Semmel, M. I. (1973). *Instructional development for training teachers of exceptional children: A sourcebook* (090 725, Vol. 1). Center for Innovation in Teaching The Handicapped.

Tripon, C. (2022). Supporting future teachers to promote computational thinking skills in teaching STEM—a case study. *Sustainability*, *14*(19), 12663.

Troia, G., Lawrence, F., Brehmer, J., Glause, K., & Reichmuth, H. (2023). efficient measurement of writing knowledge with forced-choice tasks: Preliminary data using the student knowledge of writing tests. *Journal of Writing Research*, *15*(2), 395–427.

Veronica, A. R., Siswono, T. Y. E., & Wiryanto, W. (2022). Hubungan berpikir komputasi dan pemecahan masalah polya pada pembelajaran matematika di sekolah dasar. *ANARGYA: Jurnal Ilmiah Pendidikan Matematika*, *5*(1), 115-126.

Walstad, W. B. (2006). Testing for depth of understanding in economics using essay questions. *The Journal of Economic Education*, *37*(1), 38–47.

Zhong, B., Wang, Q., Chen, J., & Li, Y. (2016). An exploration of three-dimensional integrated assessment for computational thinking. *Journal of Educational Computing Research*, *53*(4), 562–590.