

Can the Use of Liveworksheet-Based Learning Media Enhance Students' Computational Thinking Skills in Systems of Linear Equations in Three Variables?

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ABSTRACT

Computational thinking is an essential 21st-century skill that needs to be developed in mathematics learning, particularly in the topic of Systems of Linear Equations in Three Variables. However, students' computational thinking skills are still relatively low, especially in algorithmic thinking. This study aims to examine the effectiveness of Liveworksheet-assisted learning media in improving students' computational thinking skills. This research employed a Research and Development method using the ADDIE model, combined with a quasi-experimental design with a pretest–posttest control group. The participants consisted of 72 tenth-grade students at MAN 1 Semarang City, namely class X-5 with 36 students as the experimental group and class X-6 with 36 students as the control group. The experimental group was taught using Liveworksheet-assisted learning, while the control group received conventional instruction. The developed learning media was validated by two material experts, two media experts, and two language experts, indicating that it was highly valid. Data were collected through computational thinking tests and analyzed using independent sample t-test, paired sample t-test, and N-gain analysis. The results revealed a significant difference between the two groups and a significant improvement in the experimental group. The N-gain score of the experimental group was categorized as high, while the control group was in the moderate category. Therefore, Liveworksheet-assisted learning media is effective in improving students' computational thinking skills.

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INTRODUCTION

The development of 21st-century education requires students to possess higher-order thinking skills, one of which is computational thinking (CT), which plays an essential role in helping students solve problems systematically, logically, and in a structured manner, particularly in mathematics learning such as Systems of Linear Equations in Three Variables (SPLTV). CT has become a crucial competency as it supports students' ability to model, analyze, and solve data-based problems effectively (Mawaddah & Siswanto, 2022; Sari & Jusra, 2023; Elvanuari et al., 2024). This aligns with the principles of Education 4.0, which emphasize the integration of technology, project-based learning, and the development of 21st-century

competencies such as critical thinking, problem-solving, collaboration, and digital literacy (González-Pérez & Soledad, 2022; Voogt et al., 2013).

Conceptually, computational thinking consists of several key components, namely decomposition, pattern recognition, abstraction, and algorithmic thinking, which are interconnected in the problem-solving process (Grover & Pea, 2013; Mawaddah & Siswanto, 2022; Elvanuari et al., 2024). In the context of SPLTV learning, these components are highly relevant, as students are required to break down complex problems into simpler parts, identify relationships among variables, simplify mathematical representations, and construct systematic solution procedures. Therefore, mathematics should not be viewed merely as a set of procedural operations, but as a structured thinking process applicable to real-world problem solving (SÜMEN, 2022; Nurgabyl et al., 2023).

However, various studies indicate that students' computational thinking skills remain relatively low. Students often face difficulties in performing problem decomposition, recognizing patterns, and constructing logical and systematic solution algorithms (Aminah et al., 2023; Aziz et al., 2023). In particular, algorithmic thinking appears to be the weakest component, as students struggle to develop coherent and meaningful solution steps (Elvanuari et al., 2024). These findings are reinforced by preliminary classroom observations, which reveal that students tend to solve SPLTV problems procedurally by following elimination and substitution steps without understanding the reasoning behind them. Additionally, students experience difficulties in identifying patterns, breaking down problems, and developing structured solution strategies, indicating that their computational thinking skills especially in decomposition, abstraction, and algorithmic thinking are not yet well developed.

The low level of computational thinking is not only a student-related issue but is also influenced by systemic factors in education. Limited CT literacy among teachers, insufficient teacher readiness, and the lack of infrastructure and authentic assessment instruments are major barriers to integrating CT into mathematics learning. Many teachers have not yet fully understood how to design CT-based learning activities, resulting in implementations that focus merely on the use of technology rather than fostering structured thinking processes such as decomposition, pattern recognition, algorithmic reasoning, and solution evaluation (Grover & Pea, 2013; Voogt et al., 2013; Salsanabila et al., 2024; Szabó et al., 2020). Furthermore, disparities in digital infrastructure and the lack of contextually designed CT-based instructional models exacerbate the gap between educational policy and classroom practice (González-Pérez & Soledad, 2022; Junpho et al., 2022).

Moreover, the limited availability of professional development programs for teachers in integrating CT with TPACK or hybrid learning approaches, along with the absence of authentic assessments that evaluate students' thinking processes rather than merely final answers, further hinder the effective development of CT skills (Helsa et al., 2023; DEMİR, 2021). At the national level, variations in infrastructure readiness, learning culture, and curriculum policies contribute to disparities in CT development across regions. Therefore, a holistic approach is required, including teacher training, the provision of technology-based learning media, curriculum integration of CT from early stages, and the development of assessment systems that emphasize mathematical reasoning and modeling processes (Ayuso et al., 2023; Rahman et al., 2021).

In this context, the use of interactive and accessible digital learning media becomes highly relevant. One promising tool is Liveworksheet, a platform that transforms conventional worksheets into interactive digital formats with features such as drag-and-drop, auto-fill, and instant feedback. Liveworksheet allows the integration of multiple media elements (text, images, audio, and video), thereby supporting more meaningful, flexible, and student-

centered learning experiences (Maysara et al., 2023; Cristy & Pamenang, 2023; Rahmah et al., 2023). These characteristics have the potential to support computational thinking development by facilitating systematic thinking processes, repeated practice, and immediate reflection on errors.

Although several studies have examined the use of Liveworksheet in improving learning outcomes and student motivation, most of them focus on science subjects or general cognitive aspects and have not specifically investigated its effectiveness in enhancing computational thinking skills in SPLTV topics (Mawaddah & Siswanto, 2022; Elvanuari et al., 2024; Rahmah et al., 2023). Furthermore, studies that explicitly integrate computational thinking indicators into the design of Liveworksheet-based learning media are still limited, particularly in the context of secondary-level mathematics education.

Based on these considerations, this study offers novelty by developing and examining the effectiveness of Liveworksheet-based learning media specifically designed to accommodate computational thinking indicators in SPLTV learning. This study not only focuses on improving learning outcomes but also emphasizes the development of students' thinking processes through structured and interactive approaches. Thus, this research is expected to provide empirical contributions to technology-based mathematics education and offer an alternative solution for enhancing students' computational thinking skills, particularly in strengthening their algorithmic thinking abilities.

LITERATURE REVIEW

Computational Thinking (CT)

Computational Thinking (CT) is recognized as one of the essential competencies in 21st-century education, particularly in mathematics learning. CT refers to the ability to solve problems systematically through processes such as decomposition, pattern recognition, abstraction, and algorithmic thinking (Mawaddah & Siswanto, 2022; Elvanuari et al., 2024). CT is closely related to mathematical reasoning because both emphasize logical, analytical, and structured thinking processes. Through CT, students are encouraged not only to obtain correct answers but also to understand the reasoning and procedures used in solving problems.

The theoretical foundation of CT is closely associated with constructivist learning theory proposed by Piaget and Vygotsky. Constructivism explains that knowledge is actively constructed through interaction with the environment and social experiences. In mathematics learning, CT activities facilitate students in exploring problems, identifying relationships among concepts, and constructing systematic solution procedures. Vygotsky further emphasized that collaboration and social interaction support cognitive development, indicating that CT-oriented learning can be effectively developed through interactive and collaborative learning environments.

In mathematics education, CT is highly relevant to learning topics that require systematic reasoning and mathematical modeling, such as Systems of Linear Equations in Three Variables (SPLTV). SPLTV learning requires students to analyze relationships among variables, identify patterns, formulate mathematical models, and determine appropriate solution procedures. These processes correspond to CT indicators, including decomposition, abstraction, algorithmic thinking, and evaluation. Therefore, integrating CT into mathematics learning can support the development of students' higher-order thinking skills.

Several previous studies have demonstrated the positive contribution of CT to mathematics learning. Mawaddah and Siswanto (2022) reported that integrating CT into mathematics instruction improved students' problem-solving abilities and logical reasoning.

Similarly, Elvanuari et al. (2024) found that CT-based learning enhances students' analytical thinking and systematic problem-solving skills. In addition, studies by Junaidi and Lu'luilmaknun (2023) and Sari and Jusra (2023) indicated that collaborative mathematics learning integrated with CT strengthens students' communication skills, reasoning, and critical thinking abilities.

However, the implementation of CT in mathematics learning still encounters several challenges. Mathematics instruction is often focused on procedural completion and memorization rather than developing analytical and algorithmic thinking processes. Consequently, students frequently experience difficulties when solving non-routine problems requiring deeper reasoning. Moreover, teachers still face limitations in integrating CT indicators effectively into classroom learning activities. Therefore, innovative and technology-based learning approaches are necessary to support the implementation of CT-oriented mathematics learning.

Liveworksheet

The advancement of digital technology has encouraged the development of innovative learning media that support interactive and student-centered learning environments. One of the emerging digital learning platforms is Liveworksheet. Liveworksheet is an online platform that transforms conventional worksheets into interactive electronic worksheets equipped with multimedia features such as images, videos, audio, drag-and-drop exercises, matching tasks, and automatic feedback systems. These features enable students to engage more actively in learning activities and create more meaningful learning experiences.

The use of Liveworksheet aligns with constructivist learning theory, which emphasizes active student involvement in constructing knowledge through direct interaction with learning materials. Through interactive exercises and immediate feedback, students are encouraged to independently explore concepts, identify mistakes, and reflect on their learning processes. Therefore, Liveworksheet supports the development of students' cognitive abilities and increases their learning motivation and participation.

In mathematics learning, Liveworksheet has been widely used to facilitate conceptual understanding, problem-solving activities, and student engagement. The platform enables teachers to integrate multimedia components into learning activities, making abstract mathematical concepts easier to understand. In learning Systems of Linear Equations in Three Variables (SPLTV), Liveworksheet can help students visualize relationships among variables and practice solving problems systematically through structured digital exercises.

Several studies have shown that Liveworksheet contributes positively to the quality of learning. Rahmah et al. (2023) found that Liveworksheet-based learning media significantly increased students' motivation and classroom participation. Likewise, Maysara et al. (2023) reported that interactive electronic worksheets developed using Liveworksheet were practical and effective in improving students' learning outcomes. Cristy and Pamenang (2023) also emphasized that multimedia integration in Liveworksheet supports active and enjoyable learning experiences.

In mathematics education specifically, Mawaddah and Siswanto (2022) revealed that Liveworksheet-based electronic worksheets effectively improved students' mathematical problem-solving abilities in SPLTV materials. Rahmawati and Agustini (2023) further explained that interactive worksheets encourage students to engage more actively in problem-solving processes and support independent learning. Additionally, Fuadi et al. (2022) stated that interactive digital worksheets positively influence students' higher-order thinking skills and conceptual understanding.

Despite its advantages, the implementation of Liveworksheet still faces several challenges, including limited internet access, inadequate digital infrastructure, and teachers' limited competence in designing technology-based learning media. Furthermore, most previous studies mainly focused on learning outcomes and student motivation, while studies specifically investigating the impact of Liveworksheet on computational thinking skills remain limited. Therefore, integrating Liveworksheet with computational thinking indicators is considered important to support students in developing logical, systematic, and algorithmic thinking skills in mathematics learning, particularly in SPLTV materials.

METHODS

This study employed a Research and Development (R&D) approach using the ADDIE model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation. The research was conducted at MAN 1 Kota Semarang involving two classes, namely class X-5 as the experimental class and class X-6 as the control class, each consisting of 36 students. The participants were selected using purposive sampling based on their relevance to the research objectives, particularly students who were studying Systems of Linear Equations in Three Variables (SPLTV).

In the analysis phase, a needs analysis was conducted to identify students' difficulties in learning SPLTV and their level of computational thinking skills. This stage included curriculum analysis, analysis of student characteristics, and identification of the need for interactive learning media. The results indicated that students experienced difficulties in decomposition, abstraction, and algorithmic thinking, and therefore required engaging and interactive digital learning media.

In the design phase, Liveworksheet-assisted learning media were designed by formulating learning objectives, organizing SPLTV materials aligned with computational thinking indicators (decomposition, pattern recognition, abstraction, and algorithmic thinking), and developing interactive worksheet layouts. In addition, assessment instruments were designed to measure students' computational thinking skills.

In the development phase, the learning media were developed based on the design, including interactive exercises, structured problem-solving activities, and immediate feedback features. The developed media were then validated by six experts, consisting of four Mathematics Education lecturers and two mathematics teachers from MAN 1 Kota Semarang. These validators acted as content experts, media experts, and language experts. The validation process covered aspects of content feasibility, instructional design, language clarity, and media presentation. The validation results were analyzed using percentage criteria, as shown in Table 1.

Table 1. Questionnaire Validation Criteria

Average Percentage of Total	Validity Level
$80\% < P \leq 100\%$	Very Valid
$60\% < P \leq 80\%$	Valid
$40\% < P \leq 60\%$	Fairly Valid
$20\% < P \leq 40\%$	Less Valid
$0\% < P \leq 20\%$	Not Valid

Revisions were made based on the validators' suggestions to ensure the quality and appropriateness of the developed learning media.

In the implementation phase, the validated Liveworksheet-based learning media were applied in the experimental class (X-5), while the control class (X-6) was taught using conventional learning methods without the use of Liveworksheet. Both classes were given

pre-tests and post-tests to measure students' computational thinking skills before and after the learning process. Additional data were collected through classroom observations and student response questionnaires.

In the evaluation phase, the effectiveness of the learning media was analyzed quantitatively using a paired sample t-test to determine the differences between pre-test and post-test results within each class. An independent sample t-test was also conducted to compare the results between the experimental and control classes. Furthermore, the N-gain test was used to measure the level of improvement in students' computational thinking skills. The effectiveness level was interpreted based on the N-gain criteria as shown in Table 2.

Table 2. N-Gain Criteria

N-Gain Score	Category
$g \geq 0.70$	High
$0.30 \leq g < 0.70$	Medium
$g < 0.30$	Low

Qualitative data from observations and questionnaires were analyzed to evaluate the practicality and overall effectiveness of the developed learning media.

RESULT

The results of this study explain the process of developing learning media assisted by Liveworksheet analysis, starting from the needs stage, design, development, implementation, to evaluation, as well as testing the effectiveness of the media on students' computational thinking skills in the Three-Variable Linear Equation System (SPLTV) material. Next, the section describes the results of the analysis of the findings and development that have been carried out.

Analyze

The analysis was conducted through interviews with mathematics teachers to obtain information regarding classroom learning conditions, the use of learning media, and the types of media needed to support the learning process. The results of the interviews indicated that the use of learning media was still limited, with teachers primarily relying on textbooks and simple media such as PowerPoint presentations or available videos. In addition, students' computational thinking skills were still relatively low, particularly in the aspect of algorithmic thinking, as evidenced by students' difficulties in constructing systematic steps to solve problems. Therefore, interactive learning media are needed to support the development of these skills.

The results of the analysis showed that during the learning process, students still experienced difficulties in formulating problems, designing problem-solving strategies, and evaluating the results obtained. Students tended to rely on teacher assistance and were not yet able to solve problems independently and systematically. This condition indicates that students' computational thinking skills still need to be improved through more interactive and structured learning approaches.

Design Phase

At this stage, the Liveworksheet-assisted learning media were designed, including the development of SPLTV materials, the creation of storyboards, and the design of the media interface. The learning materials were developed based on computational thinking indicators, namely decomposition, pattern recognition, abstraction, and algorithmic thinking. In addition,

interactive practice exercises and evaluation instruments in the form of pre-tests and post-tests were also designed.

Development

The learning media that had been designed were subsequently developed and validated by subject matter experts, media experts, and language experts. The validation results indicated that the Liveworksheet-assisted learning media were categorized as highly valid in terms of content, appearance, language, and ease of use. However, several revisions were made based on the validators' suggestions to improve and refine the media before its implementation in the learning process.

Subject Matter Expert Validation

Table 3. Results of Subject Matter Expert Validation

Aspect	Validator 1	Validator 2	Maximum Score	Percentage 1 (%)	Percentage 2 (%)	Average (%)	Criterion
Content of the Material	14	13	15	93,3	86,7	90	Very valid
Material Accuracy	17	18	20	85	90	87,5	Very valid
Feasibility of Presentation	8	9	10	80	90	85	Very valid
Computational Thinking	21	22	25	84	88	86	Very valid

Based on Table 3, it can be concluded that the Liveworksheet-assisted learning media have a very high level of validity in terms of content, material accuracy, and alignment with computational thinking. However, the validators suggested enriching the material with more contextual examples and adding a wider variety of tasks that emphasize the development of students' algorithmic thinking skills.

Media Expert Validation

Table 4. Results of Media Expert Validation

Aspect	Validator 1	Validator 2	Maximum Score	Percentage 1 (%)	Percentage 2 (%)	Average (%)	Criterion
Substance	9	10	10	90,00	100,00	95,00	Very valid
User Aspect	13	14	15	86,67	93,33	90,00	Very valid
Writing	12	14	15	80,00	93,33	86,67	Very valid
Display	14	15	15	93,33	100,00	96,67	Very valid
Media Quality	14	13	15	93,33	86,67	90,00	Very valid

Based on Table 4, the Liveworksheet-assisted learning media are categorized as very valid in terms of appearance, usability, and overall media quality. The suggestions from media experts include: (1) improving the consistency of the visual design to make it more attractive and less monotonous, (2) adjusting font size and color for better readability, (3) adding clearer usage

instructions for students, and (4) enhancing interactivity by incorporating more varied activities such as drag-and-drop tasks or exploratory-based questions.

Language Expert Validation

Table 5. Results of Language Expert Validation

Aspect	Validat or 1	Validat or 2	Maximum Score	Percentage 1 (%)	Percentage 2 (%)	Average (%)	Criteri on
Language Clarity	23	22	25	92	88	90	Very valid
Communicativ eness	22	22	25	88	88	88	Very valid

Based on Table 5, the language aspect of the Liveworksheet-assisted learning media falls into the very valid category. The suggestions from language experts include improving sentence structure to make it simpler and easier for students to understand, as well as ensuring consistency and clarity in the use of mathematical terminology.

Implementation

The learning media used in this study was Liveworksheet, which generated an output in the form of a learning link. This link could be accessed by each student using a smartphone through web browsers such as Mozilla Firefox or Google Chrome. The initial step required students to open a web browser application, enter the provided link into the search bar, and access the learning page designed by the teacher. The page contained learning materials, instructions, and interactive worksheets that students were required to complete.

The implementation of the learning process was conducted over five meetings and was observed using a teacher activity observation sheet. The results of the observation showed that the average percentage of teacher activity reached 90.07%, which falls into the “very good” category. This indicates that the implementation of learning using Liveworksheet-based media was carried out effectively and in accordance with the planned procedures.

In the first meeting, the learning activity began with the administration of a pre-test to measure students’ initial computational thinking skills on the topic of Systems of Linear Equations in Three Variables (SPLTV). The second meeting focused on the stages of understanding the problem and planning the solution. Students were divided into groups of 4–5 members and accessed the Liveworksheet using their devices. They reviewed prerequisite materials and analyzed contextual problems presented in the worksheet. Subsequently, students engaged in group discussions to determine appropriate problem-solving strategies.

During the problem-solving stage, students worked collaboratively to identify elements of SPLTV, such as variables, coefficients, and constants, and constructed mathematical models. They then solved the problems using substitution and elimination methods. In the final stage, students reviewed their solutions by exchanging their group work with other groups to verify correctness or identify possible errors.

In the third meeting, the learning continued with the topics of combined methods and determinants. Students worked in the same groups and engaged in discussions using the Liveworksheet. They developed systematic solution steps, including the use of flowcharts to represent problem-solving procedures. The learning process followed the stages of understanding the problem, planning, solving, and reviewing the solution. The session

concluded with drawing conclusions and assigning students to review the material for the next meeting.

In the fourth meeting, students were given a post-test consisting of essay questions to measure the improvement of their computational thinking skills. The test covered various indicators, including mathematical modeling, substitution, elimination, combined methods, and determinants. At the end of the session, students participated in a brief reflection on the learning process.

In addition, students' responses to the learning process were collected through questionnaires. The results indicated that students had very positive perceptions of the use of Liveworksheet-based learning media. Students reported feeling happy, comfortable, and more motivated during the learning process. They also perceived the media as engaging, easy to understand, and helpful in learning the material. Overall, the average student response reached 83.30%, which falls into the "very good" category. This finding indicates that Liveworksheet-assisted learning media are not only effective for instructional purposes but also enhance student engagement and interest in learning.

Evaluation

The evaluation stage was conducted to determine the effectiveness of using Liveworksheet-assisted learning media in improving students' computational thinking skills. The evaluation was carried out through the analysis of pretest and posttest results in both the experimental and control classes, as well as through statistical tests, including normality tests, homogeneity tests, and hypothesis testing.

Table 6. Summary of Computational Thinking Skills

Class	Test	N	Mean	Standard Deviation
Experimental	Pretest	36	56.94	12.10
	Posttest	36	88.75	9.20
Control	Pretest	36	52.20	9.10
	Posttest	36	70.49	10.36

The results of the descriptive analysis indicate that students' computational thinking skills improved in both classes; however, the improvement in the experimental class was higher than that in the control class. The average pretest score in the experimental class increased from 56.94 to 88.75 in the posttest, while in the control class, the average pretest score increased from 52.20 to 70.49 in the posttest. This finding suggests that the use of Liveworksheet-assisted learning media has a more positive impact on enhancing students' computational thinking skills.

Table 7. Normality Test

Data	Statistic	df	Sig.	Conclusion
Pretest Experimental	0.952	36	0.120	Normal
Posttest Experimental	0.943	36	0.061	Normal
Pretest Control	0.957	36	0.169	Normal
Posttest Control	0.951	36	0.110	Normal

Table 8. Homogeneity Test

Data	Levene Statistic	df1	df2	Sig.	Conclusion
Pretest–Posttest	0.913	3	140	0.436	Homogeneous

Based on the prerequisite tests, the results of the normality test indicate that all pretest and posttest data in both classes are normally distributed, while the homogeneity test shows that both groups have homogeneous variances. Therefore, the data meet the requirements for parametric statistical analysis. Furthermore, the results of the initial equivalence test show that there is no significant difference between the initial abilities of the experimental and control classes, indicating that both groups can be considered equivalent before the treatment was applied.

Table 9. Initial Equivalence Test

Data Compared	t	df	Sig. (2-tailed)	Conclusion
Pretest Exp vs Control	1.859	70	0.067	No significant difference

To determine the difference in the average computational thinking skills between the experimental and control classes after the learning process, an Independent Sample t-test was conducted. The results of the test are presented in Table 10.

Table 10. Independent Sample t-test

Data Compared	t	df	Sig. (2-tailed)	Conclusion
Posttest Exp vs Control	3.933	70	0.000	Significant difference

Based on the analysis results, the calculated t-value is 3.933 with a degree of freedom (df) of 70. The significance value (Sig. (2-tailed)) obtained is 0.000, which is smaller than the significance level of 0.05. Since the significance value is less than 0.05 ($0.000 < 0.05$), the null hypothesis (H_0) is rejected. This indicates that there is a statistically significant difference between the posttest results of students in the experimental and control classes. Thus, it can be concluded that the use of Liveworksheet-assisted learning media has a significant effect on improving students' computational thinking skills, where the learning outcomes of students in the experimental class are better than those in the control class. Furthermore, to determine the improvement in students' computational thinking skills before and after learning in the experimental class, a Paired Sample t-test was conducted. The results are presented in Table 11.

Table 11. Paired Sample t-test

Comparison	Mean Difference	t	df	Sig. (2-tailed)	Conclusion
Pretest–Posttest	-23.26	-17.60	35	0.000	Significant improvement

Based on the results of the Paired Sample t-test, the significance value (Sig. 2-tailed) is 0.000, which is less than 0.05. This indicates that there is a significant difference between the pretest and posttest scores. Therefore, it can be concluded that Liveworksheet-assisted learning significantly improves students' computational thinking skills.

Furthermore, to determine the level of improvement in students' computational thinking skills after learning, an analysis using N-Gain was conducted. The results of the N-Gain calculation for the experimental and control classes are presented in Table 12.

Table 12. N-gain

Class	N-Gain	Category
Experimental	0,74	High
Control	0,38	Moderate

Based on the N-Gain analysis, the average N-Gain score in the experimental class falls into the high category, while the control class falls into the moderate category. This indicates that the improvement in students' computational thinking skills in the experimental class is higher than that in the control class.

Based on the results of the Independent Sample t-test, Paired Sample t-test, and N-Gain analysis, it can be concluded that the use of Liveworksheet-assisted learning media has a significant effect on improving students' computational thinking skills. The Independent test shows a significant difference between the experimental and control classes, while the Paired test indicates a significant improvement before and after learning in the experimental class. In addition, the N-Gain analysis shows that the improvement in computational thinking skills in the experimental class is higher than that in the control class. Therefore, Liveworksheet-assisted learning media are proven to be effective in enhancing students' computational thinking skills.

DISCUSSION

The findings of this study, which indicate that the use of Liveworksheet-assisted learning media can enhance students' computational thinking skills, can be theoretically explained through the constructivist framework. From a constructivist perspective, knowledge is actively constructed by learners through interaction with their learning environment rather than passively received from teachers. Liveworksheet provides an interactive learning environment through digital tasks, automatic feedback, and exploratory activities that encourage students to actively engage in the learning process. This is consistent with the findings of Mawaddah and Siswanto (2022), Rahmah et al. (2023), and Maysara et al. (2023), which show that Liveworksheet-based e-worksheets can improve student engagement and higher-order thinking skills.

From Vygotsky's perspective, the improvement in students' computational thinking skills can also be attributed to the role of social interaction in learning. The integration of Liveworksheet with group discussions allows students to exchange ideas, provide feedback, and collaboratively construct understanding. This process supports the development of the *zone of proximal development* (ZPD), where students can achieve higher levels of understanding with the assistance of peers and teachers. This is supported by studies conducted by Sari and Jusra (2023), Junaidi and Lu'luilmaknun (2023), and Prasetyo and Novita (2023), which demonstrate that integrating Liveworksheet with collaborative learning models enhances students' cognitive and metacognitive activities.

From the perspective of computational thinking (CT), the results of this study align with the concept proposed by Wing, which includes decomposition, pattern recognition, abstraction, and algorithmic thinking. Liveworksheet facilitates these processes by presenting structured and sequential tasks, enabling students to break down problems into manageable parts, recognize patterns, and construct systematic solution procedures. This is supported by the findings of Elvanuari et al. (2024), Supriatna et al. (2024), and Rahmawati and Agustini (2023), which indicate that interactive e-worksheet-based learning media can enhance higher-order thinking skills and cognitive processes.

In the context of Systems of Linear Equations in Three Variables (SLETV), the improvement in computational thinking is particularly relevant, as this topic requires analytical reasoning, mathematical modeling, and systematic problem-solving. The use of Liveworksheet enables students to identify variables, formulate mathematical models, and select appropriate solution strategies in a structured manner. This is in line with the findings of Mawaddah and Siswanto (2022) and Novitasari et al. (2022), which show that e-worksheet-based learning in SLETV can improve students' problem-solving and mathematical modeling abilities.

Furthermore, the significant improvement observed in students' algorithmic thinking indicates that Liveworksheet effectively supports students in constructing systematic solution steps. This finding is supported by Looi et al. (2024), who state that computational thinking-based mathematics learning can enhance students' algorithmic reasoning when tasks are presented in a structured and sequential manner. Additionally, the automatic feedback provided by Liveworksheet enables students to evaluate their mistakes and refine their problem-solving strategies, thereby fostering metacognitive development.

The results of this study are also consistent with previous empirical research demonstrating the effectiveness of Liveworksheet in enhancing higher-order thinking skills. Fuadi et al. (2022) found that Liveworksheet integrated with Problem-Based Learning improves student learning outcomes. Cristy and Pamenang (2023) and Rahmah et al. (2023) reported that Liveworksheet enhances student motivation and participation. Moreover, Trinanda et al. (2024) and Widyaningrum and Parmiti (2024) found that digital worksheet-based learning improves mathematical literacy and conceptual understanding.

However, the effectiveness of Liveworksheet depends on the quality of instructional design and teacher readiness. Studies by Wiradimadja et al. (2023) and Triani and Triana (2024) emphasize that the successful implementation of digital learning media is highly influenced by teachers' ability to design meaningful and interactive learning experiences. Without proper design, digital media may function merely as a visual aid without significantly impacting students' thinking skills.

Overall, the findings of this study demonstrate that Liveworksheet-assisted learning not only improves learning outcomes but also significantly contributes to the development of students' computational thinking skills, particularly in algorithmic thinking, which was previously relatively low. This study strengthens existing research while providing new contributions in the context of mathematics learning, especially in SLTV at the senior high school level. Therefore, Liveworksheet can be considered an innovative and effective learning medium for fostering 21st-century skills, particularly computational thinking, in mathematics education.

CONCLUSION

Based on the findings of this study, it can be concluded that the use of Liveworksheet-assisted learning media is effective in improving students' computational thinking skills, particularly in the aspect of algorithmic thinking, which was previously relatively low. This improvement indicates that interactive learning media can encourage students to think more systematically, structuredly, and reflectively in solving mathematical problems, especially in the topic of Systems of Linear Equations in Three Variables. The implication of this study highlights the importance of integrating well-designed educational technology to support the development of 21st-century skills, particularly computational thinking in mathematics learning. Therefore, teachers are recommended to optimally utilize Liveworksheet or similar digital media by integrating them into active and collaborative learning models. In addition,

schools should support the implementation of technology through adequate facilities and teacher training to ensure effective use of learning media. For future research, it is recommended to explore the application of Liveworksheet in other mathematical topics and to incorporate additional variables such as learning motivation or metacognitive skills to provide a more comprehensive understanding of the impact of digital media on students' thinking processes.

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