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Innovative electronic worksheets to foster computational thinking in arithmetic sequences and series

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Abstract

Background: The lack of learning media based on computational thinking (CT) for high school students, especially in the material arithmetic sequences and series, is one of the causes of students' low CT skills.
Aim: This research was conducted to develop learning media in the form of electronic student worksheets on the material of arithmetic series and sequences to improve CT skills by utilizing electronic worksheets media.
Method: This research employs the R&D method using the Tessmer development model. The research subjects are grade X students from a public high school in Palembang, selected through purposive sampling. The electronic student worksheets were validated by material and media experts and assessed for practicality by teachers and students.
Result: The validation value of the developed CT-based Electronic Student Worksheets reached 95.47%, while the practicality assessment of CT-based Electronic Student Worksheets based on the questionnaire obtained a value of 89.97%.
Conclusion: Based on the results of the study, it can be concluded that the developed CT-based electronic student worksheets the valid and practical criteria to be used in learning to improve CT skills and understanding of arithmetic sequences and series material for high school students.

INTRODUCTION

Human resources are an important thing to prepare in facing the era of society 5.0 so that they can adapt and develop in all changes and remain competent in their respective fields of work. Preparation of resources can be done by providing learning that is appropriate to the conditions that students will experience (Maharani, 2020; Salwadila & Hapizah, 2024), in accordance, Nadiem Makariem the Minister of Education and Culture of Indonesia said that there are two additional competencies that children need to have in the digital era, one of which is computational thinking (Andaru et al., 2022). These skills are important because post-COVID-19 students have enjoyed the benefits of various artificial intelligence technologies, but they may not have the competency values in utilizing these technologies.

CT is a skill that students can use to solve complex questions or problems by prioritizing logic systematically and using mathematical and efficient reasoning (Purwasih et al., 2024). In education, CT skills are defined as the thought processes seen in formulating problems and generating solutions in a way that can be understood by humans or computers Maharani (2020) and Montuori et al., (2024). The British

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government have been implemented CT in 2014 for students at primary and secondary school levels (Malik et al., 2019), to organize an innovative and dynamic education system according to education 21st century (Rahayu, 2021; (Sa'diyyah et al., 2021), because CT skills can stimulate critical thinking and problem solving so it is very important to be integrated into subjects in schools (Oyelere et al., 2023). The components of CT skills are decomposition, pattern recognition, abstraction, and algorithmic thinking (Oyelere et al., 2023; Satrio, 2020). Thus, CT skills are very suitable for mathematics because they contain activities to develop and foster students' logical, creative, critical, and systematic thinking skills (Sa'diyyah et al., 2021). These skills are essential in preparing students to solve complex problems, analyze patterns, and make informed decisions, which are crucial in both academic and real-world contexts.

However, in reality students' CT skills in Indonesia are still relatively low. This can be seen from the results of the 2022 PISA score which stated that Indonesia was ranked 68 out of 81 countries with a decreasing score (Balakrishan, 2019; Ingram et al., 2023; Ulkhaq et al., 2024). This can be linked and illustrates CT skills because CT is one of the elements of ability contained in PISA questions, namely related to the field of mathematical literacy or numeracy and mathematical reasoning (Zahid, 2020). The results of the latest research from Fitrisyah et al., (2024) and Hauda et al., (2024) state that students are still not used to solving problem-based questions systematically, especially using CT skills because they are confused about what steps to take, including decomposition and algorithm skills. This issue may arise due to several factors, one of which is that the student worksheets used in the learning activities have yet to adequately address students' computational thinking skills. Therefore, it is necessary to develop CT-based student worksheets within differentiated learning contexts (Hapizah et al., 2024). Such worksheets can accommodate diverse student needs and learning styles, ensuring that all learners have the opportunity to engage with the material meaningfully and maximize their potential in mastering mathematical concepts.

The rapid advancement of technology has significantly transformed educational practices, encouraging the creation of innovative tools to support effective learning. One such tool is the electronic worksheet, a digital resource designed to provide an interactive, personalized, and accessible learning experience through devices such as computers, tablets, or smartphones (Maharani., 2020; Sari et al., 2024). Unlike conventional worksheets, e-worksheets utilize multimedia technologies such as videos, animations, and simulations, while also offering instant feedback to help students understand the material more deeply (Fitriyah & Ghofur, 2021; Puspita & Dewi, 2021). In the context of CT, e-worksheets can support the development of skills like decomposition, pattern recognition, abstraction, and algorithmic thinking through activities such as interactive quizzes, data grouping, and problem-solving simulations (Nenggala et al., 2024). The relevance of e-worksheets is further strengthened in the Society 5.0 era which emphasize technology-based learning to foster 21st-century skills (Chu eta al., 2021; Pramesworo et al., 2023). Platforms like multimedia integration and instant feedback, making e-worksheets an effective tool for enhancing students' thinking abilities.

Mathematics, as a discipline that emphasizes structure, logic, and problem-solving, offers numerous opportunities for students to develop computational thinking (CT) skills. Among the various topics in mathematics, arithmetic sequences and series stand out as subjects that are deeply connected to symbols and patterns, making them highly relevant for fostering CT (Jannah, 2023; Zahid, 2020). The fundamental skills required include identifying number patterns and sums derived from previously collected data, encompassing CT skill indicators such as decomposition, pattern recognition, algorithmic thinking, pattern generalization, and abstraction (Kholil & Safianti, 2019). Therefore, arithmetic sequence material can be utilized as a learning resource to assess students' CT skills. However, the student worksheets commonly used in schools for arithmetic sequences and series often contain conventional questions that do not focus on CT. Additionally, these worksheets are typically printed materials and lack technological integration.

Several studies have highlighted the benefits of integrating computational thinking into mathematics education, particularly in enhancing problem-solving abilities and fostering student engagement (Luo et al., 2022; Ng et al., 2023; Richardo et al., 2025). At the same time, the use of electronic student worksheets has been shown to improve learning outcomes across various mathematical topics (Istiqomah & Suparman, 2020; S. Maharani et al., 2024; Zahara et al., 2021). Additional research has demonstrated that CT-based approaches can enrich STEM learning experiences through innovative pedagogical tools (Dolgopolovas & Dagiene, 2024; Saig & Hershkovitz, 2024). This combination highlights the significant potential of integrating CT into e-worksheets to create more interactive and effective learning methods in mathematics education.

Several innovative teaching materials have been developed for arithmetic sequences and series. Zuwandi et al. (2023) utilized a web-based articulate storyline 3 to enhance students' interest and independence, while Anwar (2017) implemented a cooperative script model to improve learning outcomes. Additionally, Ridwan et al. (2016) and Nurhandayani et al. (2022) developed problem-based learning (PBL) modules for secondary school students, whereas Sari and Hapizah (2019) explored Android-based teaching materials to support problem-solving in this topic. These studies illustrate how technology can be leveraged creatively to enhance mathematics education.

However, while many studies have explored CT integration and e-worksheet development, most focus on the general application of CT or the benefits of e-worksheets without addressing their specific impact on conceptual understanding and computational skills in mathematics (Bayaga, 2024; Mohamed et al., 2024; Nurlaelah et al., 2025). Research specifically targeting arithmetic sequences and series with a CT-based approach remains limited. Studies such as Jannah (2023), which employed STEM methodologies, Zulfa and Andriyani (2023), which focused on slow learners using Single Subject Research (SSR), which addressed money management for elementary students, provide valuable insights but do not directly address the development of CT-based e-worksheets for this topic. Therefore, this study aims to address this gap by designing and evaluating an e-worksheet grounded in computational thinking principles using liveworksheet with contextual problems.

METHODS

Design:

This research was conducted using a design research method of the development study type, this research method consists of three stages preliminary, development, and assessment. The Tessmer model will be used in this series of development research which consists of two phases, namely preliminary and formative evaluation, in the formative evaluation phase there are several stages expert review, one-to-one, small group, and field test.

Participants:

The population in this study consisted of grade X students from a public high school in Palembang during the first semester of the 2024/2025 academic year. The selection of subjects was conducted using purposive sampling, based on teacher recommendations and the availability of students. The characteristics of the students selected as subjects were those currently studying or who had previously studied arithmetic sequences and series.

Instruments:

The research instruments used in this study are:

- Questionnaire on the need for E-student worksheets development for students
- CT-based E-student worksheets with Liveworksheets media
- CT-based E-student worksheets validation sheet from the aspects of content, construction, language and Information and Communication Technologies (ICT) at the expert review
- Student and teacher response questionnaire on the use of E-student worksheets to see the level of practicality of use and understanding of the material in learning at the small group
- Student interview sheet at the one-to-one and small group

Data Analysis:

The preliminary phase, the researcher conducted an analysis of the development needs of E-student worksheets teaching materials based on computational thinking class X students. The analysis of the E-student worksheet development needs questionnaire was carried out using the Guttman scale with a scalogram scale where students' answers were given scores according to Table 1.

Table 1. Guttman Score Scale

Alternative Answers	**Alternative Answers Score**	
	Positive	Negative
Yes	1	0
No	0	1

The results of the students' questionnaire answers will be analyzed quantitatively using the following percentage formula:

$$P = \frac{f}{n} \times 100\%$$

P = Percentage
f = Frequency
n = Total response

The results of the needs analysis calculations will be interpreted based on categories with research references (Nenggala et al., 2024). The categories used are presented in Table 2.

Table 2. Percentage Categories

Percentage	Category
0 – 1,9%	Not needed
2 – 25,9%	A small portion needs it
26 – 49,9%	Less than half needs it
50%	Half needs it
50,1 – 75,9%	More than half needs it
76 – 99,9%	A significant portion needs it
100%	Everyone needs it

If the percentage result of the needs analysis is greater than 50%, it can be concluded that the development of E- student worksheets is necessary for students, but if the percentage is less than 50%, it shows that the development of E- student worksheets is not necessary. In the formative evaluation stage, an analysis of the validity and practicality of the CT-based student worksheets on the material of arithmetic sequences and series that have been developed will be carried out.

The CT-based E-student worksheets on the material of arithmetic sequences and series is comprehensively evaluated by 4 expert in mathematics education. The components of the aspects evaluated from the CT-based E-student worksheets that have been developed include content, constructs, language, and ICT. Assessment of aspects is carried out by giving a value between 1-5 with the description in Table 3.

Table 3. Validation Sheet Assessment Category

Score	Category
5	Very Good
4	Good
3	Good Enough
2	Less Good
1	Not Good

The score results from the validation data sheet will be calculated by the researcher to see the validity of the CT-based E- student worksheets that has been developed using the following formula:

$$P_v = \frac{\sum Sv}{Sv_{max}} \times 100\%$$

P_v = Validity percentage
$\sum Sv$ = Score validity
Sv_{max} = Maximum score validity

The validity score obtained will be used to determine the level of validity of the CT-based E- student worksheets which has been validated through the validity criteria in Table 4.

Table 4. Validity Categories

Validity Level	Category
82% - 100%	Very valid
63% - 81%	Valid
44% - 62%	Less Valid
25% - 43%	Invalid

(Sugiyono, 2017)

Analysis of the practicality questionnaire data obtained from students and teacher at the small group stage, students can provide assessments, comments, and suggestions on the E-student worksheets learning materials that are being worked on. Assessment of practicaly carried out by giving a value between 1-5 with the description in Table 5.

Table 5. Praticality Sheet Assessment Category

Score	Category
5	Very Agree
4	Agree
3	Quite Agree
2	Disagree
1	Very disagree

The results of the scores from the practicality questionnaire sheet will be calculated using the following formula:

$$P_p = \frac{\sum Sp}{Sp_{max}} \times 100\%$$

P_p = Practicality percentage
$\sum Sp$ = Score practicality
Sp_{max} = Maximum score practicality

The scores obtained will be used to determine the level of practicality of the CT-based E-student worksheets through the practicality criteria in Table 6:

Table 6. Practicality Categories

Validity Level	Category
82% - 100%	Very Practical
63% - 81%	Practical
44% - 62%	Less Practical
25% - 43%	Impractical

(Sugiyono, 2017)

The procedure for developing CT-based E-student worksheets follows Tessmer's model, which provides a systematic framework for instructional design and development. This process is illustrated in detail in Figure 1, highlighting each stage to ensure the worksheets are effectively tailored to enhance computational thinking skills.

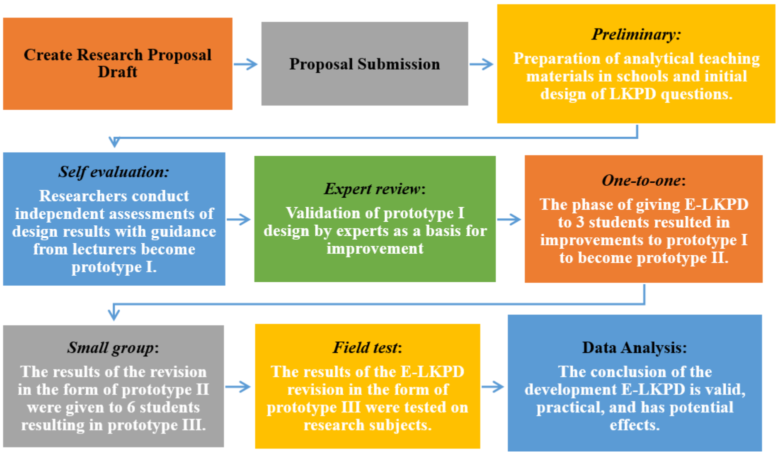


Figure 1. Research Flow

RESULTS AND DISCUSSION

The results of the research process for developing CT-based electronic student worksheets that have been carried out are as follows:

Preliminary

1. Analyzing learning problems to identify issues in the learning process

Researchers conducted interviews with mathematics teachers who teach classes covering three areas, namely electronic student worksheets, computational thinking skills, and students' understanding of arithmetic sequence and series material. Based on the results of the interview, information was obtained that the use of electronic student worksheets in mathematics learning had never been done, the learning method used was discussion so students don't know about CT skills and the level of students' understanding of the material on sequences and arithmetic series are low

2. Analyzing students to understand their learning needs

The next stage is to provide a questionnaire about the need for the development of CT-based electronic worksheets on the material of arithmetic sequences and series. The main topics of the questions in the questionnaire include the experience of learning mathematics, the need for electronic learning media, the experience of using electronic worksheets, and the need for material on arithmetic sequences and series. The results of the questionnaire filled out by students are presented in Table 7.

Table 7. The Result of Student Needs Analysis

Indicator	Value	Percentage
The development of learning methods	75	41.7%
The needs and interests in electronic learning media	99	91.7%
The experience of using electronic media in learning	72	50%
The learning material that requires it is the topic of arithmetic sequences and series	180	83.33%
Average		66.7%

The show result is the average percentage 66.7%, so according to Table 2 the result can be categorized that more than half of the students need CT-based electronic student worksheets for arithmetic series and sequence materials.

Formative Evaluation

The formative evaluation stage is also known as the prototyping stage, researchers will use the tessmer model with stages of self-evaluation, expert review, one-to-one, small groups, and field testing.

1. Self-evaluation

At this stage, the researcher will develop CT-based electronic student worksheets by considering a) the components and constructs of electronic student worksheets, b) content/material design, and c) design the instrument. The design process of CT-based electronic student worksheets on the material of arithmetic sequences and series is carried out by the researcher including the stage of self-assessment of the electronic worksheets that has been designed and equipped with direction from the supervising lecturer regarding the design and questions used in CT-based electronic student worksheets.

a. Design the components and constructs of electronic student worksheets

The content of all components required in electronic student worksheets is designed to include cover, subject identification, time of completion, author information, learning objectives, learning instructions, supporting information, sample questions, problems 1 to 4, and conclusions. The components of electronic student worksheets based on CT on the material of arithmetic sequences and series are presented in Figure 2.

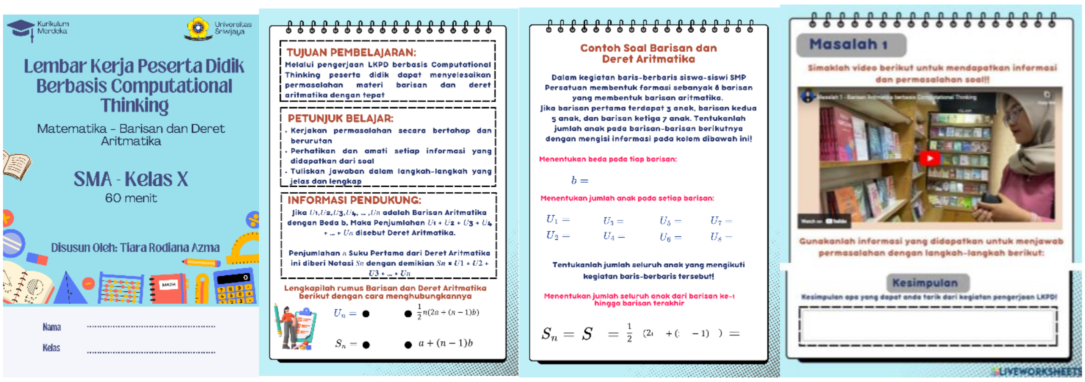


Figure 2. Component of the electronic student worksheets

b. Design the content/ material of the electronic student worksheets

The development of the electronic student worksheets design focuses on the material of arithmetic sequences and series using real problem content and solution steps using the CT component. The question material is designed for high school students in grade X in the odd semester. In the CT-based electronic student worksheets, the researcher presents 4 problems divided into 2 cases of arithmetic sequence material and 2 cases of arithmetic series. The questions given in the electronic student worksheets questions are based on the CT stages, namely decomposition, pattern recognition, abstraction, and algorithms. The appearance of the CT-based electronic student worksheets that was developed is presented in Figure 3 dan Figure 4.

Figure 3. CT-based electronic student worksheets Prototype I

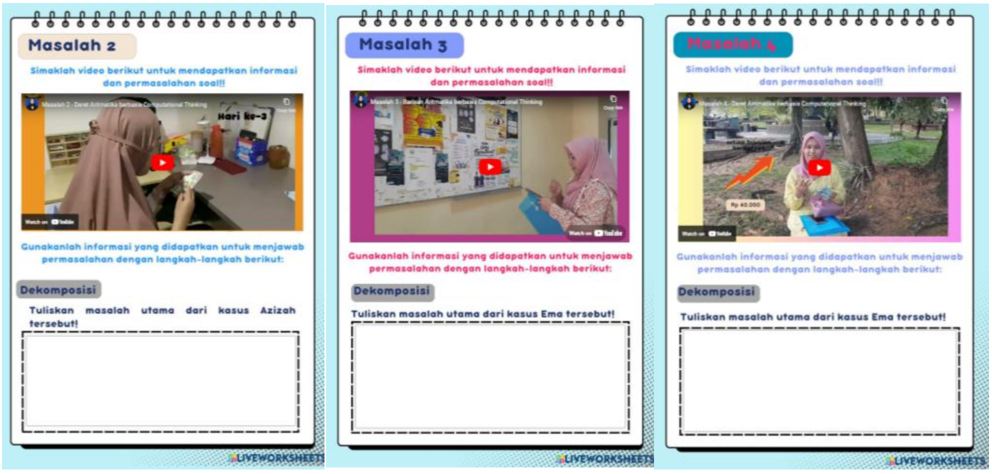


Figure 4. CT-based electronic student worksheets Prototype I

c. Design the instruments

The researcher prepared a research instrument that will be used in the development of CT-based electronic student worksheets on the material of arithmetic sequences and series. The research instrument created is a questionnaire sheet for the development needs of electronic student worksheets for students, a validation sheet for CT-based electronic student worksheets from the aspects of content, construction, language, and information and communication technology, a questionnaire response to the practicality of using electronic student worksheets for students and teachers, as well as interview and observation sheets as complementary instruments.

2. Expert reviews and one-to-one

The prototype I of the CT-based electronic student worksheets that has been designed by the researcher will be validated by 3 expert lecturers and 1 mathematics teacher. The validity test will be assessed based on the values, suggestions, and comments given by the experts on the content, construct, language, and ICT components.

a. CT-based electronic student worksheets validation on content components

The assessment conducted on the content component validation sheet includes aspects of CT skill, suitability to learning objectives, and problems in the electronic student worksheets. The results of the expert assessment are presented in Table 8.

Table 8. The Result of Content Component Validity Tests

Statement	Validator				$\sum Sv$	P_v (%)
	V1	V2	V3	V4		
E-student worksheets presented in accordance with CT components	18	18	19	20	75	93.75
The problem are in accordance with material and level of education of the students	10	9	10	10	39	97.5
Activities or problems in LKPD encourage students to play an active role	10	9	10	10	39	97.5
Average						96.25
Category						Very Valid

b. CT-based electronic student worksheets validation on construct components

The assessment conducted on the validation sheet of the construct component includes aspects of the accuracy of the electronic student worksheets content and the appearance of the electronic student worksheets. The results of the expert assessment are presented in Table 9.

Table 9. The Result of Construct Component Validity Tests

Statement	Validator				$\sum Sv$	P_v (%)
	V1	V2	V3	V4		
Activities according to CT indicators, complete and interesting questions, questions according to learning objectives, completeness of electronic LKPD components	24	24	24	25	97	97
Clarity of cover, background, color, images, videos in electronic student worksheets. Attractive appearance and increasing student motivation	25	24	25	25	99	99
Average						98
Category						Very Valid

c. CT-based electronic student worksheets validation on language components

The assessment conducted on the language component validation sheet includes aspects of clarity of question writing, language selection, and punctuation. The results of the expert assessment are presented in Table 10.

Table 10. The Result of Language Component Validity Tests

Statement	Validator				$\sum Sv$	P_v (%)
	V1	V2	V3	V4		
The language in the problems is effective and not ambiguous.	10	9	9	9	37	92.5
The language standard in accordance with PUEBI, students' level of thinking, use of punctuation, and correct writing of symbols	18	18	18	19	73	91.25
Average						91.87
Category						Very Valid

d. CT-based electronic student worksheets validation on ICT components

The assessment conducted on the ICT component validation sheet includes aspects of technology application in making electronic student worksheets and the appearance of electronic student worksheets and the videos used. The results of the expert assessment are presented in Table 11.

Table 11. The Result of ICT Component Validity Tests

Statement	Validator				$\sum Sv$	P_v (%)
	V1	V2	V3	V4		
The application of technology in E-student worksheets and video	10	10	9	10	39	97.5
The appearance video and E-student worksheets have attractive, colors and designs good, sound and writing clear.	22	23	25	24	94	94
Average						95.75
Category						Very Valid

The validation results from 4 experts on the CT-based electronic student worksheets on the material of arithmetic sequences and series include four aspects of content, constructs, language, and ICT, all of which are in the "very valid" category. The average analysis result of the four indicators is 95.47%, which is also in the "very valid" category. This shows that the CT-based electronic student worksheets that was developed has a high level of validity and is suitable for use in the next stage. At the same time, prototype I has been tested at the one-to-one stage for 3 students with different abilities. From the expert review and one-to-one stage, the following are comments and suggestions from the validator and students regarding this interactive electronic student worksheet with comments and suggestions in Table 12.

Table 12. Comments and Suggestions from and Revision Desicion

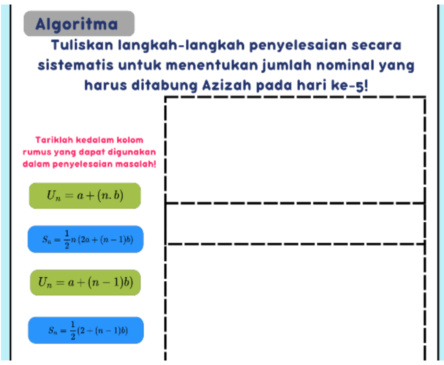
Validator	Comments/Suggestions	Revision Decision
Validator 1 (Expert in languages)	The information in problem no. 3 needs to be supplemented to provide a more realistic context for the problem.	Added some sentences to complete the problem information
Validator 2 (Expert in ICT)	Pay attention to the title so that it matches the research objectives	Discussion with lecturer
Validator 3 (Expert in Computational Thinking)	The instructions in the algorithm contain ambiguous commands	Change the command and structure
	Foreign language writing should be written in italics	Italicizing foreign language
	Need correction of sentence structure in sample questions	Correction the sentence in sample questions
	Pay attention to the use of prepositions that are in accordance with PUEBI	Correction the prepositions
Validator 4 (Mathematics Teacher)	Need correction sentence in study guides and supporting information	Correction the sentence in study guides and supporting information
	Added more instructions to the algorithm stage	Added instructions to the algorithm stage
	There is no need for an exclamation mark at the end of a command sentence	Remove exclamation mark at the end of a command sentence

Based on comments and suggestions given by the validator, the researcher revised prototype I with the results in Table 13.

Table 13. Revision from Validator Review

<table>
<tr><th>No</th><th>Before</th><th>After</th></tr>
<tr><td>1</td><td>The information in problem no. 3 needs to be supplemented to provide a more realistic context for the problem.</td><td>Added some sentences to complete the information of no. 3 problem



</td></tr>
<tr><td>2</td><td>Added more instructions to the algorithm stage

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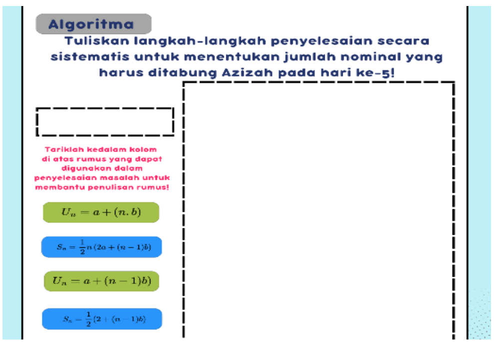
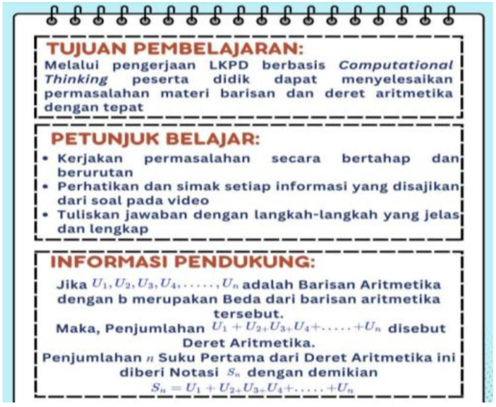
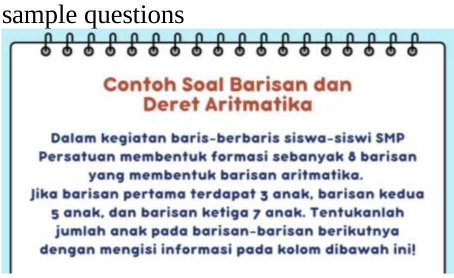
<tr><td>3</td><td>The instructions in the algorithm contain ambiguous commands.

</td><td>Change the command and structure

</td></tr>
</table>

No	Before	After
4	Foreign language writing should be written in italics	Italicizing foreign language
		
5	Need correction sentence in study guides and supporting information	Correction the sentence in study guides and supporting information
		
6	Need correction of sentence structure in sample questions	Correction the sentence in sample questions
		
7	There is no need for an exclamation mark at the end of a command sentence	Remove exclamation mark at the end of a command sentence
		

Revisions were also made based on the results of observations and interviews of students at the one-to-one stage. Students felt confused with the instructions for the questions in the algorithm section. This can be seen in the results of the students' work in Figure 5.

Figure 5. Student difficult answer algorithm section

The results of the revisions that have been made to Prototype I will form a CT-based electronic worksheets called Prototype II. The Prototype II design can be used in the next development stage on small group.

3. Small group

Prototype II was tested on 9 students with varying abilities at the small group stage. At this stage, students and mathematics teachers were asked to fill out a questionnaire about the use of CT-based electronic student worksheets that had been worked on, the results of which would be used as a basis for measuring the practicality of the CT-based electronic worksheets that had been developed.

The practicality questionnaire sheet provided includes questions on 4 aspects CT skill characteristics, constructs and content in electronic student worksheets, language, and application of technology. The results of teacher assessments of the practicality of CT-based electronic student worksheets are attached in Table 14.

Table 14. Praticality Result by Teacher

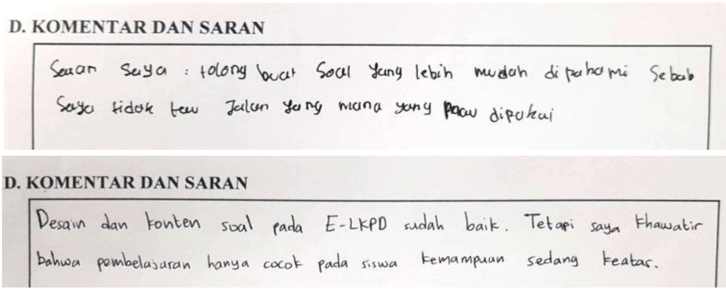
No	Component	P_p (Percentage)	Category
1	CT skill characteristics	86.7%	Very practical
2	Constructs and content in E-student worksheets	92%	Very practical
3	Language of E-student worksheets	95%	Very practical
4	Application of technology on E-student worksheets	85%	Very practical
	Average	89.7%	Very practical

The results of nine student assessments of the practicality of CT-based electronic student worksheets are attached in Table 15.

Table 15. Praticality Result by Students

No	Component	P_p (Percentage)	Category
1	CT skill characteristics	89.1%	Very practical
2	Constructs and content in E-student worksheets	89.7%	Very practical
3	Language of E-student worksheets	91.6%	Very practical
4	Application of technology on E-student worksheets	90.5%	Very practical
	Average	90.3%	Very practical

The results of the practicality assessment at the small group stage of teachers and students on CT-based electronic student worksheets on the material of arithmetic sequences and series include four aspects in the "very practical" category. The average practicality results from teachers and students were 89.97% which was also in the "very practical" category. This shows that the CT-based electronic student worksheets that was developed has a high level of practicality as a learning media. At the small group stage, suggestions and comments were obtained from teachers and students in Figure 6.


D. KOMENTAR DAN SARAN

Saran saya : tolong buat soal yang lebih mudah dipahami sebab saya tidak tau jalan yang mana yang mau dipakai

D. KOMENTAR DAN SARAN

Desain dan konten soal pada E-LKPD sudah baik. Tetapi saya khawatir bahwa pembelajaran hanya cocok pada siswa kemampuan sedang keatas.

Figure 6. Student and teacher suggestion/comments

Based on these comments, further research could explore the development of differentiated electronic student worksheets tailored to address the diverse learning needs of students, particularly those with lower abilities. By incorporating features such as adaptive difficulty levels, interactive problem-solving tools, and personalized feedback, these worksheets could provide targeted support to help struggling students grasp complex concepts. Additionally, integrating multimedia elements and contextual examples could enhance engagement and comprehension, enabling students with low abilities to actively participate in the learning process. This approach not only supports equity in education but also aligns with modern pedagogical practices that emphasize meeting individual student needs in a more inclusive and effective manner.

The development of student worksheets integrating computational thinking into the learning of arithmetic sequences and series aligns with previous research findings by Jannah (2023) and Sari et al. (2019), which highlight the importance of electronic worksheets in enhancing students' understanding of mathematical concepts. Additionally, studies by Muliyati et al. (2020) discuss the role of problem-based learning worksheets in improving computational thinking skills among students. These studies emphasize the effectiveness of structured worksheets in guiding students through complex problem-solving processes, which can be directly applied to the context of arithmetic sequences and series. Sari et al. (2019) further stress the development of instructional materials specifically designed for arithmetic sequences and series using a problem-based learning approach. Their findings demonstrate the effectiveness of electronic worksheets in meeting criteria for validity, practicality, and effectiveness in the learning process. The research findings suggest that well-designed worksheets can facilitate deeper understanding and retention of mathematical concepts.

This study aims to integrate the principles of computational thinking specifically into the learning of arithmetic sequences and series. The results indicate that this medium aids students in understanding complex concepts and enhances their problem-solving skills and logical reasoning. These findings are particularly significant in the context of digital learning, where the ability to think computationally and navigate complex information is crucial for academic success (Rafli et al., 2023). Consequently, this study recommends incorporating these worksheets into the modern mathematics curriculum, along with additional training for educators to ensure their optimal use. Thus, this research makes a significant contribution to the development of interactive instructional materials that support computational thinking, providing practical strategies to enhance students' mathematics learning experiences in the digital era

Despite its promising findings, this study has several limitations that should be addressed in future research. First, the sample size was relatively small, which may limit the generalizability of the results to a broader population. Additionally, the study focused exclusively on arithmetic sequences and series, which, while significant, may not fully represent the potential of computational thinking-based electronic worksheets across other mathematical topics. The integration of computational thinking principles into the worksheets was also limited to basic features, such as decomposition and pattern recognition, without extensive exploration of abstraction and algorithmic thinking. Furthermore, the study did not account for potential technological challenges, such as limited access to digital devices or internet connectivity, which could hinder the implementation of e-worksheets in diverse educational settings. Lastly, the effectiveness of the worksheets was assessed over a short-term period, leaving long-term impacts on students' conceptual understanding and problem-solving skills unexplored. Future studies could address these limitations by including larger and more diverse samples, extending the scope to other mathematical topics, and conducting longitudinal evaluations to better understand the sustained benefits of computational thinking-based e-worksheets.

CONCLUSIONS

The research findings, it can be concluded that the computational thinking-based electronic worksheet for arithmetic sequences and series developed in this study is categorized as valid, with evaluations from four experts yielding a score of 95.47%. Furthermore, assessments conducted by teachers and nine grade X high school students indicated that the computational thinking-based electronic worksheet is practical for use in teaching arithmetic sequences and series, with a practicality level of 89.97%. Therefore, the electronic worksheet is deemed suitable as a learning medium to enhance students' understanding of arithmetic sequences and series while also developing the computational thinking skills.

Future research could focus on expanding the development of electronic worksheets based on computational thinking to cover other mathematical topics, such as geometry, algebra, or calculus, to explore their broader applicability. Additionally, involving larger and more diverse samples from various educational levels would enhance the generalizability of findings and adapt the worksheets to different learning contexts. Further studies could also integrate richer interactive features, such as animations, simulations, or educational games, to increase student engagement.

AUTHOR CONTRIBUTION STATEMENTS

Data collection and comprehensive data analysis were carried out by TRA, ensuring that all necessary information was gathered and thoroughly examined. Meanwhile, HD focused on editing and reviewing the work, conducting detailed data analysis, and providing overall interpretation of the findings to ensure clarity and coherence in the final presentation. This collaborative effort ensured the research process was both meticulous and well-rounded.

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