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Development of Integrated Biodiversity Student Worksheets With Computational Thinking

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Abstract

Computational thinking ability is one of the important abilities to support the problem-solving process by students. The achievement of student learning outcomes can be supported by the existence of adequate LKPD. This study aims to develop student worksheets by integrating computational thinking into biodiversity material. This development research was conducted using the 4D method through 4 stages including, define, design, develop, and disseminate. Data collection was carried out using a questionnaire instrument by 2 validators consisting of language experts, material experts and teaching material experts as well as a readability test instrument by 3 teachers and 10 class X students at SMAN 3 Depok. The results of this study in the form of LKPD that was successfully developed were declared valid by the validator, with details of the material expert score with an average score of 2.99 and the language expert with an average score of 3.01. From the results of the practicality test, it was found that the LKPD produced could be used well in the learning process, with an average score of 3.58, the criteria are very practical. Teacher and students involved in the practicality test agreed that LKPD was able to increase student activity in the learning process.

Keywords: *4D, Computational, Fauna, Flora, Teaching Materials.*

Pengembangan Lembar Kerja Peserta Didik (LKPD) Keanekaragaman Hayati Terintegrasi Berpikir Komputasi

Abstrak

Kemampuan berpikir komputasi merupakan salah satu kemampuan yang penting untuk menunjang proses pemecahan masalah oleh peserta didik. Pencapaian hasil belajar peserta didik dapat didukung dengan adanya LKPD yang memadai. Penelitian ini bertujuan untuk mengembangkan lembar kerja peserta didik dengan mengintegrasikan berpikir komputasi pada materi keanekaragaman hayati. Penelitian pengembangan ini dilakukan dengan menggunakan metode 4D melalui 4 tahapan meliputi, define, design, develop, dan disseminate. Pengumpulan data dilakukan dengan menggunakan instrumen angket oleh 2 validator yang terdiri atas ahli bahasa, ahli materi dan ahli bahan ajar serta instrumen uji keterbacaan oleh 3 guru dan 10 peserta didik kelas X di SMAN 3 Depok. Hasil penelitian ini berupa LKPD yang berhasil dikembangkan dinyatakan valid oleh validator, dengan rincian skor ahli materi skor rata-rata 2,99 dan ahli bahasa dengan skor rata-rata 3,01. Dari hasil uji kepraktisan didapatkan bahwa LKPD yang dihasilkan dapat digunakan dengan baik dalam proses pembelajaran, dengan skor skor rata-rata 3,58 kriteria sangat praktis. Guru dan siswa yang di libatkan dalam uji kepraktisan sepakat bahwa LKPD mampu meningkatkan keaktivan peserta didik dalam proses pembelajaran.

Kata kunci: 4D, Bahan Ajar, Fauna, Flora, Komputasional

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INTRODUCTION

Modern learning has active metacognitive demands that are centered on students, as is in line with computational thinking skills (Angeli & Giannakos, 2020; Harjono et al., 2018; Suryaningsih et al., 2021). The use of computational thinking in learning is a problem-solving skill with identification, analysis, and application of solutions that can encourage student independence and activeness, as has been integrated by educators into the school curriculum (Barchas-Lichtenstein et al., 2020; Román-González, M., Moreno-León, J., Robles, 2019; Tyara Augie, 2021). The success of its implementation in the United States could be a milestone for applications in increasing access to learning because it is underrepresented in computer science, where biology is a candidate subject for students to take (Maharani et al., 2020)

Biology learning that focuses on memorization using the lecture method is considered boring by teachers and students and does not provide the ability to think and solve problems (Bahri et al., 2016; Fadilah et al., 2024; Santoso, 2020). By taking case studies on biodiversity material and its competence to create solutions to problems based on local or global issues and conservation efforts, students find it challenging to understand the material because of the need for explicit understanding (Novita et al., 2022; Pramaditya & Ambarwati, 2020). Therefore, efforts are needed to reduce conceptual errors in understanding biodiversity material by providing teaching materials that integrate computational thinking.

The process of creating Biology teaching materials requires a guideline, which is usually called a Student Worksheet for cooperative discussion activities, practicals, or observations (Mildaty et al., 2022). The creation of worksheets that integrate computational thinking has been widely included in STEM curricula (Gopinath & Santhi, 2021; Muliyati et al., 2021; Suryaningsih et al., 2021). Therefore, the integrated computational thinking worksheet for students in this biodiversity material refers to analyzing data on species populations or calculating biodiversity based on data provided in articles that students need to read. Students can develop skills in providing solutions to several endangered biodiversity species.

Several studies related to computational thinking state that computational thinking can help students improve their thinking and understanding abilities, as well as help teachers to quickly solve complex problems or concepts when teaching engineering and

science (Gopinath & Santhi, 2021). Worksheets integrated with computational thinking in computational physics courses received a positive response because they obtained excellent evaluation test results (Muliyati et al., 2021). Worksheets are one way to integrate computational thinking into mathematics learning (Kurniasi et al., 2022).

Computational thinking allows students to solve complex problems into more decomposed and structured problems through the process of finding patterns/algorithms in obtaining solutions to these problems so that they can be generalized for use in solving similar problems (Barchas-Lichtenstein et al., 2020).. Computational thinking skills can be one strategy to improve problem-solving skills in various fields of life (Chahyadi et al., 2021; Setiana, 2018). The development of student worksheets (LKS) by integrating computational thinking can be carried out not only in the fields of Physics and Mathematics but also in the field of Biology because computational thinking is focused on solving a problem through thinking to solve the problem by breaking it down into several stages that are effective, efficient, and comprehensive (Sari et al., 2022). The development of biology student worksheets (LKS) on this biodiversity material is different from previous studies because this student worksheet (LKS) is integrated with computational thinking. Therefore, the purpose of this study is to develop LKS that integrate computational thinking in biodiversity material to support the activeness and quality of valid, practical and effective learning.

RESEARCH METHODS

This research method refers to the 4D research model of Thiagarajan, Dorothy S. Semmel, and Melvyn I. Semmel. The selection of this model is based on the fact that this model is more appropriate to be used as a basis for developing teaching materials rather than for developing learning systems; the description of the stages also appears more complete and systematic, and in its development involves expert assessment, so that before the student worksheets readability test is carried out, revisions have been made based on the evaluation, suggestions, and input of experts. The 4D development model of Thiagarajan, Dorothy S. Semmel, and Melvyn I. Semmel consists of the Define, Design, Develop, and Disseminate stages. The stages of developing the 4D model in this study are as follows:

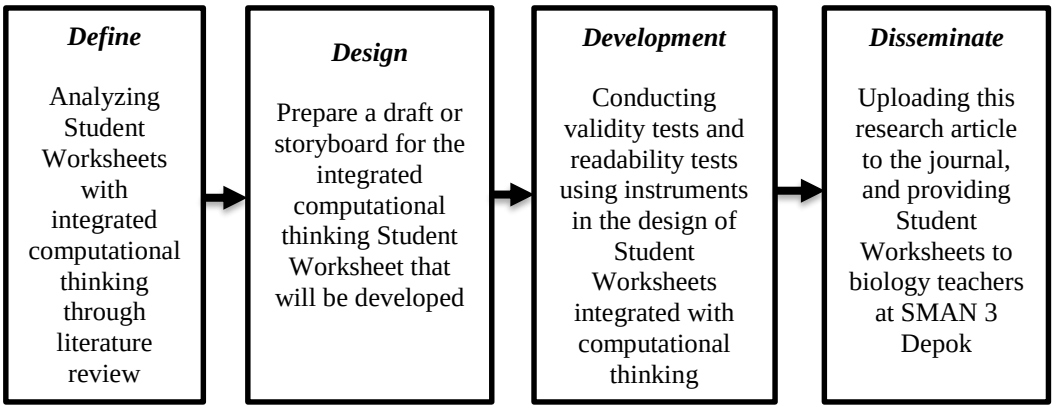

Figure 1. Research and development stage of 4D Model

Based on Figure 1, this research was conducted in 4 stages: definition, design, development, and dissemination. The initial stage is defined as the one that begins with analyzing the integrated computational thinking student worksheets. The initial step is to conduct a literature review to explore the urgency of research and materials based on learning outcomes; the material is used as a reference in compiling the student worksheets (Muliyati et al., 2021). Continued with the design stage to prepare and create a draft or prototype student worksheet design based on the analysis of the previous stage, which will be developed as well as the activities to be carried out in the next stage (Setyawan et al., 2021). The media creation process in this study used the Canva and Microsoft Word applications. This study's computational thinking skills indicators can be seen in the following table 1.

Table 1. Computational Thinking Ability Indicators

No.	Step	Definition
1	*Abstraction*	The ability to decide what information about a known entity/object to retain and what information to ignore.
2	*Algorithm*	The ability to design a series of operations/actions in stages (step by step) on how to solve a problem.
3	*Decomposition*	The ability to break down complex problems into simpler ones
4	*Debugging*	Ability to identify, eliminate, and correct errors.
5	*Generalization*	The ability to formulate general solutions so they can be applied to different problems.

Source. (Angeli & Giannakos, 2020)

Based on Table 1, the study has five indicators of thinking ability: Abstraction, Algorithm, Decomposition, Debugging, and Generalization. The five indicators are

included in the student worksheets that will be developed. The Biology material applied using this computational thinking method focuses on biodiversity material; this material was chosen because, in its application, Computational Thinking can be used to collect, analyze, and interpret Biological data. Computational thinking can help plan and implement experiments to collect data on organisms, the environment, or interactions between organisms. Computational thinking allows the creation of models and simulations that will enable researchers to understand how organisms interact with their environment. This can help in understanding the impact of environmental change on biodiversity (Christensen & Lombardi, 2020).

The development stage aims to produce integrated computational thinking student worksheets validated by expert validators in the form of material experts, teaching material experts, and language experts. Suppose the results obtained from the expert validation results indicate that the media is feasible. In that case, three teachers and a small group of 10 students can continue the user readability test. This research was conducted on grade X students at SMAN 3 Depok in semester 2. The data collection instruments were teaching material, language and material validation questionnaires, teacher response questionnaires, and student responses. The questionnaire in this study was assessed using a Likert scale with a score of 1-4. The Likert scale criteria used can be seen in Table 2.

Table 2. Scale of Instrument Assessment Score Guidelines by Expert Validator

Value	Category	Score
SS	Strongly Agree	4
S	Agree	3
TS	Disagree	2
STS	Strongly disagree	1

Based on Table 2, if the validator, teacher, and student evaluate each item of the validation statement, if they strongly agree, they are given a value of 4; if they agree, they are given a value of 3. If they disagree, they are given a value of 2 and strongly disagree with a value of 1.

Analysis of data obtained from validation, teacher assessment, and student responses are then calculated and analyzed using the available criteria. The formula used to calculate the value of each questionnaire is as follows: Interpretation of scores is calculated based on the scores obtained for each item:

$$\text{Value} = \frac{The\ score\ obtained}{Number\ of\ questions}$$

The average value results from the instrument are then adjusted to the categories in Table 3 below.

Table 3. Interpretation of Scores

Category Intei	Criteria	Keterangan
3,26 - 4,00	Highly Valid	It can be used without revision
2,51 - 3,25	Valid	It can be used with minor revisions
1,76 - 2,50	Less Valid	It can be used with multiple revisions
1,00 - 1,75	Invalid	It cannot be used yet and requires consultation

Table 3 shows that if the value of each validation reaches a score interval of 3.26 - 4.00, the validation results are declared very valid for use without revision. If the score interval ranges from 2.51 - 3.25, the validation results are valid for use with a little revision. If the score interval is 1.76 - 2.50, the validation results are less valid, so many revisions need to be made based on suggestions from the validator, as well as in the score interval range of 1.00 - 1.75, the validation results are invalid, so that the product cannot be used and further consultation is needed. The final stage in developing the 4D model learning device is dissemination. If the student worksheet testing results in the development stage get positive comments, it can be continued with the dissemination stage. (Bahri et al., 2016; Harjono et al., 2018). In this study, if the testing in the development stage gets positive comments, then only limited dissemination is carried out. Dissemination is carried out by providing student worksheets to Biology teachers at SMAN 3 Depok so that they can be absorbed (diffusion) or understood by teachers and can be used (adopted) in their classes.

RESULT AND DISCUSSION

Research and development of integrated computational thinking biodiversity student worksheets are carried out through 4 stages of the 4-D development model (Define, Design, Develop, and Disseminate), which refers to S. Thiagarajan, Dorothy S. Semmel, and Melvyn I. Semmel (1974) including:

Define Stage

The define stage helps determine and define needs in the learning process and collects various information related to the product to be developed. This stage is divided into several steps, namely: *Front-end Analysis:* conducted to identify fundamental problems in developing integrated computational thinking biodiversity student

worksheets. At this stage, the urgency of development research is raised through a literature review from various sources. Based on the literature review, it is concluded that biology learning, especially biodiversity material at the high school level, requires teaching materials such as integrated computational thinking student worksheets to train students' problem-solving skills.; *Concept Analysis:* determining the material's content in the integrated computational thinking biodiversity student worksheets developed. Concept analysis is made in a learning concept map.; *Specifying Instructional Objectives:* determining learning outcomes based on material and curriculum analysis. According to the results of several researchers, it was revealed that the Biology learning process requires a guideline which is usually called the Student Worksheet (LKPD) for cooperative discussion activities, practicums, or observations (Mildaty. Muldayati, N.D. Sunandar, 2022).

The results of the defined stage in the computational thinking student worksheets found this research's urgency: biology learning requires more students to memorize, so learning is boring. Many teachers only use simple teaching materials and do not introduce computational thinking to students, so students lack motivation and curiosity to learn. In addition, students' ability to solve problems is not yet evident because students tend to be able to work on Biology questions only from the explanation given by the teacher. Low knowledge about conservation also results in poor conservation attitudes of students later in society because, in learning at school, student worksheets do not include facts and phenomena of flora and fauna conservation problems in Indonesia. According to Maharani et al.(2020) research results, it is revealed that by including Computational Thinking in learning, it can increase access for all students to learn to solve problems in subjects such as Biology in high school. The literature review results were continued by analyzing the objectives and learning achievements, which will later become a reference in the drafting stage of integrated biodiversity student worksheets and computational thinking in the next stage.

Design Stage

The second stage is designed based on the research's urgency, so it is necessary to develop student worksheets—biodiversity integrated with computational thinking. The design of this student worksheet teaching material begins with creating a storyboard. The design is continued using the Canva application until the initial student worksheet design is formed, where the product is completely designed into a prototype. The final result of

the design is in the form of an initial design called a draft. Canva was chosen to develop student worksheets because it is easy to design teaching materials and contains many templates that can be selected to create exciting material content. (Mila et al., 2023).

The design stage is to design integrated computational thinking biodiversity student worksheets. The biodiversity student worksheets are created based on the results of the define stage, namely problems related to biology learning that require Integrated Computational Thinking Biodiversity student worksheets. The results of the design of the Biodiversity student worksheets are shown in Figure 2.

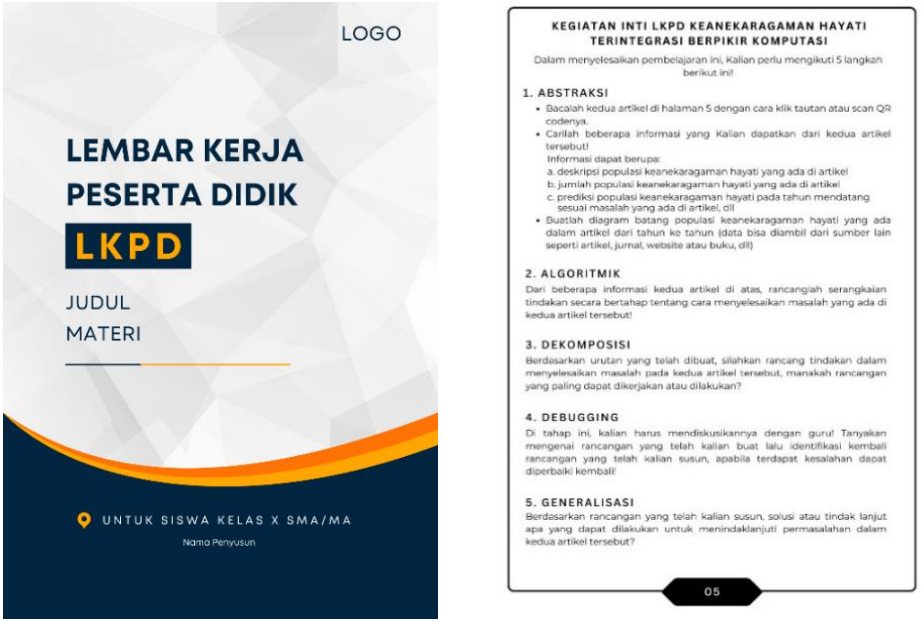

Figure 2. Results of the Initial Draft Student Worksheets Design

Based on Figure 2. The integrated computational thinking biodiversity student worksheets have the following contents: cover or cover page, learning objectives, supporting information, work steps, and core activities. In this core activity, the researcher included five components of computational thinking in the Biodiversity student worksheets by the research. Angeli & Giannakos (2020) Namely Abstraction, Algorithm, Decomposition, Debugging, and Generalization. The completed student worksheets in PDF format can be accessed at the link: https://bit.ly/Draft1_LKPDKehati.

***Develop* Stage**

At the development stage, it is carried out to produce feasible student worksheets based on the results of expert validation and readability tests by teachers and

students. Expert validation assessments are carried out through 2 expert validators who are selected based on recommendations from various parties and have received approval from the expert validators. Expert validation is carried out with three assessments: language experts, material experts, and teaching material experts. Three biology teachers and ten students at SMAN 3 Depok carried out the readability test assessment. The following are the results of the validation test by the validator.

Table 4. Material Validation Test Results

Aspect	Expert Validator		Average
	1	2	
Content Aspect	3,25	3,00	3,13
Presentation Aspect	3,33	3,00	3,17
Contextual Assessment Aspect	3,20	3,00	3,10
Average	**3,25**	**3**	**3,12**
Category	**Valid**	**Valid**	**Valid**

Based on Table 4, the results of the material validation test that was carried out show that the highest assessment results were obtained in the presentation aspects. This is because the material in the student worksheets is under the objectives of biodiversity learning. In addition, the content presented in the student worksheets contains aspects of knowledge and skills contained in the learning achievements of the independent curriculum so that it is relevant to the biodiversity material taught in schools.

The suitability of the presented biodiversity material can help students understand the material well. In addition, students can also solve problems related to flora and fauna in Indonesia. This is under previous research, which states that biodiversity material requires students to be able to analyze, identify, and communicate efforts to preserve various types of biodiversity in Indonesia. (Suryanda et al., 2016).

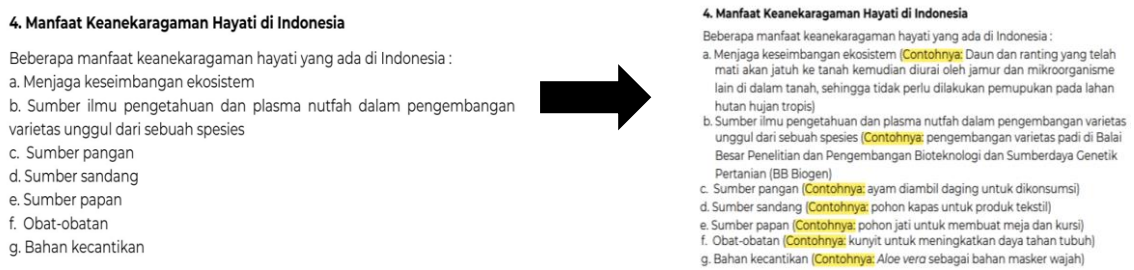

Figure 3. Benefits of Biodiversity Before and After Improvement

Based on Figure 3, the improvements made to the assessment of the material by the expert lecturer are in the form of "on the benefits of biodiversity, it would be better if examples of organisms were given." Improvements have been made by adding examples of organisms using biodiversity in everyday life.

Table 5. Results of the Teaching Material Validation Test

Aspect	Expert Validator		Average
	1	2	
Content Aspect	3,25	3,00	3,13
Presentation Aspect	3,17	3,00	3,08
Material Aspect	3,00	3,00	3,00
Language Aspect	2,50	3,00	2,75
Conceptual Aspect of Computational Thinking	3,00	3,00	3,00
Average	**3,05**	**3,00**	**2,99**
Category	**Valid**	**Valid**	**Valid**

Based on Table 5. in the validation test of teaching materials, the average value obtained is in the valid category. In the validation test of teaching materials, the highest average value was obtained in the content aspect. This shows that student worksheets are arranged systematically, explanations for unfamiliar terms are made in the glossary, student worksheets are by the level of development of students' thinking, and student worksheets can encourage students' activeness in learning biodiversity. This is by previous research by (Suryaningsih et al., 2021) and (Harjono et al., 2018) Which states that learning in schools has the characteristics of being able to demand student-centered learning and the need to activate students in learning (active learning).

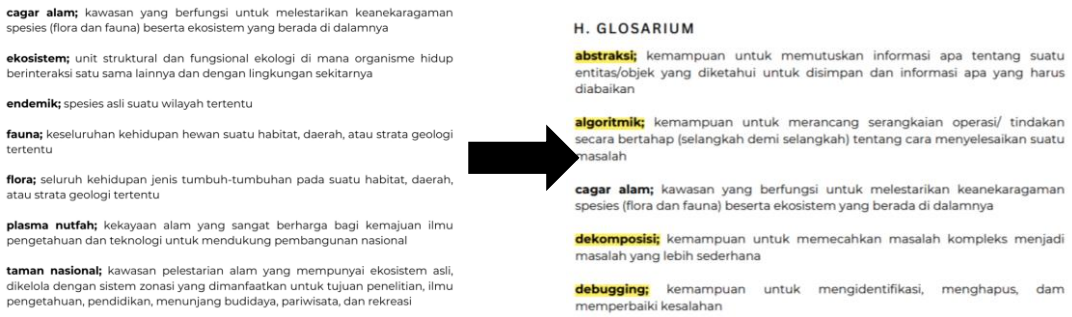

Figure 4. Glosarium Before and After Improvement

Based on Figure 4, revisions were made related to the results of the expert validation test by improving the student worksheets based on suggestions from the validator for the

assessment of teaching materials. In this student worksheet, it is suggested that a description of the terms of the stages in the task be added to the glossary. These terms are such as decomposition, debugging, and others.

Table 6. Language Validation Test Results

Aspect	Expert Validator		Average
	1	2	
Presentation Aspect	3,00	3,00	3,00
Format Aspect	3,20	3,00	3,10
Average	**3,10**	**3,00**	**3,05**
Category	**Valid**	**Valid**	**Valid**

Based on Table 6. the third validation test, namely the language validation test with a valid category. In the language validation test, the highest average value was obtained in the formal aspect of the student worksheets. This shows that the student worksheets have a straightforward sentence structure and are under the thinking abilities of students, as well as the use of sentences in the student worksheets that can trigger students' curiosity in studying the material further.

Figure 5. Links to Core Activities Before and After Repair

Based on Figure 5, revisions were made to the results of the language expert validation test by improving the student worksheets based on suggestions or comments from the validator. Improvements were made, such as writing links listed in the student worksheets so they could be clicked directly without copying and pasting, correcting typos, and adjusting the terms written in the barcode instructions but presented as QR code images.

Expert validators have validated the student worksheet product, which has been improved; then, the student worksheets will be tested for readability by teachers and students to see the response related to the development results of the integrated biodiversity student worksheets for commutative thinking. The readability test was carried out with the help of 3 Biology teachers and 10 class X students of SMAN 3 Depok. The following are the results of the readability test by teachers and students.

Table 7. Biology Teacher Readability Test Results

Aspect	**Biology Teacher**			**Average**
	1	**2**	**3**	
Material Aspect	3,25	3,50	3,75	3,50
Language Presentation Aspect	3,40	3,60	3,40	3,47
Format Aspect	3,29	3,86	3,86	3,67
Conceptual Aspect of Computational Thinking	3,00	4,00	4,00	3,67
Average	**3,23**	**3,74**	**3,75**	**3,58**
Category	**Practical**	**very practical**	**very practical**	**very practical**

Based on Table 7, the Biology teacher's readability test results obtained an average value with a very valid category. In the teacher trial, the highest assessment was in the format and conceptual aspects of computational thinking. This is because the student worksheets have an attractive appearance and proportional layout, and the selection of font size, color, and clarity of images in the student worksheets are appropriate and easy to read and understand.

Table 8. Student Readability Test Results

Aspect	**Average**
Material Aspect	3,33
Language Presentation Aspect	3,30
Format Aspect	3,31
Conceptual Aspect of Computational Thinking	3,38
Average	**3,33**
Category	**Highly Valid**

Based on Table 8, the results of the trial of students show that student worksheets are classified as very valid. In the student trial, the highest assessment was in the conceptual aspect of computational thinking. This is because student worksheets contain a series of gradual actions on how to solve a problem and formulate solutions in everyday life regarding flora and fauna in Indonesia.

The validity of the integrated Biodiversity student worksheet with computational thinking was obtained from the validation assessment of experts and users, namely teachers and students. The results of the validation of material experts obtained an average final assessment of 3.12 (valid category). The validation of teaching material experts obtained an average final assessment of 2.99 (valid category), and the validation of language obtained an average final assessment of 3.05 (valid category). Meanwhile, the

assessment results of 3 biology teachers obtained an average final assessment of 3.58 (highly category), and the assessment of 10 students obtained an average final assessment of 3.33 (highly category). Thus, the validity category of the integrated Biodiversity student worksheet with computational thinking shows that the experts stated that the integrated Biodiversity student worksheet with computational thinking was valid and worthy of use as teaching materials in biology learning in high school.

Based on the improvements/suggestions that the researcher obtained from expert lecturers in material, teaching materials experts, and language experts, along with biology teachers and students at SMAN 3 Depok, the final product design of the integrated computational thinking Biodiversity student worksheet is shown in the following link: https://bit.ly/LKPDKehatiBerpikirKomputasi.

The validator stated that the integrated Biodiversity student worksheet computational thinking has been adjusted to the concept of biodiversity material and computational thinking, where the student worksheet has referred to the stages of computational thinking. Student worksheet has five stages of computational thinking in core activities, including abstraction, algorithmic, decomposition, debugging, and generalization; this aligns with research (Angeli & Giannakos, 2020). The core activities have been adjusted to the biodiversity material in the high school phase. Computational thinking can help analyze data on environmental changes and their impact on biodiversity. This is based on research (Gopinath & Santhi, 2021), which states that computational thinking can help students improve their thinking and understanding abilities and help teachers quickly solve complex problems or concepts when teaching science.

Each core activity in the integrated computational Thinking Biodiversity student worksheet has stages that lead students to solve each problem by breaking it down into several effective, efficient, and comprehensive stages. In computational thinking, students are asked to break down complex problems into more minor problems. Furthermore, students must find patterns and use them to obtain solutions to their problems. This is based on research (Barchas-Lichtenstein et al., 2020), which states that computational thinking can be generalized so that it can be used to solve other problems. This distinguishes the integrated computational Thinking Biodiversity student worksheet from the student worksheet in previous studies. The researcher designed the integrated computational thinking Biodiversity student worksheet in core activities through five

stages of computational thinking, thus providing a new impression further to introduce computational thinking skills to high school students.

Disseminate

The last stage in this 4D is dissemination, which is carried out on a limited basis because no validation or effectiveness test of the student worksheet product was carried out in this development research. Dissemination is carried out by distributing the integrated Biodiversity student worksheet teaching materials with computational thinking to the schools studied in this development research, namely SMAN 3 Depok. Dissemination was carried out after the student worksheet product received a positive response from expert validators, Biology teachers, and students at SMAN 3 Depok. The student worksheet product received a positive reaction and a valid assessment category from Biology teachers and students at SMAN 3 Depok. This proves that the response of biology teachers and students is very high towards the integrated Biodiversity student worksheet with computational thinking, which raises factual problems of biodiversity in real life, so the interest of biology teachers and student learning motivation increases. This is supported by the statement (Hidayah & Kuntjoro, 2022) that one of the factors that influences learning motivation is using student worksheet in classroom learning. The results of the study stated that the Biodiversity student worksheet integrated with computational thinking was feasible in terms of validity and readability tests, as well as positive responses from biology teachers and students so that it could be used in implementing learning by integrating computational thinking in the classroom. This study's results align with (Kurniasi et al., 2022), who stated in their research that computational thinking-based worksheets for high school students obtained valid and practical results, where worksheets are one way to integrate computational thinking in learning.

CONCLUSION

Integrated Computational Thinking Biodiversity Student Worksheets were successfully developed and are suitable for use in learning because they obtained a valid category based on assessments from expert validators with an average language validation score of 3.05 (valid category), an average material validation score of 3.12 (valid category) and an average teaching material validation score of 2.99 (valid category). Meanwhile, based on the readability test by biology teachers, the average score was 3.58

(very valid category), and the average readability test score by students was 3.33 (very valid category). Based on the results of a series of validation tests and readability tests that have been carried out, the integrated computational thinking biodiversity student worksheet teaching materials have the advantage of an attractive appearance and a glossary that makes it easy for students to learn new terms, the images presented are clear with simple and easy-to-understand discussions. The student worksheet has a neat and orderly layout, and the materials presented discuss biodiversity studied in schools. In addition, this integrated computational thinking biodiversity student worksheet contains five stages of computational thinking: abstraction, algorithmic, decomposition, debugging, and generalization, which are different from student worksheets in general. The five stages of computational thinking can be integrated into student worksheets to help students understand biodiversity material by finding problems related to biodiversity in Indonesia and solutions to its conservation.

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